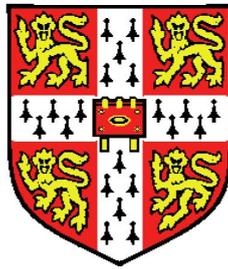


Student persistence in STEM fields:  
School structures and student choices in  
Finland, Sweden and the United States

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# Declaration

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text.

The word count is 79,410 excluding front and back matter, figures, tables and footnotes.

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# Abstract

## **Student persistence in STEM fields: School structures and student choices in Finland, Sweden and the United States**

Jennifer von Reis Saari

In science, technology, engineering, and mathematics (STEM) education, producing high level talent and increasing equity of access and engagement are prominent but sometimes conflicting policy directives. Yet, retention and persistence are important outcomes both for the production of elite talent and for promoting equity within STEM fields. This dissertation investigates the effects of policy on student persistence in Finland, Sweden and the United States.

Drawing on interviews with upper-secondary school students and teachers (Finland: 26 students, 8 teachers; Sweden: 29 students and 10 teachers; United States: 19 students, 2 mentors) and surveys (Finland: 255 students, Sweden: 130 students, United States: 288 students), this study investigates the effects that different structures (including contrasting policies of stratification and differentiation, specialist magnet schools and enrichment programmes) have on students' intentions to persist in STEM fields.

This study supports the theory that educational policies mediate student persistence both through structural possibility, and through the development of students' identities and non-cognitive skills. Here, non-cognitive skills (such as self-efficacy and self-concept) are considered part of an 'adaptive habitus' and a latent variable comprised of domain-specific non-cognitive skills is used in models of student persistence. The models illustrate the domain specific interactions of educational structures, student background, adaptive habitus and student persistence.

Analysis of the interviews further explores these relationships, suggesting the importance of programmes that include exposure to challenging real-world STEM learning and interaction with STEM professionals, and that such features are effective in part because they foster an adaptive habitus towards STEM fields. The policy implications for both efficiency and equity are considered.

A framework of Mechanism, Transparency and Permeability is introduced for analysing the effects of policies on efficiency and equity. Drawing on the interviews, this framework is used to give a comparative characterisation of the educational systems Finland, Sweden and the United States. Permeability is highlighted as particularly important for retention and persistence, and a key consideration for educational policies that seek to produce elite talent, and promote equity in STEM fields.



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# Chapter 1

## Introduction

Improving science, technology, engineering and mathematics education is often given prominent economic and social justifications. Schools are called upon to assure the production of ‘... talented and motivated individuals who will comprise the vanguard of scientific and technological innovation’ (National Science Board, 2010, p. v). Elite STEM talent is thus positioned as a public good in which students are ‘... conceived as a natural resource that should be covered into useful things’ (Husén, 1963, p. 165). Linking STEM education to national economic and policy concerns raises the visibility of STEM policy initiatives, and firmly frames science and mathematics education as a public utility, what Labaree (1997) terms the economic efficiency goal of educational policy.

However, there are other reasons that policy makers might consider mathematics and science education important for all students. Osborne (2007), for example, dismisses the idea of mass science education for the sake of utility and instead advocates educating for scientific literacy, literacy in particular that would empower students to approach these subjects as something to be ‘discussed and evaluated’ (Osborne, 2007, p. 182). Such a justification for widespread science education positions STEM education as an important tool for discursive citizens. STEM education might also be justified in terms that bring it closer to arts education, by arguing that scientific, mathematical and technological advances represent an important part of human cultural inheritance. They are certainly powerful ways of understanding and influencing the world, worthy of wonder (Holmes, 2010).

Despite these alternative, and perhaps more sound, justifications for STEM education, economic concerns dominate policy rhetoric. The focus is particularly on the sufficient production of STEM talent. Accordingly, a significant body of research takes as its moti-

vation the problem of interesting and retaining students in these challenging fields (e.g., Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2010; Aschbacher, Li, and Roth, 2010; Dickson, 2010; Bracey, 2011; National Science Board, 2010). A closely related policy issue is the *disparities* of retention between different groups in STEM fields. Differences in the rates of persistence among qualified students (according to socio-economic background, gender, and race) run across national borders, and have been termed a ‘global phenomenon’ (Adamuti-Trache and Andres, 2008, p. 1558). The ‘leaky pipeline’ metaphor used to describe such disparities originated in the United States (Barr, Gonzalez, and Wanat, 2008) and has been adopted in countries ranging from Sweden (Brandell, Leder, and Nyström, 2007) to Australia (Watt, 2006) as a shorthand for discussing this wide-spread policy issue. These inequalities in rates of persistence are important from the standpoint of economic efficiency as they represent a loss of talent in STEM fields. However, on the individual student level, in addition to resulting in limited access to desirable and well-compensated professions, this difference in engagement in science, technology, engineering and mathematics also results in a difference in power and influence. Scientific and technological innovation are human endeavours, and thus it matters who is *doing* the innovation, and to whom it is *done* (See e.g., Washington, 2007). In turn, differences in engagement affect what questions are asked in scientific inquiry, what new technologies are developed, and who has the knowledge to voice opinions and make judgements regarding new discoveries and innovation. Osborne (2010) suggests that science learning is important for the skills of argumentation and critical thinking it should foster, but content knowledge in STEM disciplines is just as important for an average citizen to critically reflect on the personal impact of policies regarding health, finance, and technology for example. A citizen’s capability to impact the direction and use of STEM innovations is also dependent on whether she has the education, skill and confidence to search out information and access forums in which her questions and ideas are heard. Thus, beyond economic concerns, disparities in STEM fields may have consequences for equity on the individual level, as well as for the direction of scientific, economic and technological progress on a societal scale.

Underlying these different possible motivations for STEM education policy, then, are contentious normative questions about the role of public education systems in society and the responsibilities educational institutions have to the young people who are required to navigate them. One common point of mutual interest, however, across these disparate visions of the purpose of STEM education is the goal of increasing the engagement and persistence of students in STEM fields. Understanding how to do so speaks both to the goal of increasing the number of underrepresented students pursuing advanced STEM

study and to the goal of seeking to understand how to more efficiently cultivate and retain talent in STEM fields. In particular, the reduction of *secondary effects* (Boudon, 1973) in rates of persistence, that is, differences in retention of underrepresented groups despite equal prior attainment, represents a loss of qualified students from the STEM pipeline. Reducing secondary effects would both increase equity, and increase efficiency since more qualified students would remain in the STEM talent pool. Thus increasing retention and persistence should be concerns for policy makers and educational leaders concerned both with the efficient production of talent, and with the reduction of inequalities.

Yet, as will be discussed in the next section, many educational policies that are justified by the goal of producing STEM talent are also those implicated in inhibiting the access and persistence of students in general, and underrepresented groups in particular. Rather than concede that such a binary opposition must necessarily exist between the goals of efficient production of high-level talent and improving equality, there is cause to carefully examine the assumptions behind the apparent contradiction. That is, keeping in mind the persistence of qualified talent as a possible point of mutual agreement, there is a need to question whether trade offs between the production of talent and equity are unavoidable. There is a need to understand how elite talent is developed in STEM fields, and what the uses and effects of stratified educational structures are in practice and to what extent they contribute to the generation of talent and inequalities. Perhaps progress can be made towards furthering both efficiency and equity if the question is not simply the binary choice of whether or not to stratify, but a new question: Can stratification be done *better*?

The next section (Section 1.1) begins with an overview of the connections between different forms of stratification and inequality. Section 3.13 examines the connections between stratification and the development of high-level talent. Section 1.3 introduces *habitus* as a tool for conceptualising the interactions of school structures and student choices. The last substantive section, Section 1.4, introduces a framework for facilitating the analysis of the stratified structures themselves. The chapter concludes with the research questions that orient the Student Persistence in STEM Fields project within the different stratified educational systems of Finland, Sweden, and the United States.

## 1.1 Stratified school structures and the generation of inequities and inefficiencies

A common policy response to heterogeneous populations is to differentiate students. The resulting stratification is a feature of nearly all formal educational systems today, occurring through the separation of students within a school, or by differences in provision of education between schools. Allocation within a stratified system might come about through student choice, test score results, or reflect a family's ability to pay for tuition at private or independent schools. Differentiation itself may be essentially neither good nor bad; arguably society at large benefits from diversity in educational outcomes. However, how and why stratification happens in practice can have variable consequences that raise issues of justice and fairness, and produce life-long consequence for individuals, educational systems, and the societies in which they are embedded. Stratification becomes problematic when lack of educational access can have profound effects on human flourishing, and when assignment within a stratified system relates more to social class than merit.

The first issue with stratification is that allocation within stratified structures (such as ability grouping and between-school tracking) has been amply shown to be related to students' socio-economic background, apart from their prior achievement or motivation towards schooling (e.g., Rousseau and Tate, 2003; Oakes, 2008; Gamoran, Nystrand, Berends, and LePore, 1995; Schnabel, Alfeld, Eccles, Köller, and Baumert, 2002; Ma, 2005; Mickelson and Heath, 1999). That is, allocation to a track or ability group is highly related to family background rather than academic potential. This disparity in allocation becomes compounded, since stratification lends itself to differential access to curriculum and resources over time. It should not be surprising that students in elite strata tend to have access to better resources such as superior teaching (e.g., Hanushek, 2006) and opportunities to access accelerated curricula. The problem is that other students do not, and yet such resources have also been amply shown to benefit standard level students as well (e.g., Burris, Heubert, and Levin, 2006; Ma, 2005; Hanushek, 2006). In this way, various forms of differentiation are not only biased in their allocation, but in their way that resources are distributed to students, with the benefits accruing to already privileged students, thus increasing disparities.

Such structural differences in opportunity make less advantaged students less likely to have access to the resources to prepare themselves for advanced STEM learning. In addition to these structural impediments, the ways that students are differentiated can

impact their self-confidence and desire to persist in schooling. It would be naive to assume that the students themselves fail to recognise and react to the injustices associated with their allocation within a stratified system. Particularly in systems where allocation has little to do with student choice, students question the validity of their placement (Yonezawa and Jones, 2006) and express desire to escape subaltern positions within the stratified educational structure (Zevenbergen, 2005; Hallam and Ireson, 2007). Students understand their provision within disadvantaged tracks to be wanting (Dupriez, Dumay, and Vause, 2008, pp. 257–258).

Again, such perceptions have been shown to be well-founded; not only are students in subaltern positions within stratified structures less likely to have access to advanced curricula and quality instruction, teachers have lower expectations for students outside elite classrooms (Vanfossen, Jones, and Spade, 1987; Oakes, 2005; Zevenbergen, 2005; Yonezawa and Jones, 2006). Such expectations have been shown to impact student outcomes and choices, regardless of previously demonstrated ability (e.g., Wigfield and Eccles, 2000). Placement impacts not only access, but it is a label that impacts others' perceptions and expectations for students.

It is understandable, then, that students might look for ways to rebel against structures that pre-define their potential and limit their position in a competitive field (Van Houtte and Stevens, 2008). Given what is, in some cases, an unfounded allocation within a stratified system of schooling, and one moreover often based largely on socio-economic background, students might come to cope by disassociating from the goals and values of that system (e.g., Willis, 1977), thus being able to experience agency by denying themselves a structure and valuation that has put them at a disadvantage. It is not only a difference in cognitive, academic skills that is being constructed through differential access to curricula, but one of affective, non-cognitive development such as dispositions towards schooling.

Perhaps this explains in part the secondary-effects of retention in education, which are a prominent issue in STEM fields in particular. Lower rates of persistence of qualified students from underrepresented groups such as first generation university students, women and minorities refer exactly to the 'leaky pipeline' to STEM fields mentioned above. Noyes (2004) offers a more illuminating metaphor that ties this problem of retention to educational stratification. He notes that in England differentiation in mathematics education '... acts like a prism, diffracting the social and academic trajectories of the children as they pass across it,' (Noyes, 2004, p. 59). This *diffraction* can be seen visually in the graphs of rates of student persistence across transitions (e.g., Jackson, Erikson,

Goldthorpe, and Yaish, 2007), with less advantaged students having lower chances of persisting, again, despite being qualified academically.

Such effects play upon and exaggerate the differences that students bring with them into the educational structure. Both through hindering access and through influencing the development of students' dispositions towards schooling, educational structures are implicated in the generation of these secondary effects. Again, this lack of retention of *qualified students* also represents a loss of talent to STEM fields.

Despite the problematic outcomes of different systems of stratification, and long-term attention to the issue of the inequalities such systems engender (e.g. Oakes, 2008), there has been little progress in reducing stratification in countries such as the United States, Australia and the United Kingdom, and, as will be discussed in this dissertation, it is arguably increasing in Finland and Sweden. Understanding why such an impasse exists requires examining the motivation for and the use of stratification. In order to consider how such structures might in practice be altered to be more equitable, it is necessary to understand the ontology behind them, how they function both for the elite students who benefit most from them, and their actual potential to produce the elite talent that educational systems are urged to cultivate.

The next section will focus on the ontology and justifications of stratification, the actual uses of stratification in practice, and what research implies about cultivating elite talent, which contrasts with the ontology behind most forms of stratification.

## 1.2 Fostering elite talent

Exploring policy balances and trade-offs between developing of elite students on one hand and producing satisfactory, equitable attainment on the other presupposes an understanding of *how* to promote the learning, engagement and retention of high-performing students. Focusing on the discourse of gifted education research and policy, this section will give an overview of some of ontological assumptions about the development high-performing students and professionals.

Nagel (1991, p. 135) defines a binary opposition between the goals of maximalism (the desire to produce individual talent to its full potential) and equality. He admonishes that '[e]quality of opportunity is fine, but if a school system also tries to iron out distinctions, the waste from failure to exploit talent to the fullest is inexcusable.' Yet, to fully understand the extent to which the maximalist goal is in conflict with goals of educational

equality, there must first be an understanding of how elite talent comes to be. In this section, a critical perspective is taken in the analysis of the assumptions surrounding key educational structures related to gifted education. However, this is not to argue that the goals espoused (that classrooms be engaging and students challenged) are not important goals for educational policy; rather it is to better understand how such worthy goals might be realised more efficiently for more students.

Drawing on Benbow and Stanley's (1996) recommendations for gifted education policies as an example, there are several key assumptions made regarding giftedness (having an elite talent or ability):

1. It is possible to identify giftedness and not everyone has it;
2. Identified giftedness in a given domain predicts future high-level performance in that domain;
3. It is not something that can be developed, but if one has it, it needs to be cultivated in order to realise its potential;
4. It is usually best cultivated by segregating the gifted individual from ordinary people.

The third justification for differentiation immediately contradicts itself, so the focus will be on the first, second, and fourth points.

## **Identification**

One perennial issue in educational policy is how to identify, and thus allocate, students to differentiated educational opportunities. Within the gifted education paradigm, there is an argument that future talent can and should be identified in some individuals over others, and that it can and should be done as early as possible. For example, in studying summer programmes associated with a long-running talent search programme run by the Center for Talented Youth at Johns Hopkins University, Brody and Mills (2005, p. 99) noted how '[i]t has been clearly documented that mathematically precocious students can learn a great deal of mathematics in a much shorter period of time than is typically required in school.' While this statement may be true, their use of this argument assumes that precocious students differ from other, standard students in this regard. However, research suggests that this is not the case, but rather that most students benefit from such enrichment and acceleration (Burris, Heubert, and Levin, 2006; Ma, 2005).

Furthermore, identification implies that students can be meaningfully separated into talented and non-talented groups. Yet even research that supports early identification, such as that by (Hotulainen and Schofield, 2003) in Finland, finds that there is a large overlap in later performance between those identified as gifted by early testing and those deemed to have normal abilities. Such overlaps bring into question whether such distinctions are tenable, when there is such a fuzzy distinction between those identified and those left behind, and moreover whether they are either fair or efficient, when some students capable of high-performance are excluded, and when such identification is used to determine access to important educational resources. This is the problem of identification.

As noted in the previous section, it is difficult to separate the effects of social class in the allocations of students into privileged educational positions. Gifted identification, for example, often happens through parental choice, assessments on the part of teachers, and some times standardised testing. Yet even performance on standardised tests, are in part a function of economic resources. This difference is not a matter of genetic inheritance alone; research has shown conclusively the importance of environment. The heritability of intelligence varies by social class (Turkheimer, Haley, Waldron, D'Onofrio, and Gottesman, 2003; Nisbett, Aronson, Blair, Dickens, Flynn, Halpern, and Turkheimer, 2012). This is not because the transfer of raw genetic material works differently for the poor than the rich, but because there are huge disparities in resources between the poor and the rich that affect how they express their raw genetic material. Thus even the use of testing (particularly for young children), which might seem more meritocratic, means that, in part, what is being identified is social position and identity (e.g., Berry, 2008, p. 479). Identification for and access to elite programmes is never simply about revealing a raw physical or mental talent; it is intertwined with social position.

### **Failure to predict**

While intelligence as measured by standardised testing does impact student outcomes, other factors have been shown to be more salient in terms of educational, social, and employment outcomes over the life-course (e.g., Heckman, 2008; Ericsson, Roring, and Nandagopal, 2007). However, within the paradigm of gifted education, the failure of identification and participation in differentiated gifted education programmes to coincide with achievement and performance results in further recommendations to increase differentiation, rather than to question the validity of the identification.

For example, Fredricks, Alfeld, and Eccles (2010) found that students who had been

identified by their elementary schools as academically gifted, and received higher than average marks at the primary level, in many cases did not evince academic engagement or achievement, particularly when compared with students deemed talented in other domains such as music or sport at the end of secondary school. That is, neither the mechanism used for early allocation, nor participation in the programme, seemed to correspond with elite performance later. However, their conclusions do not question the way in which gifted students are identified.

Another view of the data they present is that it brings into question both the validity and the benefit of the gifted identification itself. This is exemplified in the following quote by one of their participants, who had been identified as gifted and who ended up dropping out of tertiary education (Fredricks, Alfeld, and Eccles, 2010, p. 24):

If I didn't do well, then I felt really bad, cause that was who I thought I was, like the smart person, you know. I wasn't that fun maybe, and you know maybe I wasn't even that nice, and maybe I wasn't cute, but I was smart. So if I wasn't smart anymore then I wasn't anything, so I had to make sure I maintained that.

The study drew an unfavourable contrast between programmes for gifted children, and programmes for art and sports; students in art and sports were much more passionate and engaged. The authors recommended more stratified options for students. Yet, perhaps it is a difference in how students are selected into academic programmes versus arts and sports that is the cause. The student quoted was not selected because of dedication or passion for a particular academic domain, as students often are for sports or arts, or for traits such as resilience, grit or self-efficacy, important non-cognitive traits (Heckman, 2008), discussed further below in Section 1.3.

Indeed, the impact of the differentiated gifted and talented programme may have been negative on this student's self-concept; that elite academic environments can have such an effect is an established finding (Marsh and Hau, 2003). Certainly, the participant exhibited the belief that ability is fixed, rather than something that is possible to change with effort, a belief that is associated with poorer academic outcomes (Dweck, 1999, 2006). Insofar as gifted education identification programmes and talent searches (e.g., Brody and Mills, 2005) presuppose giftedness as a trait to be uncovered or mined, such programmes are structurally aligned with what Dweck (2006) might term a fixed-mindset ontology about the nature of ability. Given, as the last section suggests, students' sensibility to educational structures, it should also be questioned whether structures that are undergirded with a fixed mindset would in turn encourage students' to develop similar

maladaptive beliefs, a question that is explored in this dissertation.

Considering the emerging research regarding the importance of mindsets and other non-cognitive attributes to elite attainment, discussed further in Section 1.3, gifted identification might even be detrimental for the development of the individual if it coincides with the development of a fixed mindset, which is inversely related to attainment and resilience (Dweck, 2006). Certainly, an alternative analysis of Fredricks et al.'s data might suggest this.

## Segregation

Setting aside for the moment the problematic issue of identification, once a future elite talent has been identified, the general policy suggestion is that they be to some extent segregated from other students. The purported purpose of differential tuition (tracking, setting, ability grouping, separate schools)<sup>1</sup> is to increase the academic fit between a student and his or her coursework. Furthermore, it is based on the idea that, particularly in the case of highly able students, such segregation is likely necessary in order for them to reach their full academic potential. However, despite a few countervailing studies, such as that by Terwel (2005, p. 655), most studies show little academic benefit to high performing students from such segregation into elite programmes (e.g., Hallam and Ireson, 2007; Linchevski and Kutscher, 1998). Again, this is true across different modes of differentiation and across cultural contexts. For example, studies of selective magnet schools both in Estonia (Toomela, Kikas, and Mõttus, 2006) and the United States (Abdulkadiroglu, Angrist, and Pathak, 2011) failed to find any value-added to academic performance for students who attended selective magnet schools. Perhaps even more troubling, is the ways in which such segregation excludes some students from access to advanced courses and acceleration, when it has been shown that they *would* benefit from such provision (i.e., Burris, Heubert, and Levin, 2006; Ma, 2005).

Regardless of the lack of evidence for an added academic benefit to segregation, and furthermore, evidence that placement in elite environments has been shown to reduce academic self-concepts (e.g., Marsh and Hau, 2003), students who are fortunate to access elite programmes are often positive about the experience. Rather than academic learning, the key benefit reported by students who attain a privileged position is the improved environment (Hertberg-Davis and Callahan, 2008; Bleske-Rechek, Lubinski, and Benbow, 2004).

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<sup>1</sup>In publicly or state funded systems.

A highly selected peer group is particularly important, often overshadowing the academic provision of such programs even in research that advocates for differentiation. For example a respondent quoted by Hertberg-Davis and Callahan (2008, p. 204) reports: ‘I would say that it’s not necessarily that the instruction is better in the AP class, but the student environment.’ A participant in a study by Zevenbergen (2005, p. 615) put it more directly: ‘ “I prefer to be in the higher class because you don’t get interrupted all the time by idiots.” ’ This points toward other influential socially and consumer-driven functions to this segregation, a perspective that will be considered further in Chapters 5 and 6.

Some advocates of stratification acknowledge the lack of academic benefit, but point to other, pragmatic reasons for keeping such structures. Finn and Hockett (2012) acknowledge that while there is no academic value-added in terms of performance for students who are differentiated through elite magnet schools in the United States, such schools are valuable for the sort of environment they offer for the students who are lucky enough to get in:

Insofar as students benefit from peer effects in classrooms, corridors, and clubs, and insofar as being surrounded by other smart kids challenges these students (and wards off allegations of ‘nerdiness’), schools with overall cultures of high academic attainment are apt to yield more such benefits.

Conceding the lack of academic benefit, Finn and Hockett argue that a benefit of these selective schools might be in ‘the retention of middle-class families’ in communities and public educational systems, presumably in areas with otherwise poor public schools. Research does support this justification; selective differentiation, such as through gifted or enrichment programs, seems to attract parents to schools and catchment areas they might otherwise avoid (e.g., Reay, 2008).<sup>1</sup> However, this is not the *stated purpose* of such programs. Furthermore, the end result of the way these structures are used in *practice* leads to social segregation within and between schools, without providing the academic benefits they promise.<sup>2</sup>

In unequal societies, where allocation within stratified structures corresponds closely to

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<sup>1</sup>Which is not to say that magnet schools are not worthwhile in terms of STEM persistence; Chapter 8 gives examples from Finland of two magnet schools that are successful in engaging students in STEM fields and fostering achievement, but also discusses how the way such schools are implemented and led is important to their effects.

<sup>2</sup>That their stated goals differ markedly from their actual application is also an issue of *transparency*, discussed further in Section 1.4 below, and which potentially compounds the negative effects on equity of opportunity. This idea, that the conflict between the stated purpose and use leads to inefficiency, is discussed throughout this dissertation, but particularly in Chapter 5 and 9.

social class, the cost of such segregation accrues to those already disadvantaged, as described in Section 1.1 above. Furthermore, there is a danger that inequalities over the life-course may in turn come to be justified in part by purportedly meritocratic differentiation, and the segregations, labelling and tracking that ensues. It should be carefully questioned whether the inequalities these structures have repeatedly been shown to foster over time and across different modes of stratification are worth the benefits they provide (which seem to be largely non-academic). Furthermore, it might be considered that there would be other, largely non-academic, benefits by providing students opportunities for integration.

However, returning to the problem of producing elite talent, it should be considered what better structures for dealing with talented, quick, and high-achieving students might be developed that *would* provide academic benefits, and be more efficient in terms of enabling talented students to persist in STEM fields. The next section moves in this direction, considering what research implies about the development of high-level talent.

## **A research-based conceptualisation of the development of elite talent: non-cognitive skills, grit and deliberate practice**

This section will focus on research that points towards an alternative, evidence-based conception of what talent is, and how it might be cultivated.

While structures such as gifted education and magnet schools have not yet been shown to consistently increase a student's predicted performance, research does have suggestions for how to cultivate elite performance across a variety of domains. Rather than focusing on ability or talent as a static resource with seemingly little predictive value, contemporary research focuses on the factors that actually predict world class performance within a given domain and high-achievement over the life-course.

Expert performance, for example, refers to reproducibly high levels of achievement (Ericsson and Charness, 1994). Rather than focusing on the idea of genetic talent that may or may not be realised, this definition is focused on traits and actions that lead to high level *outcomes*. Such a definition is particularly useful when considering STEM education policy, where the goal in terms of talent production is to produce expert, world-class professional scientists, not higher scores on a standardised test.

A robust body of research supports the idea that expertise and high performance are attained through a process known as deliberate practice, rather than being due to raw

untempered ability (Ericsson, Roring, and Nandagopal, 2007). This conceptualisation has been supported by studies particular to STEM domains such as mathematics (Butterworth, 2006) and medicine (Moulaert, Verwijnen, Rikers, and Scherpbier, 2004). Ericsson and colleagues suggest that one of the key factors in attaining high levels of performance is *deliberate practice*, which refers to a difficult, concentrated effort focusing on areas of weakness, and that in addition, factors such as expert mentorship are key to development (Ericsson, 1985; Ericsson, Roring, and Nandagopal, 2007). Other bodies of research suggest traits like passion, perseverance and self regulation are key characteristics of elite performers (Duckworth, Peterson, Matthews, and Kelly, 2007), and furthermore, that the effect of these traits works through deliberate practice (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011), and that it is through the habit of deliberate practice that the trait of ‘grit’ becomes achievement.

A vanguard of STEM innovators, then, might be best cultivated by taking into account the growth of traits like perseverance and diligence (Almlund, Duckworth, Heckman, and Kautz, 2011; Borghans, Duckworth, Heckman, and ter Weel, 2008; Heckman, 2008), what Heckman calls ‘non-cognitive traits’, and by developing students’ capacities for demanding activities like deliberate practice that require intense self-regulation (Ericsson, Roring, and Nandagopal, 2007). That is, the realisation of talent is through concerted effort and work that demands passion and perseverance (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011; Ericsson, Roring, and Nandagopal, 2007). The idea that such traits are connected with persistence is explored in this dissertation, for example in the analysis of a survey reported in Chapters 3 and 4, and the importance of mentorship arises, for example, in Chapter 7 in terms of students’ exposures to STEM professionals. The development and impacts of these affective, ‘non-cognitive’ traits is explored particularly through the analysis of the surveys, but also in Chapters 7 and 9.

In the next section, these non-cognitive traits, which play an important role here in explaining student persistence and the generation of secondary-effects on retention, are linked with the concept of *habitus*, a connection that is discussed in more detail in Chapter 3 in relation to the survey design.

### 1.3 Non-cognitive skills and *habitus* in student persistence

Undergirding the previous two sections regarding stratification with regard to inequality and inefficiency, is the idea that outcomes are based not only on the official, *structural possibility* (both in terms of educational policies and student resources) of student persistence, but on students' decisions to engage in mathematics and science learning when they do have such an opportunity. That is, that educational policy research must consider not only the effects that are *necessary* to a given structure (those outcomes that will occur wherever and whenever a policy is implemented) (Sayer, 2000b, p. 21), but also those that are contingent on the interaction of the individual and the local context in which the policy is implemented. Individual tastes and family norms outside the school environment, for example, can have causal powers perhaps even more powerful than the educational structures themselves.

Societal norms can influence the end result of policies that otherwise might seem innocuous in their effect on persistence in STEM fields. For example, van Langen, Rekers-Mombarg, and Dekkers (2008) observed in the Netherlands that when mathematics and science at the upper secondary level shifted from a choice of individual courses to choice between a 'technology and science' track versus a 'health and science' track, the number of young women qualified for advanced STEM study at university decreased. In this case, the health and science track was greatly preferred by young women, however it was designed so that it did not offer the same advanced science and mathematics courses as the technology track. That such bundling of courses can have a negative effect on persistence (through decreasing the transparency and permeability of course choices) will be revisited in Chapter 5 and particularly Chapter 9. In the Netherlands, the phenomenon of increasing disparities in persistence was due in part to a structure that did not take into account the current reality of gendered disparities between students interested in health (primarily women) versus technology (primarily men). Deciding to include rigorous mathematics and science material only in the technology course, which was preferred by young men, resulted in increased gender disparities in STEM persistence, with young women being less likely after the change in structure to be qualified for STEM programmes at the tertiary level.

Of course, such differences in choice could be seen as the responsibility only of the young women in question. They could, after all, have simply chosen to study technology. However, placing the burden of unequal outcomes on the individual ignores the ways that

people learn to limit, both consciously and unconsciously, their aspirations within the classed, gendered and racialised social structures in which they live. To consign the explanation of such difference to choice is to extract the choice from the social reality and it is ‘... also an implicit rejection of alternative remedies for the problem, such as government intervention to correct systemic causes of inequity’ (Opfer, 2006, p. 286). Indeed, implicit in the very idea of increasing retention in STEM fields is the assumption that more students can and should be convinced that pursuing STEM fields is a good idea. That is, there is an assumption that students might ‘... fail to recognise that these things might nevertheless improve their lives’ (Sayer, 2011, p. 18), and that educational policies might help to nudge students towards better choices, and reduce the loss of qualified and underrepresented students in the STEM pipeline.

One tool for helping to make visible the conscious and unconscious impacts of structures and culture on and individual and his or her choices is by making use of the concept of *habitus*. The concept of habitus was developed as an alternative to the rational choice model of human behaviour (e.g., Bourdieu and Wacquant, 1992, p. 120). Continuing with the understanding introduced above that student decisions are culturally imbedded, Bourdieu’s idea of habitus suggests that actions may be rooted in elements of identity that are formed at the unconscious level in relation to societal constraints, and lead to decisions that are counter to one’s own self-interest. Habitus, as it will be used in this dissertation, is a dynamic conscious and unconscious identity that is formed not only by family background, and within the larger society, but also in interaction with the educational structures. Habitus might be considered to be ‘... the result of the internalization of external structures... [and which] is creative, inventive, but within the limits of its structures, which are embodied sedimentation of the social structures which produced it.’ (Bourdieu and Wacquant, 1992, pp. 18–19). Within mathematics education, this notion has been used, for example, by Noyes (2003, p. 142) to describe the processes that lead qualified students to lower academic tracks in England: Habitus is ‘... not a deterministic construct but one which regulates choices and thereby action.’

Again, the concept of habitus, which will be related in this dissertation to ideas of identity, disposition and non-cognitive skills (see Chapter 3 in particular), carries with it a large body of research that elucidates the ways that choices are dependent not only on structural possibilities, but the ways that people’s choices and dispositions are shaped by their experience within structures. As Noyes has shown, habitus is a useful concept in understanding student choices to persist in schooling. In particular, Noyes, describing this impact of habitus with regards to mathematics education, notes that ‘... “structural

limitations” that have been belatedly acknowledged are deeply embedded, not only in objective school structures but in the dispositions and strategic actions of teachers, children and their parents and society at large.’ (Noyes, 2006, p. 60). Noyes highlights one of the key aspects of the idea of habitus here: it is a tool for understanding how structures impact people on an unconscious as well as conscious level. In Noyes’s investigation of school transitions, he uses the idea of habitus to map students’ changing identities, and provides, I would argue, a vivid illustration of the secondary effects of social class in England. In that case, the secondary effects can be explained by making use of habitus as a metaphor for understanding the ways that structures come to influence student identities, and the choices students make, choices which may seem not to be in their self-interest.

What Noyes is illustrating is that structures of stratification do more than react to or ‘read’ the abilities and social capital that people bring with them into the structure. Rather, structures also seem to shape the ongoing development of their inhabitants. Researching Australian mathematics classrooms, Zevenbergen (2005, p. 617) uses the idea of field and habitus as a framework for understanding how stratification impacts students’ dispositions and identities: ‘[t]hrough the practices within the field [of school mathematics], ability-grouping constructs a *habitus* that either includes or excludes students from the subject.’ The process Zevenbergen describes is one that reinforces the existing academic differentiation (as it does in the case that Noyes describes as well). That is, students in the elite courses hold positive views of themselves and mathematics (encompassed in this idea of habitus) and students in the lower courses report frustration at their placement and disengage with the subject and school.

While Noyes, like Zevenbergen, uses the idea of habitus as a tool for examining the interaction of school structures and student identity, Noyes’s research focuses on how students’ habitus, related to their family background and available cultural capital are read by the school structure, particularly through the eyes of teachers. Within the domain of science education, Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2010) have recently delineated a similar process using the idea of *family habitus* to describe how family background and disposition towards science mediate student opportunities and interactions at school and in extracurricular activities. Zevenbergen uses the idea of habitus to describe how the school structure forms students’ identities and dispositions (their habitus). Thus, stratified school structures can be seen as both reading and reacting to an existing habitus, and in the ongoing formation of students’ habitus.

In addition to contributing to understanding how secondary effects with regards to reten-

tion that plague STEM fields are generated within school structures, the notion of habitus is also a useful concept in considering the persistence and development of elite students. This is particularly the case when research links elite performance with non-cognitive skills as outlined in Section 1.2 above. Furthermore, with regards to the preparation of an elite STEM workforce, some have argued that what is needed is not more engineers, but engineers with ‘soft-skills’— non-cognitive skills such as self-regulation (Salzman and Lynn, 2010). That such non-cognitive skills can be linked to the concept of habitus is the focus of Chapter 3.

From a policy perspective, not only are habitus and non-cognitive skills important in the modelling and explanation of persistence; there is also a need to understand how educational structures as they are realised in practice influence the development of adaptive, non-cognitive traits and dispositions towards mathematics and science (and school in general)—both for elite students, and for all students in general. Such outcomes may become key goals of educational policy in themselves, above and beyond their importance to student persistence.

This section has focused on developing a conceptualisation of the ways that educational structures, particularly stratified structures, influence equity and efficiency not only through the structural possibility, but the effect of structures on student identity, and the interaction of structures with existing societal norms and constraints. The next section returns the focus to the nature of the structures themselves.

## **1.4 Efficiency and equity in school structures: introducing the Mechanism, Transparency and Permeability framework**

The framework presented in this section is focused on analysing the efficiency and equity within a system. Resting on the understanding of the interactions of structure and the individual as outlined in the previous section, it aims to move past simple comparisons of different forms of stratification that obscure how stratification functions at a local level, which is a particularly important concern in comparative policy research. For example, focusing on *between* school tracking (i.e., Hanushek and Wößmann, 2006) obscures the ways in which students in the United States are tracked *within* schools, often just as rigidly and with similar effects (e.g., Schnabel, Alfeld, Eccles, Köller, and Baumert, 2002).

Similarly, focusing on the comparatively unstratified compulsory school in Finland (i.e., Oakes, 2008) obscures the ways in which such a flat system is combined with an highly stratified, competitive upper-secondary school structure.

The Mechanism, Transparency and Permeability framework developed in this study is an attempt to work towards an ‘abstraction and careful conceptualisation’ (Sayer, 2000b, p. 19) of key aspects that impact equity and efficiency across different structures, structures that might incorporate multiple modes of differentiation. It is meant to be an alternative to coarse taxonomies that obscure the complexity of local forms of stratification. Simple classifications of systems often used in comparative research ‘divide what is in practice indivisible’ and ‘conflate what are different and separable components’ (Sayer, 2000b, p. 19).

The similarity of the effects of very different forms of differentiation across cultures suggests that perhaps it is not only the particular *mode* of stratification (e.g., tracking vs. ability grouping) that should be the focus of research, but these key features of the systems. Improving understanding of what aspects of stratification are the most salient is important for meaningful policy change. If certain forms of stratification are linked to the generation of inequality, for example, perhaps abolishing differentiation is not the only solution; policy makers might also consider *how* differentiation is done. Perhaps a highly stratified system might be deemed more equitable, for example, if it incorporates other features, such as a students’ ability to change their allocation within a given stratified system over time. This will be discussed further in the framework below, and illustrated in Chapter 9.

This framework is as follows:

#### MECHANISM

*What physical, tangible criteria (including geography, financial resources, and age) determine how and when a student’s assignment within an education system will take place?*

Age upon first differentiation in a stratified system, for example, impacts what students are selected into elite strata. Perhaps the most important effect in this regard is that the earlier selection occurs, the more the process is dependent on the actions and capital of the parents; in earlier stratification, the less likely it is that student agency and interest are the deciding factor, and the more likely it is that socio-economic background is an influence (Schnabel, Alfeld, Eccles, Köller, and Baumert, 2002, p. 194). This dependent relationship makes the age aspect of mechanism more important and influential than the

overall form of differentiation.

How students are selected can create unequal chances in other ways, highlighting the arbitrary nature with which some mechanisms act to identify and ultimately constrain students' educational trajectories. For example, due to early selection by performance in Germany, being a year older when students are stratified into different educational tracks increases the probability of entering a higher, in the sense of being more prestigious, academic track (Mühlenweg and Puhani, 2010, p. 427). This is a very arbitrary sort of structural inequality, indeed. It should be noted that it is the students without family resources that are most at the mercy of the caprices of a particular mechanism of selection. As discussed above, selection is related to a family's financial, social and cultural resources across different forms of stratification. Family capital is critical to accessing valuable extracurricular learning as well (Aschbacher, Li, and Roth, 2010; Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2012), discussed further in Chapter 7.

#### TRANSPARENCY

*How clear and understandable are the allocations of education, and the consequences of these allocations for educational access and future opportunities?*

Transparency alone does not guarantee equal access within a system of stratification, as LeTendre et al. (2003, p. 62) note regarding the tripartite division of secondary schools in Germany. There the structure is quite clear but leads to unequal outcomes based on student background. A lack of transparency can help to explain some unequal outcomes, such as the difficulty of some families in navigating complicated educational choices, which (Lund, 2008, p. 646) suggests is a possible outcome of the complicated Swedish upper-secondary school markets, discussed further in Chapters 5, 6 and 9. It also refers to the possible existence of hidden educational pathways that are used by better-positioned families and are not made transparent, and thereby unavailable, for others. Transparency is an aspect of educational system that interacts particularly with family background and resources.

#### PERMEABILITY

*Is it possible to move from one educational stratum to another over time? Does this possibility exist for adults as well as young people?*

In the discussion of allocation mechanisms above, it is noted that an opportunity to adjust one's position in the educational system upwards at age 16 in Germany is mediated by the effects of early tracking. This is an example of the importance of permeability, or the

possibility that one has to influence one's position in a stratified educational system over time. If early placement is characterised by reflecting the social background of a young person, then permeability can be seen to provide an avenue for individual agency, as well as flexibility from a developmental perspective, acknowledging the variety of different capabilities people exhibit according to their individual timelines, rather than the timeline of the educational system.

Permeability was also a key area of focus of Finnish educational reforms in the post-war era, when modern educational structures were developed: '[T]he present system leading to educational blind alleys should be replaced by another, which permits to combine and utilise previous studies to a larger extent. An endeavour to open passages is indeed one of the basic motives underlying the entire school reform in Finland.' (Nyberg, 1970). Permeability is particularly discussed in Chapter 9. Arguably, it is a feature of educational structures that deserves more attention from policy researchers.

## **Mechanism, transparency, permeability as an alternative frame of analysis**

In addition to focusing attention on the dual issues of equity and efficiency, the purpose of this framework, which is both a method and an outcome of the comparative study that will be described in this dissertation, is to move policy analysis past simple conceptualisations of stratification. One of the insights of this study, described particularly in Chapter 5, is to show how all of the systems included in this study stratify students. However, they do so *differently*.

Throughout this work, the terminology of mechanism, transparency and permeability are used to highlighting key interactions between educational policies and outcomes with regards to equity and efficiency across the different settings included in this study, moving past classifications that set up binaries of tracked and untracked systems (i.e., Hanushek and Wößmann, 2006; Dupriez, Dumay, and Vause, 2008; Oakes, 2008), thus obscuring how stratification functions in each local context. All systems stratify, but perhaps by digging deeper, it is possible to understand how it might be done *better* in terms of equity and efficiency.

## 1.5 Overview of the structure of this dissertation

In this introduction I have drawn attention to the issues of stratification, efficiency and equity as they relate to student persistence. I introduced a framework of Mechanism, Transparency, and Permeability to help understand these issues in a cross-cultural context that moves past focusing on a single form of stratification, when systems are often composed of many different forms of stratification working together. I have suggested that, in addition to school structures, student persistence is in part due to non-cognitive factors, or an adaptive habitus that is dynamically developed within an educational and social system. Looking at educational systems in three different contexts represented by Finland, Sweden, and the United States, this study aims to bring new insight into the relationship between different educational policies and student persistence.

The United States National Board report ‘Preparing the Next Generation of STEM Innovators’ (National Science Board, 2010, p. 25) concludes with the following guidance for future research:

1. Support research focused on identifying the characteristics of a learning ecosystem that facilitates near-term academic achievement and longterm production of innovation. Cross-cultural studies might be especially useful.
2. Investigate the individual contributions of, and the interplay between, the cognitive and non-cognitive attributes of an individual, and the learning ecosystem, in leading to future development of STEM innovators.
3. Study the impacts of self-perception, cultural identity, and external pressures (e.g., perceptions, stereotypes) on learning and future innovative achievement in STEM. Examine methods to overcome obstacles associated with these factors.

The research reported here is a cross-cultural investigation of school structures and students’ intentions to persist in STEM fields (relating to point 1) that is particularly concerned with the interplay of these structures and so-called non-cognitive outcomes, which I argue can be considered part of an ‘adaptive habitus’ (relating to point 2). The purpose of both the comparison and the development of a methodology that includes the concept of non-cognitive skills, tied to habitus, is to shed light on how different educational structures (including enrichment and specialist STEM schools) impact the development and retention of talent in STEM fields.

Looking at educational systems in three different contexts (Finland, Sweden and the United States), with three contrasting educational systems, this study aims to bring new insight into the relationship between different educational policies and student persistence. In particular the questions the Student Persistence in STEM Fields study attempts to address are:

1. What different sorts of educational structures, including access to extracurricular learning, are available to students in Finland, Sweden and the United States?
  - (a) How do these environments interact with, or foster the development of non-cognitive skills (adaptive habitus), including adaptive beliefs about ability, as well as character traits such as grit and perseverance?
  - (b) How do these structures inhibit or promote students intentions to persist?
2. What factors, including school structures, impact students intentions to persist in STEM fields?
  - (a) Can adaptive habitus be modelled in part by an intersection of these non-cognitive skills?
  - (b) What can a model of persistence with adaptive habitus tell us about the interactions of school structures and enrichment on student persistence?

This dissertation is organised as follows. Chapter 2 gives the methodology of study. Chapter 3 goes into more detail regarding the connection between the concepts of non-cognitive skills and habitus, focusing on the development and validation of corresponding questionnaire items. Chapter 4 reports and discusses the structural equation models relating school structures to habitus (and non-cognitive skills) and ultimately to students' intentions to persist in STEM fields. Chapter 5 gives a description of key aspects of stratification in mathematics and science in each country. Emphasising the homologies in the consumption of stratification across different structures, Chapter 6 focuses on educational stratification in Sweden and Finland, two systems that are sometimes assumed to be comparatively undifferentiated. Chapter 7 turns the focus towards the production of talent, drawing a characterisation of what forms of enrichment were suggested to be the most salient for the development of STEM ability and intentions to persist. In Chapter 8, two effective STEM magnet schools are compared, with consideration to both equity of access and their efficacy in producing future STEM professionals. Chapter 9 returns to the Mechanism, Transparency, and Permeability framework, illustrating its use in the comparison of Finland, Sweden and the United States by following the trajectories of

four students whose desire to persist in STEM fields increases over time. The framework is then used to give a comparative characterisation of each educational system. Chapter 10 concludes.



# Chapter 2

## Methodology

In this chapter, the rationale and design of intensive, mixed-method comparative study is described. First, I discuss the use of international comparison. While personal experience in Finland, Sweden, and the United States motivated and helped frame the research questions for this study, international comparisons of educational structures can also be seen as a method of research. Here, I focus on those aspects of the school structures examined that are pertinent to the study of student persistence in STEM fields. Second, I explain the use and structure of interviews in the study, as well as sampling for the interviews. Finally, I describe the use of surveys in the study as well as the survey design process. Further information about the justification of the survey design can be found in Chapter 3. In each section, an overview of the actual results of the data collection will be given. The main data collection for the Student Persistence in STEM Fields study occurred between Spring 2010 and Spring 2012.

### 2.1 Countries as contrast spaces

The impetus behind this research project is to move towards a better understanding of school structures, such as stratification and enrichment opportunities, and their impact of student choices. Underlying the question of student choice and persistence are issues of equity and efficiency. As described in the last chapter, there is often a policy impasse with regards to equity and stratification; the purpose of this comparison is to invite new viewpoints and challenge assumptions that may be taken for granted in a single national context. Comparing schools between countries and also schools within countries

is a way of finding contrasts that ‘...alert us to the situation that there is something to be explained at all.’ (Bhaskar and Lawson, 1998, p. 12). Comparative research can help make such structures visible, and challenge notions about what is possible for educational structures. This may be particularly important for schools, which are as much the offspring of tradition and habit as anything else.

Yet new solutions must acknowledge current reality. Any reforms ‘...are grounded in the nature of the present in terms of what we are now.’ (Sayer, 1992, p. 257). Here too, the argument that comparison may serve to alert us to something that would be invisible in a single national context is important. Comparison is useful both for understanding the current status of a system, and for distinguishing regularities that might aid in the creation of new policies.

Thus, the aim of the comparative work here is not so much about evaluating as understanding the effect of three very different school structures on student outcomes, and ultimately looking for new ways of considering how educational structures impact student choices. Given the prominence of Finland in educational policy discourse today, this study aimed to provide a more nuanced comparison focused on the relation of these different school structures and student’s intentions to pursue STEM fields after secondary school.

The trio of educational systems here (Finland, Sweden, and the United States) is in some ways one of the greatest weaknesses of the research design here. It complicated not only the data collection phase, but also the analysis. However, it is also one of the strengths of the study. Many small-scale, intensive comparative studies are binary in design. By allowing the comparison to move between three different structures of varying degrees of similarity and contrast, the temptation of producing a simplistic explanation was reduced. Furthermore, the Finnish educational system has deep connections with the Swedish system. By including both in the study, their similarities and differences both with each other and with the American system can be better understood. The school structures that make this trio of countries an interesting ‘contrast space’ (Sayer, 2000b, p. 161) will be introduced next.

It should also be noted that while the inspiration for this comparison came from personal experience in each of these countries, an effort was made to choose research sites and participants to fit the study design and to construct a meaningful contrast space. Prior to conducting this study, I had not lived in any of the metropolitan areas where data was collected, nor did I have prior contact with any of the schools involved. While this removed some biases, it likely created others, as will be discussed in the sections on

sampling below.

## Introducing the main structures

This section will give a brief overview of the national and social structures of education in Finland, Sweden, and the United States. In particular, I introduce the key contrasts between the structures that make for a useful comparative study.

Three different metropolitan areas of comparable size were used in this study. Specifically, I examined cities in Finland, Sweden and in the state of Oregon, which is of comparable size both geographically and in terms of population to Finland and Sweden. The population of these metropolitan areas were similar: rough estimates are 1,100,000 for Sweden, 1,000,00 for Finland, and 1,000,000 for Oregon.

### Finland: Lukio

The students and teachers in this study were drawn from Finnish upper secondary schools, called *lukio* in Finnish. Lukio is a three year school, usually attended by students from ages 17 to 19 years old. In Finland, there is an elementary school from age 7 up to age 13. During elementary school, there is minimal stratification and students tend to attend their neighbourhood school. School choice comes into play during the transition to lower secondary, where in addition to switching schools, students and parents might select a specialist program for mathematics, languages, music and other disciplinary tracks. This lower secondary school is for ages 14 to 16 year old students.

Almost all students proceed to upper secondary education, but they must apply to a particular school or track. There are both vocational and academic programmes, and either may be highly selective, with competitive admissions that are comparable to elite schools in the United States. It is important to note that while students are in untracked comprehensive schools to age 16<sup>1</sup>, after that point there is a fierce competitive application process to upper secondary schools.

There is a marked increase in educational stratification at the transition to upper-secondary school, and allocation is mostly based of a standardised national exam. Within each school, students must further choose between a long and a short mathematics course.

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<sup>1</sup>When the PISA exams are given, which may play a part in Finnish performance; students have a real incentive to learn at that point, as evidenced in some of the interviews for this study

In most schools, students are not allocated to the course due to prior performance or testing, but instead are able to choose to take advanced mathematics if they wish. Students can also choose science courses freely, but there is not the clear bipartite track as there is in mathematics. University admissions are not strictly dependent on the mathematics course that is chosen, and students may take the long course, but take the exam for the short course, if they choose.

### **Sweden: Gymnasium**

The basic educational structures in Sweden are similar to those in Finland. There is a six-year elementary school (ages 7 to 13), a three-year lower-secondary school (ages 14-16) and a three-year upper-secondary school (ages 17-19), which is called the *gymnasium*. Sweden has a liberal policy for the creation of private schools. School choice is also liberal and available at all school levels. Accordingly, school choice plays a bigger role earlier in students' educational experiences.

Specialist programmes are increasingly regulated, but have historically been more diverse than in Finland. Like Finland, entry into upper-secondary school represents a key point of stratification. Entry is competitive into schools as well as particular tracks within a school. In Sweden, there are two main academic tracks: the natural science line and the social science line. The natural science line is the only programme that provides students with rights to study most STEM fields at university. In addition, fields such as economics sometimes require the programme. In the natural science programme, advanced science is bundled with advanced mathematics.

### **United States: High school**

The Oregon research site comprised several different school districts. Students' school placements were allocated by their residential location, that is, by catchment area, but there is also opportunities for parents to apply for transfers through a lottery system, or pay fees to send their children to neighbouring districts. In most districts there was a primary school from ages 5/6 to 10/11, a lower-secondary school from ages 11/12 to 13/14, and an upper secondary school, called 'high school,' from ages 14/15 to 17/18.

In Oregon, as in Finland, most schools allow for course choices independent of each other. This allowance is in contrast with Sweden's bundling of courses into tracks; thematic tracks such as those found in Sweden are available only as exceptions. In practice,

there are many different streams within the schools, starting in lower secondary school. Students taking advanced science are almost always, and in some cases required, to take advanced mathematics. In this study, the advanced stream is considered to be one in which students take a calculus course or higher by the end of high school. Where available, the stream of students aiming for more prestigious universities would be students taking honours, Advanced Placement, or International Baccalaureate courses, which in some schools are described as provision for gifted and talented students.

### **Summary of key STEM structures**

For the sake of the comparison, students were identified primarily by their mathematics courses. In advanced STEM students Finland, were was students taking Long Mathematics, in Sweden, students taking the Natural Sciences programme, and in the United States, students taking Calculus. Further details about these distinctions are discussed in the sections on sampling below.

### **The intent of the comparison**

As mentioned above, comparative research can highlight aspects of structures that are invisible or taken for granted in their native contexts, and also help to imagine policies that move past what is currently available in any of the compared contexts. Particularly in educational policy, the practical benefit of research would be lost if a research agenda ‘...was unaware of the fact that what *is* need not necessarily be, and which failed to note that people have powers which remain inactivated in the society in question but which *could* be activated’ (Sayer, 1992, p. 257). The outcomes of educational structures are dependent also on the wider societal norms and structures in which the schools are situated. However, these norms and structures are also possible to change. The current range of policies, and indeed, ideas of what a school is, need not be taken as the circumscription of the future of education. In addition, school structures are not the only thing that might be transferred from one nation to another; norms and educational goals might also be taken up in new contexts. The outcomes of policies or ideas will depend on the local context.

It is not the aim of this study to engage in broad policy recommendations based on simplistic characterisations of each national school system. As I noted in the introduction to this dissertation, research sometimes offers views of educational structures that obscure

underlying systems (i.e., Hanushek and Wößmann, 2006; Oakes, 2008). For example, to consider Finnish schools as completely unstratified is to ignore the highly stratified Finnish upper-secondary education system, which looms large in Finnish consciousness as key point of social distinction. Osborn (2004) cautions against broad policy proscriptions gleaned from large scale studies and ‘...argues for the importance of seeking to understand through cross-cultural comparison the relationship between national context, institutional ethos and classroom practices in mediating the development of a learners identity’ (Osborn, 2004, p. 266). Osborn’s statement is a close description of my own goals for this project. This research combines a detailed, intensive survey with interviews to get a more tailored picture of school structures and how they shape students’ identities, their habitus, and ultimately their choices within their local contexts.

Despite the benefits of national comparisons, this comparative framework presents extra challenges for data collection. One challenge is the definition of samples and cases to compare in different contexts. How this was handled in the PSTEM study will be discussed in the following two sections.

## **Key challenges in the data collection**

One of the key challenges in the data collection was simply the finite amount of time and research funding available. This primarily impacted the data collection in the United States and Sweden. Since I live in Finland, I was able to be more flexible with schools regarding data collection. As a consequence, the sample for both the interview and survey portions is most robust for Finland.

Data collection in the United States was limited in part by early mistakes about the nature of applying for school board approval from large urban districts. The pilot study for this project took place in Washington State, and the intention was to collect data for this main study there as well. An application was made, but due to external issues including a public scandal and change of leadership, the evaluation of that proposal was delayed despite the fact that neighbouring districts that would have been included in the survey had already given approval.

Consequently, a second site was chosen, this time in the neighbouring state of Oregon. Changing locations in this way required new research for constructing the sampling databases for the interviews and surveys, described below. Approval was gained from the main urban school board as well as the school boards of surrounding districts. However, at that point, there was limited time to conduct the study and gain access to schools,

since travel between Finland and the United States was cost prohibitive. The consequences of this will be described further below. Schools were approached by mail, email, and phone. In the United States and Sweden, these communications were in English. In Finland, they were primarily in Finnish, which seemed to improve the response rate, but made the process of recruitment more time consuming for a researcher for whom Finnish is a third language.

## 2.2 Interviews as a method

Scott (2007, p. 15) has argued that ‘... accounts which focus on either structures or agents to the exclusion of the other cannot account for the totality of the social experience, and it is the interaction between the two which needs to be the focus of the research.’ This research is grounded in the idea that student choices to persist in STEM fields is a product of this interaction, in part by how they impact students’ identities and ultimately their choices.

Interviews were chosen as the primary method for exploring the wider context of students’ educational trajectories and students’ understandings and explanations for their choices. Teacher interviews were included to give their perspective on the purpose and use of the educational structures and school environments the students were navigating. Interviews, compared with more costly forms of data gathering such as ethnography, meant more ground covered. Additionally, different school contexts could be brought to light through interviewing teachers. In a practical sense, interviews are also less invasive to participating schools, and in this case, as there was no prior relationship with the schools in question, it was easier to get access for a less invasive project.

The interviews conducted were qualitative and semi-structured (Robson, 2002, p. 271), with a view of allowing space for unexpected contributions from the participant, while still providing thematic comparison across the interviews (Arksey and Knight, 1999, p. 7). Since there was an exploratory element to this study, and as stated in the research questions, one goal of the study was to understand student experiences and choice, semi-structured interviews were deemed appropriate. Some structure was necessary for two reasons. First, semi-structured interviews allowed for some consistency across the sites. Second, it was necessary to have an interview outline for approval applications for schools and school boards.

The second reason, that of needing to give a detailed outline of the interviews for approval,

arguably had consequences for this study. A student researcher has tenuous access to schools, particularly if there is no prior relationship to the schools involved in the study, as was the case here. Having such an approval process led to more cautious interview schedules. Since there was a formal approval process, it also created an obligation to follow the interview schedules more carefully. These schedules are available as an appendix. The end result was that sensitive topics that arose as part of the interviews were perhaps not always explored as deeply as they could have been.

The validity of interviews is complicated to assess. Yeung writes 1997, p. 63 that ‘...social actors...may be trapped in false consciousness, unable to explain truly and to account fully for their action. Quite often this happens when social actors are constrained and bound by social structure.’ Several interviews were with young people whose personal narratives embodied contradictions. That is, their statements at times did not match up with their apparent realities or the narratives they were giving in the interviews. However, other students had a great awareness of their trajectories, in line with Zevenbergen (2005, p. 611) finding that ‘...students are aware of the structuring practices within the field.’ Students in this study exhibited both awareness and what Yeung refers to as ‘false consciousness’.

Such contradictions raise an ethical question. The conduct of the interviews was influenced by Brinkmann (2007, p. 1134), who sets forth an idea of an epistemic interview where, instead of positioning the interviewer as a passive participant in the creation of meaning, ‘...opinions and beliefs are debated, tried, tested, and challenged in an open conversation...’ Such candour was not always possible but it inspired me to attempt to be as forthright as possible with participants, and to challenge, where I could, any statement that I suspected I would contest later in analysis. This was more easily done with teachers; it seemed less appropriate to challenge the beliefs of young people whose lives I was only briefly visiting.

The interviews design was also influenced by suggestions set forth by Kvale and Brinkmann (2009). There was an attempt to avoid emotional trickery, that is, to avoid faking friendliness, admiration or approval in an attempt to get more intimate material. My interviews aimed to follow the outlines of good practice as set forth by Kvale and Brinkmann (2009). The interviews were perhaps weakened by adherence to Brinkmann’s 2007, p. 1134 suggestion that ‘...the interviewers do not try to suck as much private information out of the respondents as possible, without themselves engaging in the conversation with all the risks that are involved in this.’ Combined with a sense of obligation to follow the interview schedule, this meant that I did not dig deeper into sensitive areas that might

have yielded interesting quotes.

Kvale and Brinkman's take on interviewing is important here because there is an ethical dimension to interviewing, particularly with young people. Interviews can be physical and emotional. They are physical because they ultimately involve the meeting of two people in a private place, creating an abnormal space which functions, for some people, as a confessional. Sometimes participants want to hug or touch the interviewer. They are emotional, because even topics like mathematics or science course choices can relate to people's rich, complex, and difficult experiences in and outside of school. However, the effect is arguably larger for the interviewer; by taking people's stories and repeating them, untangling them, they enter into our consciousness and our understanding of the world far more than we did theirs. Their stories become our responsibility.

The interviews and their analysis were also influenced by readings of previous research, notably by Zevenbergen (2005), Ball, Maguire, and Macrae (2000) and *The Weight of the World* (Bourdieu, 1999), particularly the chapter by Broccolichi (1999).

## **2.3 Interview design: targeting key cases**

In each site, the aim was to choose four schools from the central district of the metropolitan area selected for the study. For schools in these central districts, I collected test scores, profiles from school websites, evidence of STEM extracurricular activity and competition, local news stories, and neighbourhood demographics. In turn, I used these to construct a qualitative database from which schools were selected. From each of the four schools, the aim was to include six students and two teachers in the interviews.

Also in the spirit of targeting key cases, half of the students were drawn from advanced mathematics or science courses, and the teachers interviewed were either mathematics or science teachers. Additionally, I aimed to interview at least one teacher who was responsible for advanced courses and another who was responsible for standard-level courses.

### **Piloting the interviews**

Interviews were first piloted on colleagues and classmates in the United States and Finland. Exploratory pilot interviews with students took place between Spring 2008 and

Fall 2009. These student interviews were comprised of usually two group interviews of two to three students, with four schools for the United States, three from Finland, and two from Sweden participating. While these interviews are largely excluded from this dissertation, the interviews from the United States have been important to the ongoing analysis of this research project. Due to difficulties with the data collection in the United States, these interviews have become important for giving examples of the wider context of educational trajectories there. The piloting of the interviews was also important for developing a sense of the educational structures in each setting from the student perspective, and to pinpoint the criteria to use to select participating schools for the main study.

## **Constructing a sampling database for the interview schools**

The sampling at the school level was aimed at providing access to what Danermark et al. (1997, p. 170) call strategic cases. Schools were chosen to create a mapping, a homology, between schools in the different areas. The idea was to ensure that the following key criteria that emerged in pilot studies were covered in each setting. These criteria were chosen so that a range of student experiences, and selectivity would be included. Since access to extracurricular STEM activities is unevenly distributed, the criteria also aimed to ensure that schools with extensive and active STEM enrichment programmes would be represented in the study. Schools included in the interviews were excluded from the survey sampling data bases.

The criteria considered to be indicative of key cases for the interviews schools were:

1. An elite, selective school
2. A non-selective school in an economically disadvantaged area of the city
3. A specialist STEM magnet school
4. A large average school
5. An International Baccalaureate school
6. A school with a high level of STEM extra-curricular involvement.

The selective, non-selective and average schools were chosen to provide a general perspective of the range of schools. The International Baccalaureate programme was included as a programme with some continuity across all three sites, and because in all three

countries it is considered to have a more rigorous mathematics and science curriculum than the typical national or state level programme. ‘Magnet school’ here refers to schools that are accessed primarily by choice rather than catchment area. The magnet schools considered here have a profile that emphasises science, technology and engineering, or mathematics. The targeting of magnet schools and schools with a high level of STEM extra-curricular participation were to ensure that students who had had access to environments that prioritised STEM learning, and extensive enrichment programmes were included in the study. These criteria were also developed in part through the experience of the pilot interviews.

In order to find these schools, a detailed qualitative database was made for the schools in each city. Since I did not live, and had not attended school in any of the three cities, building this data base was also useful in gaining a better understanding of the educational field in each city. The database included information about the following:

### **The demographics of the school.**

In the case of Oregon, the ethnicity and socio-economic make-up of each school was easily found along with school scores on standardised tests. In Oregon, both the number of students receiving free school lunches, and the ethnic and racial demographics of the school were noted. In Sweden and Finland, this information was less readily available. In Finland, I was only able to estimate this by the neighbourhood demographics of the school, taking information from municipal publications. In Sweden, I could find the information about the number of immigrants in each school laboriously from individual reports from the Ministry of Education, but no information about the economic status of students. These sources were publicly available and specific to the municipality in question and thus are not referenced here in more detail, but can be supplied on request.

### **Participation in STEM extracurriculars.**

Using a variety of sources, such as online local newspapers and participation in regional and national STEM enrichment competitions, an idea each school in the city’s level of participation was developed. Participation was noted over the previous two to three years. Examples of the enrichment programmes used include the following:

- Finland: Mathematics competitions (e.g., <http://www.maol.fi/>)
- Sweden: Mathematics competitions (e.g., [www.matematiktavling.org/](http://www.matematiktavling.org/))

- Oregon: Mathematics competitions, FIRST Robotics teams, US National Science Bowl.

When the information involved the results of competitions, the top performing schools were noted. Also noted were the schools with a high number of participants, regardless of their performance. In addition to such sources, school websites were examined for special programmes. Evidence of participation in local university or research centre enrichment programmes was gleaned through programme or university websites, as well as local newspapers. Many schools, particularly in Sweden and Finland, did not evidence any such activity.

### **Academic results and rankings.**

In the United States, it was possible to easily access both test scores and school demographics, which are highly related. The scores in the United States were based off of a state standardised test. In Finland and Sweden they related to results on national exams used for university entry. Thus, the scores were not comparable in their raw form. Instead, I calculated the z-score (the distance from the mean) for each school. The purpose was to develop a simple ranking of the schools. While such a concept is controversial in Finland, where the media is dissuaded from providing school rankings, the interviews in this study suggest that savvy students are very aware in any case. The rankings helped to identify elite schools. However, because academic results are often correlated with student background and demographic data about the economic status of students was lacking in Finland and Sweden, this information was also considered to ensure that schools with less-privileged students were included in the study. This information came from the following sources:

- Finland: Optushallitus (Finnish Ministry of Education, [haku.koulutusnetti.fi](http://haku.koulutusnetti.fi))
- Sweden: Skolverket (Swedish Ministry of Education, [siris.skolverket.se](http://siris.skolverket.se))
- Oregon: The *Oregonian* Newspaper schools service ([schools.oregonlive.com](http://schools.oregonlive.com))

After the schools were selected, approval was sought from school boards and school leaders. The schools, labeled with the pseudonyms used in this research, can be found in Table 2.1. While this sampling process went well in Finland and Sweden, it faced challenges in the United States. These challenges, along with the rationale for including interviews with a competitive robotics team in this study, will be discussed in the next section.

## **Selection of students and teachers within schools**

The goal with the sampling of students within schools was to get about half the students from advanced mathematics or science programmes, and about half from regular classes. The goal for the teacher samples was to get two from mathematics or science, one of whom would be responsible for advanced courses. From each Finnish school, I asked for three students from Short Mathematics and three students from Long Mathematics. From each Swedish school, I asked for three students from the Natural Science line and three students from other lines at the school. From the Oregon schools, I asked for three students taking, or who would take, Calculus or above; I also asked for three other students. In Finland and Sweden the students were mostly in their last year (ages 18 to 19). In the United States, participating students included members or a robotics team in their second and third years of upper- secondary (ages 15 to 17), none of whom were in advanced mathematics or science tracks, as well as a reanalysis of the pilot data, that included advanced mathematics and science students in their last or penultimate year of high school (ages 16 to 18).

## **Results of the sampling**

I had one school decline to participate in Finland and Sweden. The school leadership responded immediately, and using the database, a suitable replacement was found. In Finland, five schools were invited, four participated. In Sweden, six schools were invited, five participated. The additional 5th Swedish school was invited to provide coverage of the key criteria as described in Table 2.1. In the United States approval was ultimately given for six schools to be contacted, two accepted, one refused, and three never responded. None of the schools participated. In the pilot study, which took place in districts where school board was not necessary, four schools were contacted, and three accepted. Two students from the fourth school, who heard about the study independently also reached out.

School leadership and teachers. Granted permission for the study. Participants were typically chosen by teachers or guidance counsellors. They were asked to sign active consent forms. In the United States, active parent consent forms were also required. While going through a school board increases the protection of students and teachers, it also increases the distance between the researcher and the school.

**Table 2.1: Schools participating in the interviews, grouped by research sites. Each schools coverage of key characteristics is noted.**

<i>School Psuedonym</i>	<i>Elite school</i>	<i>Enrichment</i>	<i>Average school</i>	<i>Poor school</i>	<i>IB programme</i>
FINLAND					
Historical Lukio	X	X			X
Large Magnet Lukio		X	X		
Small Magnet Lukio	X	X		X	
Suburban Lukio				X	
SWEDEN					
Historical Gymnasium	X	X			
Magnet Gymnasium	X	X			
Private Gymnasium		X	X		
International Gymnasium				X	X
Suburban Gymnasium				X	
OREGON					
Robotics Team		X	X	X	
WASHINGTON: reanalysed to provide additional illustration					
Columbia High	X	X			
Cougar High			X		
Sahale High	X	X	X		X
Olympus High				X	

### **The inclusion of the Robotics Team**

As mentioned earlier in this chapter, the site for this research was moved from Washington to Oregon. After the central school board approved the research project, contact was made with the schools chosen for the interviews. Two of the four schools agreed quickly, and travel arrangements were made. However, in the end, it was impossible to gain access to teachers at those schools. Only one school refused outright, and other schools ignored communication completely. Each replacement school had to be approved by the district school board. At some of these schools it was not clear that school leadership ever received my requests. In one case, there was skepticism and hostility about including teacher

interviews. This was a completely different climate that conducting research in Finland, were once a school head had agreed to the study, it progressed without incident.

One of my key goals had been to include a school with an active robotics team. As such, this was one of the criteria I used when selecting schools. These robotics clubs have increased tremendously in popularity over the last few years leading up to this study (see Figure 2.1). In 2008, I had interviewed a student in Washington involved in robotics, but the importance of these teams has been growing exponentially since then. Such enrichment programmes are an exciting feature of STEM education in the United States.

While gathering information for the sampling database, I found a local news story about a robotics team that had been removed from a school, and was sustaining itself with community support. The news story was not flattering to the school in question, and the story received a good deal of local media attention. While I was very interested in this case, at first I was hesitant to make contact as it was already apparent to me that schools in that district were not welcoming to researchers.

However, the team in question seemed to be critical for this study. Not only were they a robotics team, but they were serving students who normally would not have access to this sort of enrichment activity. I did contact them, and through this team, I believe I was able to interview people that I would not have been able to through schools. This raises interesting questions about the difficulties facing meaningful qualitative research schools, since it may be difficult to access (or to notice) students who distinguishing activities take place in an unrecognised out-of-school space.

None of the students in the robotics team were in advanced or elite courses. As such, their narratives combined with the previous interviews done for the pilot study and reanalysed along with this work, provided adequate coverage of the key cases, although certainly not with the careful sampling and data collection that was possible in Finland and Sweden.

## **Interview Key**

This reference can be found in Appendix A. The interview key lists the student participants, their schools, and a brief description of their educational trajectory for quick reference.

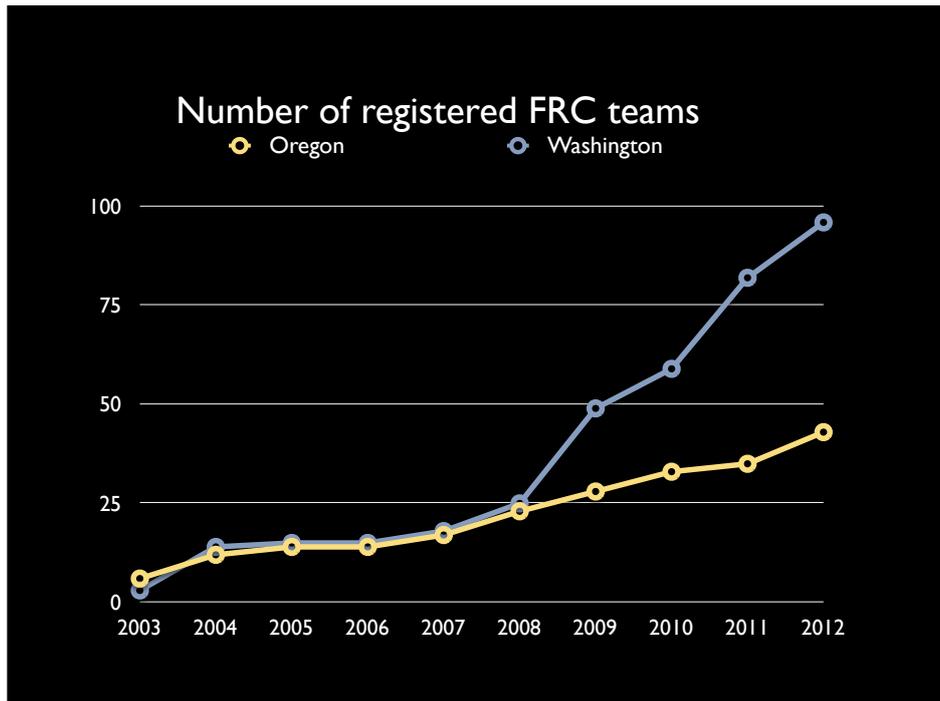


Figure 2.1: The growth of competitive robotics clubs in Oregon and Washington, from Saari (2012).

## Analysis

The interviews were recorded, and then transcribed and coded using TAMSAalyzer (Text Analysis Mark-up System), a free open source qualitative analysis tool (Weinstein, 2006). I analysed the interviews in three main ways.

First, I looked for themes across the data. The main themes considered were:

- Enrichment: both through gifted programmes and extracurricular activities
- Choice: of school and track
- Non-cognitive or adaptive habitus: grit, self-efficacy, loss of self-concept
- Social aspects: peer relationships, both in group and out group; teachers and guidance counselors; family
- Future plans: plans for study and career after school

Themes also emerged in the coding, including social exclusion, and in addition, it became apparent that the framework of *transparency*, *permeability* and *mechanisms* were also important in navigating students' narratives.

Second, I looked at themes across individuals. Influenced by reading Ball, Maguire, and Macrae (2000) the interviews were also considered as individual, linear narratives. That is, I pieced together the students' accounts of their educational trajectories. The interviews themselves jumped back and forth in time, and pulling them apart into themes lost a sense of the student experiences that linear summary recaptured.

Third, I analysed the interviews at the school level, looking at how interviews fit together within one school, and the interplay between the teacher narratives and the student experience. These different levels of analysis are used at different points in the dissertation. For example, Chapter 8 looks at the school level, focusing on the two schools that were of particular interest to the issue of fostering persistence in STEM fields, and Chapter 9, which focuses on illustrating the Mechanism, Transparency, and Permeability framework, focuses on individual students' trajectories within each of the three systems represented.

The survey, described in the next section, provided for another layer of analysis.

**Table 2.2: Summary of interview participants**

FINLAND	
Male	15
Female	11
Teachers	8
SWEDEN	
Male	15
Female	14
Teachers	10
OREGON	
Male	2
Female	1
Mentors	2
<b>Total Participants:</b>	<b>58 students, 20 teachers, 2 team mentors</b>
<i>Reanalysis of Washington interviews for illustration: an additional 16 students</i>	

## 2.4 Surveys as a method

The mixing of interviews and surveys is a common-place practice in educational research as this powerful combination can support and strengthen understanding. Reay, Davies, David, and Ball's 2001 study, for example, combines demographic questionnaires with in-depth interviews to deepen understanding of constraints on students' university choices,

In the present study, the survey is positioned as a way of accessing another level of analysis as well as enabling the illuminating tools of quantitative models. Catherine Marsh (1982) noted that by the time she graduated from the University of Cambridge '...I had absorbed a sufficient amount of the prevailing Zeitgeist to be convinced that survey research was hopelessly empiricist, the product of vulgar American sociology, a theoretical and generally a waste of time.'

The PSTEM survey did indeed take a great deal of time. Designing and entering the survey responses by hand as well as its administration were time-consuming, and the questionnaires were arguably too long. However, the PSTEM was hardly a 'waste of time.'

The surveys offered another level of analysis for this study. Surveys by questionnaire allow for the inclusion of a large number of participants in a study in an economical manner; it would not be possible to interview 673 students in this case. Such large numbers allow for statistical analyses like multiple regression that can test relationships that might be assumed to exist. The generalizability of such results is another question, dependent in a large part on sampling. The sampling for this survey will be discussed below.

While a more rigorous sample can be found in large scale international studies, such as PISA, those studies do not include students after age 16. Thus, in Finland and Sweden, PISA for example, misses the entire upper-secondary school experience. Furthermore, no previous study, in any of the three countries, has used the assortment of variables included here. The rationale behind the variables used in this study, and the validation of those items are discussed in detail in Chapter Three.

One of the weaknesses of surveys is that they are only as meaningful as the items they include (Marsh, 1982, p. 7). Creating a new, fit-for-purpose survey instrument was an opportunity to include variables not normally combined. This was a purposeful breaking of norms to some extent, in the case of measures of non-cognitive skills like self-efficacy and self-concept, to marry these measures with the discourse of habitus. Methodologically, the main questions in the survey analysis were:

1. How to construct an indicator for habitus from measures of non-cognitive skills
2. Whether such an indicator would be statistically valid according to current guidelines
3. Whether the model so constructed would resonate with the qualitative data
4. What new insights such models might provide about the relationship of structures, habitus, and persistence in STEM fields across the three sites.

Creating a new survey also allowed for the inclusion of location specific measures of enrichment and extra-curricular involvement, and gifted identification, which are absent from large cross-national studies such as PISA and TIMSS. For the research questions proposed here, a longitudinal survey would have been ideal, but it was beyond the scope of the project, given the available time and funding. The key items involved in the study, and the validation of the scales used in the analysis will be given in Chapter 3.

## Approaching habitus, identity and persistence through surveys

Surveys are sometimes questioned as valid research tools because ‘... the findings are seen as a product of largely uninvolved respondents whose answers owe more to some unknown mixture of politeness, boredom and a desire to be seen in a good light than to their true feelings, beliefs or behaviour.’ (Robson, 2002, p. 231). Indeed, while this may be said of interview respondents, the uninvolved nature of the interaction might in some cases improve the validity. Questionnaires, which are impersonal and anonymous, might be *more* intimate and accurate than interviews. Vaisey (2009, p. 1688) argues that:

The unstructured or semistructured interview puts us in direct contact with discursive consciousness but gives us little leverage on unconscious cognitive processes. Discursive consciousness is incredibly good at offering reasons that may not be at all related to the real motives behind a person’s behaviour ... interviews may not be the best way to understand how people make judgments. Carefully constructed and implemented, forced-choice surveys may be better suited to the study of the culture–action link.

Vaisey argues, then, that a questionnaire, particularly a forced choice questionnaire, might give insight into the way people make choices. Indeed, in his analysis, Vaisey finds that such answers are predictive of behaviour several years after the survey in question was administered. This is perhaps because the surveys tap into automatic, unconscious or semi-conscious schemas. Respondents ‘... may be much better able to pick themselves out of the proverbial lineup than to describe themselves to a sociological sketch artist’ (Vaisey, 2009, p. 1705). Vaisey describes the durable heuristics by which people make choices and links these to the idea of habitus (p. 1687). This connection is also in line with the heuristic forms of decision making that human brains generally tend to apply according to research in fields such as psychology and economics (Goldstein and Gigerenzer, 2002). In other words, there is some sense in which behaviours are guided by simple heuristics or moral boundaries, and that these might be more clearly tapped precisely because a survey is more superficial, in some sense, than an interview, and also because the survey provides privacy.

Returning to the issue of the content of the survey, quantitative analysis is limited to the variables that are predicted to be important during the design of the instruments. The survey conducted here was itself intensive. It was arguably too long and complex, but as such provides a less shallow conceptualisation of each participant that is generally considered. Whereas a common problem in secondary data analysis is not having the

desired variables, the problem surveys such as the PSTEM is that complex and messy data requires time to develop the skills to be able to do full justice to it. Sayer cautions that ‘...context-dependent actions or properties such as attitudes might therefore be considered unsuitable for quantification. If we do insist on quantifying them, we should at least be extremely wary of how the results are interpreted.’ (Sayer, 1992, p. 177). Yet I also argue that quantification enables the use of increasingly powerful tools of analysis. Rather than shying away from quantification, there is a need to rethink and recombine variables in ways that push the boundaries of the rote use of comfortable, acceptable analyses in order to understand the interwoven and context dependent nature of the objects of our study. For this research, the quantification has been useful exactly in understanding these context-dependent regularities. ‘... [M]uch information on structural context and contingency is not obtainable directly from individual case studies and/or interviews. Sometimes, the researcher must elevate him or herself from the data to get a broader and clearer picture.’ (Yeung, 1997, p. 57).

Using structural equation modelling, albeit in the atypical way it is done here, is qualitative in nature. A visual comparison, for example, of six different models allows for surprising commonalities, as well as intriguing differences, to emerge. The combination of the survey results and interview data allows these patterns to find resonance with narrative description. The complexity of the questionnaire data here is a challenge, but it also allows for the establishment of ‘empirical regularities’ that can aid in the abstraction of causal mechanisms,’ (Yeung, 1997, p. 63).

## **2.5 Survey design**

The content of the questionnaires and the validation of the scales are discussed in detail in Chapter 3. In the next chapter, the arguments behind the adaptive habitus variables, and the items associated with those variables will be explained in detail. In this section, I will outline the overall survey design.

### **Six different questionnaires**

As discussed in Chapter 3, some of the key variables in the survey design include self-concept, assurance or self-efficacy (Bandura, 2006), and growth mindset or the belief that ability can be changed through effort (Dweck, 1999, 2006). These traits have been

shown to be both mutable and domain specific. This implies that such items should not be measured en masse for STEM subjects. However, to measure each item for science, technology, engineering and mathematics separately was untenable. Mathematics and science, as the only two compulsory subjects represented, and as they are the gateways to STEM fields, were chosen as the foci for these measures of adaptive traits. Accordingly, a (fateful) decision was made to separate the questionnaire into a mathematics version and a science version for each of the three research sites, resulting in six different questionnaires. In retrospect, it would perhaps have been advisable to have a more limited questionnaire in ways that would have combined more fully the mathematics and science domains. It could be that variables function differently for mathematics and science, and accordingly, that students' have different habitus toward mathematics and science, and that each might impact their persistence in different ways. The result of the separation into a mathematics or science focused survey meant that there were six different samples of students needed, which in turn resulted in smaller samples per model, reducing the power of analysis.

However, for use in future exploration, there were several key variables that were kept the same across each survey:

### **Key variables measured across versions**

1. Persistence (by subject and binary coding)
2. Educational aspirations
3. Gifted identification
4. Extracurricular participation
5. Self-concept for mathematics, science, and general
6. Meritocratic ideology
7. Optimism
8. Mathematics and science grades

The variables that were included in the adaptive habitus variable are further explained in Chapter Three. These were mostly domain specific:

## **Key variables measured for the domain**

1. Assurance
2. Diligence
3. Misfit
4. Anxiety
5. Growth mindset/ effort beliefs
6. Fixed mindset/ talent beliefs
7. Classroom environment measures including teacher and peers
8. Value for mathematics or science, engineering or medicine
9. Reasons for track choice
10. Transition

The resulting questionnaire was 15 pages and produced over 200 data points per questionnaire. The rate of response on questions ranged 100% to 90% on substantive variables, but on demographic variables, which appeared at the end, the response rate was down to almost 80%. Even this response rate seems high, given the length of the questionnaire. The questionnaires can be found in Appendix B.

## **Translation and piloting**

To aid the translation and provide possibilities for further corroboration of results, preference was given, where possible, to questionnaire items that had been previously used in Finland, Sweden and the United States. The questionnaire was designed in English, and the translated by professionals into Finnish and Swedish. Items that were already translated were included, in order to check the quality of the translation. The translated questionnaires were then sent to native speakers for editing and testing. Ultimately, the Finnish and Swedish versions had fewer errors than the English version. Due to limited resources, the questionnaire was piloted by native speakers with a convenience sample of university students and researchers. The piloting of this survey was weak, and the testing went much faster than with students in the classroom. The testers' time averaged under 15 minutes; actual participants ranged from 10 to 45 minutes, with some students not finishing the survey.

## Selection of participants

Participating schools for the survey were drawn from the larger metropolitan area, covering several different municipalities and school districts in a contiguous urban area in each site. In contrast, the interviews were drawn from schools within a single, central municipality. A new database was constructed for the survey sampling, and schools that had participated in the interviews were excluded.

It was important to ensure a range of participating schools to secure the inclusion of a variety of social groups and school climates that would represent the diversity of each setting. To this end, stratified random sampling was chosen. The groups for the stratified random sampling were defined by z-scores on standardised tests given in each site. What the z-scores provide here is a sense of a school's relative standing within its local context. The standardised tests were not comparable themselves, and this sense of local status gives an opportunity to compare across countries what would be considered a strong, average, or weak school in the local context. Group 1 was schools with an average score greater than one standard deviation above the mean. Group 2 was schools above the mean and within one standard deviation. Group 3 was comprised of schools below the mean and within one standard deviation, and Group 4 included schools greater than one standard deviation below the mean. Schools were randomly selected from each group.

This could be considered an oversampling at the extreme ends of the distribution. However, particularly if normal distributions and linear relations are assumed (as they are in structural equation modelling), '... oversampling extreme cases is almost always rational.' (Stinchcombe, 2005, p. 33). This oversampling can allow for more robust comparisons between groups within each country. Also, because extreme interest in mathematics, or extreme involvement in enrichment are certainly of interest to this study, sampling from the extremes is advisable since '... they have much information on why they are not average, which is what we need for causal theorizing' (Stinchcombe, 2005, p. 33). The sampling was aimed to provide extremes of dependent variables, like family background and prior attainment. It was not done in such a way as to expect extremes on the dependent variable of persistence, which Blalock (1967) warns against as confounding models.

Nevertheless, the schools that most quickly responded were those with an interest or focus in STEM fields. Thus, since there was not time to continue recruiting schools from the United States and Sweden, specialist schools are overrepresented there, which must be taken into account when considering the findings here.

## Stratified random sampling

For the questionnaires, a simpler database was constructed by mining the publicly available websites for standardised test scores. The test scores used for each setting were quite different in nature, however. Because test scores are linked to the socio-economic status of the school and the desirability of the school, they are useful indicators of the status of the school, even if the exams are more or less meaningful academically. For Oregon, I used mathematics scores from the Oregon Assessment of Knowledge and Skills test for tenth graders, which is administered by the Oregon Department of Education. For Sweden, I used the scores from the National Exams for Mathematics D. For Finland, I used the overall points for the school leaving exam (*Ylioppilastutkinto*). A z-score was then calculated for each school in the metropolitan area, and then the schools were separated into four groups: greater than one standard deviation above the mean score, between one standard deviation and the mean, between the mean and one negative standard deviation, and below one negative standard deviation.

**Table 2.3: Schools participating in the survey**

School Code	Country	Z-score
FI1A	FINLAND	1.618
FI1B	FINLAND	1.062
FI2A	FINLAND	0.529
FI3B	FINLAND	-0.205
FI3A	FINLAND	-0.916
SE2A	SWEDEN	0.859
SE3A	SWEDEN	-0.579
US2A	USA	0.208
US3A	USA	-0.028
US4A	USA	-1.922

## Participants

The sampling across the three sites was uneven. Data collection ran into physical constraints as well as time constraints. In Finland, the sample was quite strong, which is due largely to the fact that I live there and could be more flexible with the data collection.

In total, nine schools in Finland were asked; three said no, and I managed to collect data from five schools. In Sweden, eight schools were asked, two said no, and three agreed to participate, and I was able to collect data from two. In the United States eleven schools were asked, five said no,<sup>1</sup> two did not reply within in the timeframe I had allocated, and four schools agreed to participate. In the end, I was able to collect data from three schools. Participants were informed that the survey was completely voluntary. Parents and guardians in the United States were sent passive consent forms, and two students did not take part for that reason.

Participants were informed that the survey was completely voluntary. Parents and guardians in the United States were sent passive consent forms, and two students did not take part for that reason.

**Table 2.4: Survey participants by self-identified gender, ethnicity, and track.**

Country	% Female	% Male	% Eth.Majority	% Eth.Minority	% Elite Track	Total <i>n</i>
FINLAND	57	38	89	5	58	255
SWEDEN	51	46	86	11	82	130
USA	46	35	52	29	26	288

*Note: Demographic questions appeared at the end of the questionnaire and so had the highest levels of missing data, near 20 percent in some cases*

### The administration of the survey

The questionnaire was given to students in classrooms by me, or by teachers if they preferred to do so. The questionnaires were then coded and entered by hand, all 673 of them, over the course of several difficult months. While in some sense it was a boring process, and seemed like a waste of time given that most surveys are conducted through digital media now, there was also a great deal of information in these paper questionnaires that would have been lost in an electronic format. For example, one student added a note to tell me that while they strongly agreed that United States society is unequal, they did not think my scale allowed them to agree enough. The process also highlighted faults with the questionnaire; entering it by hand it becomes clear when participants drop out

<sup>1</sup> The five schools that declined to participate did not necessarily do so officially. In one case, a secretary told me, after the third time I had called, that the school was going through a crisis and I would be better off asking elsewhere; I never spoke with the principal.

because of poor questionnaire design, or become angry at questions. So, there certainly is a benefit for paper questionnaires from the standpoint of learning how to do research. Furthermore, I would argue that going through the questionnaires carefully, detailed as they are, I sometimes had a more intimate view of the individual (and sometimes in a heartbreaking way) than I did in the majority of interviews I conducted. Given a detailed questionnaire, particularly one that includes open-ended questions, it is possible to read hope and struggle from the responses participants give.

## **Overview of the weaknesses of the survey design and suggestions for improvement**

Much space was wasted at the beginning of the questionnaire attempting to gather information about current course work. In the end, these questions were confusing to students, and given the opaque way that courses were named at some of the participating schools, difficult to usefully interpret. The questionnaire would have been stronger without these sections. As mentioned above, a leaner, more restrained questionnaire would have been easier to administer and evaluate, and restricting the questionnaire to three versions rather than six would have made the translation, printing, recruitment, administration, and analysis much simpler.

## **2.6 Challenges and suggestions for future research designs**

Several major setbacks occurred while gathering the data for this study. A previous site had been chosen in Washington State, however mistakes were made in the initial research approval process, and in the second attempt, while partial approval was reached, a political scandal in the governing body of the main school district and others in the corresponding area caused further delays. A decision was made to find a new site in Oregon for the study. There, the school board approval processes proceeded smoothly, however, gaining access to schools did not. In retrospect, the study would have benefited from me bypassing the official communication structures and asking teachers for support directly rather than school leadership. The formality of my approach worked well in Finland in particular, but if anything, it was detrimental in the United States. Yet, because of the legalistic process of gaining school board approval, particularly given my

aborted attempt in Washington State, I felt more bound to follow the official procedures. In comparison, my pilot study, which in my ignorance I approached school in the United States much less formally, I had a better response rate.

On a related note, there was a desire to make the sampling as rigorous as possible, rather than use the schools that might have been more readily available to me. It is difficult to access schools, particularly in the United States, and yet the use of convenient schools in educational research troubles me. I aspired to have a sample that fit the purpose of the study.

This strategy worked excellently within the Finnish and Swedish contexts, and allowed my sample to be governed by the priorities of the research. However, in the United States, this was not successful, and in combination with formal approaches, it would have been necessary to ask for favours in terms of introductions, and bypass administration to a certain extent. The litigious atmosphere between different interest groups within education systems in the United States is chilling, particularly for a low-status student researcher.

However, in this way, the research experience itself was informative with regards to aspects of educational structures and the cultures that surround them in Finland, Sweden and the United States. If asked to conduct the study again, I would certainly design the research differently. And yet, the process itself has been so informative, even the data collection and inputting described here, and thus it is difficult to genuinely regret the many mistakes that have been made.

The next chapter will focus on the questionnaire items, delving in particular, into the notion of adaptive habitus and its relation to so-called non-cognitive skills. Chapter Three will also examine the reliability of the survey items in preparation for structural equation modelling.

## Chapter 3

# Questionnaire items: theoretical development

The aim of the Student Persistence in STEM Fields (PSTEM) survey was to investigate the connection between school structures and students' intentions to persist in STEM fields. The structures considered include mathematics track, gifted programmes, access to extracurricular enrichment, and students' transition to more stratified upper secondary systems. In addition, survey was designed to examine the theory that school structures, beyond allocating access to content, influence important non-cognitive (Heckman, 2008) aspects of students' development, such as their self-confidence and willingness and ability to work hard in math and science. As discussed in the previous chapter, a hypothesis underlying this study is that school structures influence young people's developing identities, beliefs, and ways of being, including the development or acquisition of non-cognitive skills. Such effects are theorised to be important in terms of STEM persistence. Yet as these effects also pertain to young people's wellbeing; they should perhaps also be considered as important outcome variables on their own.

Accordingly, the PSTEM questionnaires were developed to look at the relationship of educational structures on students' intentions to persist in STEM fields. Furthermore, since educational structures are theorised to act in part through the development of non-cognitive skills, or adaptive habitus, an attempt was made to include an indicator for this in each survey. A large part of this chapter is devoted to arguing for the use of these indicators, that is, the measures used to indicate a students' adaptive habitus.

Each of the six PSTEM questionnaires included a mix of new items as well as those previously used in earlier research. This is a reflection of a desire to be able to eventually relate

the findings to other research, but also to meet the need for novel, fit-to-purpose measures. The measures of structure and the experience of structure, are new. In particular, the new measures were designed to highlight homologies between different structures in Finland, Sweden and the United States. These new measures will be introduced in this chapter and the manifestation of these concepts in each of the three national settings will be further elaborated upon in Chapter 5.

The questionnaires sought to address the main research questions regarding (1) students' experiences in STEM education, and (2) how educational structures impact students, and students' intentions to persist. Each questionnaire was designed to measure both the structural variables and the aspects of student identity and disposition, such as their self-concept and diligence, that Heckman (2008) terms, rather contradictorily, 'non-cognitive factors.' Ultimately, six questionnaires were created for the survey across three different national settings and two different domains: mathematics and science. Each questionnaire was 16 pages long and had roughly 250 data points. The questionnaires can be reviewed in Appendix B.

In the remainder of the chapter, I argue that so-called non-cognitive skills should be considered as an 'adaptive habitus' that would facilitate students persistence in STEM fields. Further, I offer an overview of the non-cognitive variables by scale, including the actual items presented on the questionnaires. A brief description of the validation of these scales is presented at the end of this chapter, as well as a brief description of other variables, including a variable for classroom environment, and an overview of the process of validating the key variables. The chapter closes with a short summary.

### **3.1 STEM education and non-cognitive skills**

Economist James Heckman 2008 has defined 'non-cognitive outcomes' as traits that typically fall into the domain of social psychology. These traits include self-regulation, self-efficacy, and self-concept. The term suggests that for Heckman, such traits are not related to IQ or academic performance. However, 'non-cognitive outcomes' are misnamed, since many processes related to for example, anxiety, happen in the brain, although they often have physical manifestations, as most people who have experienced fear or anxiety can attest. That is, many of these states or characteristics are both mental and physically embodied, a complexity that is obscured by the term 'non-cognitive'.

In everyday language, non-cognitive outcomes relate to, respectively, the ability to govern

one's own actions, the belief that one can accomplish a given task, and the general belief in one's capabilities in a given area, aspects of what we might commonly term self-confidence. Indeed, the wealth of equivalent terminology in this area suggests a lack of cohesion among those fields of study that explore non-cognitive outcomes. Is there a practical difference, for example, between self-control, control-expectancy, or self-regulation? As Duckworth and Kern (2011) suggest, there is significant overlap between these concepts.

From an applied perspective, however, the definitions of 'non-cognitive outcomes' are less interesting than the behaviours and ways of being each definition seeks to explain. Research challenging previously-held assumptions about what makes people successful and what factors are important for persistence – whether it be in STEM fields or another domain – has recently gained prominence in educational policy. Heckman (2008) has argued extensively that what he terms non-cognitive outcomes of early childhood programs are significant across the lifespan. As Heckman shows, an educational intervention may not change in the participants' GPA or IQ, but wondrously, such intervention is certainly related to their likelihood of unemployment, incarceration, and divorce. Similarly, Duckworth, Peterson, Matthews, and Kelly (2007) show that perseverance and passion for a given domain, what they call, 'grit'<sup>1</sup> is more predictive of success than prior academic results. Closely related to this idea is Dweck's (2006) concept of *growth mindset*, the belief that ability can be changed through effort. Heckman, Duckworth and Dweck argue that they can predict real outcomes over the course of the lifespan not through IQ, but rather by measuring something that is closer to character and disposition, or, as I suggest, *habitus*. Since the traits the Heckman and Duckworth highlight are positive, I use the term, *adaptive habitus*, discussed further below, to signal that what is being considered is a habitus that is adaptive, in the sense it is used in the biological science, to success in the domain of school and perhaps larger mainstream society, considering Heckman's findings over the life course. That is, the traits and ways of being are linked with positive outcomes within current school and employment structures. While Heckman's research has focused in part on disadvantaged segments of society, research also suggests that these non-cognitive outcome traits are important for the production of high-level expertise. Duckworth, Kirby, Tsukayama, Berstein, and Ericsson (2011) find that grit is mediated through deliberate practice, which Ericsson, Roring, and Nandagopal (2007) describe as the taxing and even unpleasant practice of skill that requires effort and concentration.

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<sup>1</sup>,Which in (Western) American English does not refer to passion so much as dogged toughness determination against all odds, see *True Grit* (Portis, 1968), which happens to be a favourite childhood book. Especially in the context of that novel, grit has a striking resemblance to the iconic Finnish trait of *sisu*, which is often credited for Finland's ability to maintain independence from Russia after the Second World War.

While such traits may be important for persistence in general, they are also critical to the persistence and realisation of high-level talent in STEM fields.

Non-cognitive outcomes must be considered if a policy goal is to produce entrepreneurs and innovators who would likely require a high degree of resilience. Framing non-cognitive outcomes as skills to be learned in school, policy makers have lately become keen to find ways of developing non-cognitive resources amongst students. For example, the European Reference Framework includes as a key competence to be developed in schools a ‘sense of initiative and entrepreneurship’ along with mathematical, technological and scientific competences (Gordon, Halasz, Krawczyk, Leney, Michel, Pepper, Putkiewicz, and Wisniewski, 2009, pp. 10–11). Often these recommendations seem to promote non-cognitive skills as necessary for the modern workplace, rather than in the framework of student wellbeing. The Assessment and Teaching of 21st Century Skills framework urges schools to promote ‘a self-concept that supports a willingness to change and further develop skills as well as self-motivation and confidence in one’s capability to succeed’ (Binkley, Erstad, Herman, Raizen, Ripley, Miller-Ricci, and Rumble, 2012)). So, non-cognitive skills are seen as important outcomes in their own right, important for life outcomes, success and important to employers. What about non-cognitive traits and student persistence in STEM fields?

## **Adaptive traits for persistence in STEM fields**

International scholarship has made strong the connection between non-cognitive traits, like self-concept and student persistence, and mathematics. Much of the disparate research in this area suggests that students’ decisions are based on an estimation of their own abilities, their confidence when they complete a given study trajectory, and their feeling for what futures would be possible for them. In turn, these traits are affected by school structures. For example, in Australia, Watt (2006) found that students with higher self-perceptions and expectancies of success were more likely to persist in mathematics. For Watt, this seems to explain in part the gender disparity in participation between girls and boys. Aschbacher, Li, and Roth (2010, p. 572) conclude that students who were diffracted from science and mathematics had ‘... come to view their [STEM] career interests as impractical or risky, as they considered the long years of difficult study with no guarantee of a job afterwards.’

School structures have also been shown to influence non-cognitive variables. For example, a lowered self-concept has been linked to attending a selective school (Marsh and Hau,

2003). Similarly, related research has found durable effects of non-cognitive variables years after students leave selective school environments (Marsh, Trautwein, Lüdtke, Baumert, and Köller, 2007), and that participation in enrichment related to increased expectations in, and value for, mathematics and science (Simpkins, Davis-Kean, and Eccles, 2006). The idea that STEM career choices might be deemed ‘risky’ relates directly to self-efficacy, which generally refers to one’s level of confidence that one can accomplish tasks in a given domain. Zeldin, Britner, and Pajares (2008) find that ‘[r]obust career self-efficacy beliefs provide people with the motivation needed to be persistent, resilient and devoted to their academic and occupational goals.’ (Zeldin, Britner, and Pajares, 2008, p. 1055). Thus many of these constructs, across different bodies of research, are intertwined. They have all been demonstrated, separately, to be important to persistence in STEM fields.

However, two aspects that are missing in this research is a critical viewpoint of what these non-cognitive skills are, and how these skills are positioned in larger society. Regarding self-efficacy, for example, Bandura’s (2011) discussion is inspiring: ‘[b]y their choices of activities and environments, people set the course of their life paths and what they become.’ (Bandura, 2011, p. 13). While emphasising agency, Bandura’s discussion tends to ignore the ways in which an individual’s choices might be circumscribed externally; are not there certainly instances where people do not have choice? In Chapter 1 for example, it was discussed how students are aware of and displeased with their placements in a stratified educational system, but cannot always work to change them (e.g. Zevenbergen, 2005).

The robust and highly replicated research pertaining to non-cognitive traits and persistence is important in understanding the processes *behind* persistence in education. However, I want to suggest that, at times, the meaning of the objects being studied with relation to the social structures in which they are imbedded is lost. One empirical and metaphorical tool that can be used to think critically about development of non-cognitive outcomes is the idea of *habitus*, drawn from the work of Pierre Bourdieu. In the next section, examples of how this tool has been used in math and science education are given, and the idea of considering these educationally important, non-cognitive attributes, as indicators of a habitus is further introduced.

## **Habitus as an analytical tool**

Bourdieu has given many different explanations for the concept of habitus. One helpful definition defines *habitus* as, ‘a subjective but not individual system of internalized

structures, schemes of perception, conception, and action...’ (Bourdieu, 1977, p. 86). Within the domain of STEM education, habitus is the conscious and unconscious schema that influences decisions and perhaps limits the possible futures that are considered by a student. Habitus is positioned less as a ‘thing’ to be defined, however. It is more a conceptual tool, a metaphor for tracing regularities in the intersections of the individual, society, family background and school structures. In this way, it is a ‘powerful tool to steer social inquiry and trace out operant social mechanisms’ (Wacquant, 2009, p. 137). Certainly, it has been used to give strong explanations for student outcomes in mathematics and science, which will be the focus of this section.

Significant qualitative work has been done using the idea of habitus to understand how school structures impact students. Zevenbergen (2005) considers how a mathematics habitus developed in mathematics classrooms in a stratified school in Australia. For Zevenbergen, the habitus is in part an internalisation of the individual students’ interaction with school structure, which creates predispositions that make further studies in mathematics probable or improbable. Zevenbergen shows how students in the higher strata were exposed to different (and more comfortable) environments and teacher interactions. Zevenbergen found that the elite students ‘...have come to see themselves as clever and worthy of their positive experiences’ (Zevenbergen, 2005, p. 617). As Zevenbergen describes it, this is the effect their privileged position has on their habitus, From a social-psychology perspective, this could also be described as students increasing their self-concept and having greater feelings of belonging due to positive peer and teacher relationships.

Similarly, the students from lower strata ‘saw little point in the study of mathematics, and which had marked them as inferior’ (Zevenbergen, 2005, p. 616). In turn, these students had low expectations for themselves. Zevenbergen describes this as the development of habitus but it could also be discussed within a framework of Expectancy-Value models. Indeed, the findings from Zevenbergen’s 2005 study are strongly echoed in other work (e.g., Aschbacher, Li, and Roth, 2010, p. 572), without habitus being mentioned. Zevenbergen’s findings were echoed in preliminary research for this project, where students in elite mathematics tracks described themselves and their classmates as hard working, interested and dedicated, and peers in lower tracks as lazy and uninterested, particularly in the more stratified schools in the United States (Saari, 2009). The power of Zevenbergen’s description is that it explains the regularities produced by the intersection of school culture and social class. This is a relationship a psychometric model might control for, while obscuring its generative power .

Similarly, Noyes also uses the idea of habitus to illuminate persistence in mathematics education, describing it as a ‘embodied disposition’ (Noyes, 2006, p. 45). He is most interested in how habitus mediates the student’s relationship with educational structures. Noyes explains how one student, Matt, ensconced in a supportive family, navigates the transition to year seven mathematics in England, exhibiting comfort with his teachers who ‘appreciate Matt’s good manners and work ethos’ (Noyes, 2006, p. 55). Noyes uses habitus to explain how, after graduating to a new school, another student engages in behaviour that simultaneously gains position with her peers and damages her academic prospects, relating this to her family background and the tension between her developing identity (habitus) and the new school environment. These descriptions could also be in the terminology of positive psychology; that is, described in terms of changing self-efficacy, self-regulation, and task-value. Again, both points of view are useful; Noyes explanation makes the impact of social class and social disadvantage visible. He also shows how the effect of adaptive traits such as confidence and diligence are further compounded by how they impact interactions with teachers and school structures.

Psychometric research, on the other hand, can point to regularities, ways of identifying at-risk students, and possible interventions that might be useful in informing general policies. Self-management skills, within mathematics education, seem to be at least partially teachable. Working within the field of science education, Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012) use the notion of *family science habitus* to explain how families with and without science-related cultural capital influence the development of student engagement in science. In their study, ‘[h]abitus provides a practical “feel” for the world, framing ways of thinking, feeling, and being, such as taken-for-granted notions of “who we are,” and “what we do, and what is “usual for “us”.’ (Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2012, p. 5). In their study, habitus is linked to interest, value, and confidence. Again, these are notions that covered in part, by psychometric concepts such as task-value and self-efficacy. In Archer et al.’s analysis, habitus plays a key role in explaining the ways in which students’ trajectories in science education are related to these familial dispositions, and mediate students’ access to extracurricular activities related to science.

## **Bringing together two distinct bodies of research**

Clearly, psychometric indicators, such as those for task-value, self-efficacy and so on, are related to how the term *habitus*, is used in mathematics and science education. However,

there is almost no substantive overlap in these bodies of research, despite the growing interest in moving towards the idea of identity (Eccles, 2009) and agency (Bandura, 2011). Yet, I argue that these two bodies of research, distinct in terminology and methods, are in substance clearly related and have much to offer each other, and moreover that connecting them is of use when considering educational policy. Below, I outline the ways in which the psychometric research on non-cognitive skills and the social theory drawing on *habitus* and social class can inform each other, particularly in research endeavours such as this one, where the interaction of the individual and the wider social structure and context is of interest.

**Psychometric research  $\implies$  social theory** Within the framework of social psychology, the interaction between structure and the individual has been attacked through the construction of high-quality, replicable results that come near to establishing causality, and certainly the order of correlations. In so doing, they have themselves developed a cadre of important tools, but tools that are often ensconced in a particular field. Nevertheless, the complexity of the methods developed, are worthy of consideration for researchers interested in the interaction of structure and the individual.

**Social theory  $\implies$  psychometric research** Many of the psychometrically oriented studies cited here (e.g., Duckworth and Kern, 2011; Watt, 2006; Marsh, Trautwein, Lüdtke, Baumert, and Köller, 2007) either leave out social class or treat it, as well as gender and ethnicity as things to ‘control for’ rather than framing them as live causal agents involved in the interaction of the individual with the social structure (of which educational structures are of primary interest here). In contrast, by using the tool of *habitus*, the conceptualisation of the very nature of the questions change. Self-concept for example, is itself in part a product of a structured and classed social interaction, in which an individual’s ability to navigate may be visibly and invisibly constrained.

Considering *habitus* invites the researcher to look for different regularities in outcomes. Echoing the way that *habitus* is used in the empirical examples above and elsewhere, as a schema or identity that may create boundaries in which students imagine their possible futures, Bandura further writes that ‘[self-beliefs of efficacy] affect the slate of options people consider and the choices they make at important decisional points. By their choices of activities and environments, people set the course of their life paths and what they become’ (Bandura, 2011, p. 13). However, activities and environments are, *emphatically*, not always matters of choice, as shall be seen in the following chapters.

Both the critical social theory seeking to explain and sometimes emancipate people from social contexts and structures, and psychometric studies of individual characteristics, par-

ticularly relating them to long-term outcomes, offer important understandings of complex social structures and the individuals who make them up. Those of us in practical disciplines cannot afford to ignore either perspective. By not focusing on a single variable (self-efficacy vs. self-concept, for example), using the framework of habitus allows for the research on non-cognitive attributes and their relation to attainment and persistence to be used omnivorously. The question here is the worth of the concept in a practical sense, as a analytic tool. The use of habitus also assists in connecting these outcomes to their generation in a structured, classed, raced and gendered reality. In other words, habitus is a tool that facilitates thinking critically about the place of this psychometric research and non-cognitive outcomes in general in educational policy evaluation and development.

However, studies that use habitus are dominated by intensive qualitative research. As tools for statistical analysis improve though, the possibilities of incorporating complex, multidimensional relationships increases. In a statistical sense, it is not enough to simply ‘control’ for social class, gender and race when these things cause, interact, and are otherwise entwined with an individual’s beliefs, taste, personality, and life choices. The metaphor of habitus brings with it an explanation of complex and evolving processes. It has been shown in the research cited here to be a convincing and powerful explanatory tool.

As a metaphor or abstraction, habitus might be contrasted to research that casts student traits and outcomes as single uni-dimensional attributes. Self-concept is one example of an attribute. Yet such a reduction is also a use of abstraction and metaphor. These choices of abstraction are important because:

So much depends on the modes of abstraction we use, the way of carving up and defining our objects of study. Unfortunately, the bulk of the methodological literature on social science completely ignores this fundamental issue, as if it were simply a matter of intuition. Thus many kinds of social research operate with categories used in official statistics even though they are often based on bad or incoherent abstraction.

(Sayer, 2000a, p. 19)

Habitus has been a convincing way to understand students’ engagement and persistence with mathematics and science, and this usefulness does not disappear if a study moves from an intensive to more extensive design. Thus, there is a need to consider how to incorporate aspects of habitus into a mathematical model.

## Including *habitus* in a quantitative model

Bourdieu's language of capital, particularly cultural capital, has been included widely in statistical models. In comparison, measures of habitus have been sparse, and are varied in application when considered. It is interesting to note that Bourdieu (1977, p. 85) criticises the practice of creating a statistical definition of a personality type, when the idea of a personality would certainly encompass aspects of habitus. While this might bring into question the measurement of habitus as well, Bourdieu's main point, however, seems to be that the object being cannot be reduced to the data points of which its measure consists ('the principle which unifies and explains these regularities being reducible to the regularities in which it manifests itself'). Such misunderstandings are a human problem; as measurement is useful, it is easy to conflate, for example, intelligence with test scores (Gould, 1996).

Dumais (2002, p. 51), drawing on McClelland (1990), introduces one interesting example of incorporating habitus into a statistical analysis. Dumais uses students' future career expectations as a measure: 'It is extremely difficult to represent one's habitus, or world-view, in a single variable, or even a large set of variables. However, one component of habitus in one's beliefs about the future (...) I do the same here, with the dummy variable students' expectations representing whether or not the student said that he or she expected to have one of the following occupations at age 30: professional, managerial, or business; business owner; or science or engineering. She finds these expectations to contribute to students academic performance when background factors are controlled (Dumais, 2002, p. 59). Dumais indicator of habitus is a single question regarding students future professional expectations.

Dumais's measure has been criticised, for example by Vaisey (2010, p. 84) and Reay Reay (2004, pp. 11–12), because Dumais's measure of habitus, which is uni-dimensional, falls short of an ideal conceptualisation. This is something Dumais noted herself: 'There are certainly many other factors that constitute a students' habitus than occupational expectations, and judging from the significance that this one small part of habitus has on grades, it will be important to develop measures for these factors in future research.' (Dumais, 2002, p. 62). Reay argues that there are 'aspects of circularity inherent in habitus' (Reay, 2004, p. 439), and that it should be '...viewed more fluidly as both method and theory; a way of understanding the world' rather than a fixed object. While a particular model might be a snapshot in time, it is also possible for mathematical models to represent circularity, for example, as feedback loops are considered in biology and ecology. Mathematical models are rushing to embrace such complexity.

Like Dumais, Vaisey also relates a measure to habitus by secondary analysis on a single question, Vaisey (2009) finds that a question about moral decision making predicted later behaviours, or rather, choices to refrain from certain behaviours. He identifies this as a ‘moral habitus’ (Vaisey, 2009, p. 1689). Vaisey argues that the survey form itself can have advantages when trying to shed light on dispositions behind people’s choices, because people are forced to make quick decisions that perhaps best reflect their habitus:

That is, even though we see in the interviews that respondents have a hard time offering an account of their moral reasoning that contains consistent substantive content, they seem to have little difficulty choosing a substantive response that reflects, however imperfectly, something about their moral dispositions or “habitus.” The fact that this association endures over a three-year period suggests that these associations are more than purely ephemeral and may in fact reflect enduring, internalized cultural schemas.

(Vaisey, 2009, p. 1699)

A richer picture of habitus is included in a model in a recent dissertation by Edgerton (2010). Building on Dumais, Edgerton uses student aspirations, but combines them with scales relating to what is termed ‘student dispositions towards further study and towards teachers.’ These dispositions include items that relate to the psychometric scales used here.

Interestingly, using examples by Vaisey, Dumais, and Edgerton, the outcome variable here, students’ intentions to persist in STEM fields, and their educational aspirations in general, would be the signifier of habitus. The models are welcome to be considered accordingly. These conceptualisations, however, do not draw on the vast work of measurement of affective characteristics being done by researchers situation in psychology and social-psychology, although Vaisey (2010, pp. 1683–1684) acknowledges a relationship between cognitive science and habitus. In focusing on students’ aspirations, I argue, these measures miss something of the unconscious, embodied aspect of habitus.

## **Non-cognitive skills as indicators of habitus**

There is a clear relation between the framework of habitus and psychometric measures such as self-efficacy. Similarly, when psychologists talk about deep and contradictory emotional and cognitive processes, for example, the ways in which people rationalise unjust structures, they could also be considered to be discussing habitus: ‘To understand

these seemingly paradoxical cases, that is, to understand how and why the ideas people hold contribute to their own state of disadvantage.’ (Jost, Pelham, Sheldon, and Sullivan, 2003, p. 14). The rejection of what has been denied, as in Noyes’s 2006 example of the girl who begins to rebel at school, is also a way of making sense of, and feeling agency in, a disadvantaged position.

These are the processes made visible to social researchers though defining habitus, a way in which people’s internal sense of the game may lead them to act against their objective interests Reay (2004, p. 433). This is related to the opposition of habitus as a theoretical concept to the rational choice model of human behaviour (Bourdieu and Wacquant, 1992):

... [C]ontrary to a wide variety of influential theories in social science, people are at least sometimes willing to forgo feelings of personal adequacy, group esteem, and self-interest in order to preserve the belief that the social system, its outcomes, and its authorities are legitimate, justifiable, and more or less beyond reproach.

(Jost, Pelham, Sheldon, and Sullivan, 2003, p. 33).

Habitus is a way for people to make sense of their position in society. Within educational systems, this is illustrated, for example, by Willis’s 1977 study of young working class men who develop identities and habitus that devalue the educational system that has already discounted them. At a micro level, in terms of psychometrics, these behaviours would be described as loss of self-regulation, diligence, and loss of value for schooling. Bourdieu stated, using the particular example of inequality of power between women and men, that ‘... we cannot understand symbolic violence and practice without forsaking entirely the scholastic opposition between coercion and consent, external imposition and internal impulse.’ (Bourdieu and Wacquant, 1992, p. 172). Much of social research, and indeed school policy, particularly those of stratification, are built on the assumption that people are rational actors with full information about the availability, benefits, and costs of particular choices.<sup>1</sup>

What Bourdieu is saying is that people (we) cannot always see so clearly, that our conscious options and estimations of costs and benefits are limited by the habitus, the dispositions and identities, conscious and unconscious, we have developed, and indeed, are developing. Aschbacher, Li, and Roth (2010) demonstrate this in the study discussed

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<sup>1</sup>It is also here where the psychologists and sociologists might disagree; positive psychology does not often include the potential negative costs of ‘good’ behaviour.

earlier when students cease to consider futures in mathematics and science, deeming such goals impossible, although the students' abilities were adequate. Also in the United States, Demerath, Lynch, and Davidson (2008), describe the development of adaptive dispositions, what they call 'psychological capital', with an interesting reluctance to use habitus; the term is not mentioned a single time in the paper. Yet their descriptions of relatively privileged students in a suburban high school adopting identities and beliefs that support their competitive, effortful status-driven work as students attempting to enter the starkly stratified world of higher education in the United States, is better described by habitus than by capital.<sup>1</sup>

Regardless of the words they use, this description by Demerath et al. is illuminating. This is especially true at a time when psychological research in education is dominant and positive psychology (not to mention personality tests in the labour market context) begin to define probable success just as IQ scores once did. While focusing on positive psychology and the development of adaptive traits, in contrast with psychological research that focused on traits deemed negative, as Bandura advocates, might lead to liberation, seemingly positive traits can have a negative side as well. One can also imagine a dystopia where schools are very good at fostering adaptive dispositions and identities in students that ensure tolerance of inequities rather than fostering democratic agency, for example. Such considerations are absolutely important when considering the development of future engineers and microbiologists; the thrust of scientific innovation is not value-free or monotonically positive.

### **Practical use in educational policy research**

Is there a benefit to using habitus as a tool when considering the relationship of non-cognitive outcomes and school structures? In contrast with reliably measured, individual personality traits, '[t]here is an indeterminacy about the concept that fits well with the complex messiness of the real world' (Reay, 2004, p. 438). The objective of using this term is not to reify or claim to measure it in all dimensions. Reay argues that Bourdieu intended the notion of habitus '... first and foremost ... [as] a conceptual tool to be used in empirical research' (Reay, 2004, p. 439). As Bourdieu states:

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<sup>1</sup> There is a marked tendency in North America, noted by in the United States by Vaisey (2010) and by Edgerton (2010) in Canada to embrace the metaphor of capital while shying away from the metaphor of habitus. I am also guilty of using STEM family capital, when a better term for my measure would have been STEM family habitus, following the definition of science family habitus by Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012).

...[T]he main purpose of this notion is to break with the intellectualist (and intellectual-centric) philosophy of action represented by the theory of homo economics as a rational agent, which rational choice theory has recently brought back in fashion at the very time when a good number of economist have repudiated it (often without saying so or realising it fully).

(Bourdieu and Wacquant, 1992, p. 120)

A wealth of independent experimental work in psychology and economics supports this idea. For example, Jost, Pelham, Sheldon, and Sullivan (2003) show how people irrationally justify systems at their own expense, but do so in ways that make sense with the explanation of habitus. In a controlled experiment, Cihangir, Barreto, and Ellemers (2010, p. 167) were able to induce differences in self-concept (they call it self-esteem) that effect how subjects (people) respond to discrimination. Major, Gramzow, McCoy, Levin, Schmader, and Sidanius (2002) show how members of lower status groups may endorse ideologies that rationalise unjust situations. While their deeply held beliefs may inhibit social change, at the same time, they ‘... may allow individuals to maintain a perception of the world as ordered, predictable and controllable.’ (Major et al., 2002, p. 281). Such beliefs can be manipulated experimentally, and lower status, disadvantaged groups (such as women) are more susceptible to such priming (McCoy and Major, 2007).

The point is that these are processes that are readily explained and predicted using the metaphor of habitus. Furthermore, experimental researchers are showing how, in isolated conditions, beliefs, identity and self-concepts can be manipulated. This supports the conceptualisation of habitus as a dynamic system that is both shaped by and shaping interactions as the individual navigates, and acts to generate, the social and physical environments that he or she inhabits.

Again, these ideas are important for STEM educational policy for several reasons. First, the framework set forth in this research suggests that educational structures, particularly the ways students are stratified, impacts students’ habitus, their dispositions towards math and science, and the futures they consider for themselves within those fields.

Second, and more urgent to the countries studied here, positive psychology is having an important impact on educational policy. At the same time, by excluding the work done with habitus and related theories regarding school policies, there is a danger in misunderstanding how adaptive non-cognitive attributes are formed and their real impact on students and student agency. Habitus is a tool that encourages us to think critically about who has, for example, self-control or self-esteem, and for what purpose, and to not

only control for class, race, and gender, but to see them, in combination with the school structures, as generative, rather than erased as they seem to be in many quantitative studies with a psychological bent. Indeed, the purpose of such studies is to look for regularities, and I do not mean to discount the extremely important work being done by such studies. However, to effect real change, policy makers must look for explanation and cause, and also evaluate the *significance* in terms of importance of an effect.

An example of a robust, highly replicated finding with minimal practical impact might be the big-fish-little-pond (BFLP) effect, the finding that a student's academic self-concept is likely to decline in elite academic contexts. The finding is remarkably well demonstrated across national contexts (Marsh and Hau, 2003) and durable even after students have left school (Marsh, Trautwein, Lüdtke, Baumert, and Köller, 2007). Yet, these robust findings have had little impact on the proliferation of elite environments. Certainly, as will be discussed in subsequent chapters, many, but certainly not all of the students in this study experienced this effect when transitioning to more elite upper-secondary schools. However, such effects beg the question of whether a decline in self-concept is necessarily negative; in some cases, when combined with an increase in effort, it might be deemed a positive outcome, as cases in this study suggest. For other students, their point of reference changes to that of a more elite group, and they may be making strategic decisions to focus on the skills that will be most likely to allow them to excel at an elite level; their position in the wider competition is less relevant. Self-concept, locally defined, is but one facet of a more complex habitus, such as those developed by elite students and described by Zevenbergen (2005). Other aspects of habitus might include increased sense of agency and entitlement, adaptive beliefs about the structure of society, for example, an increase in collegial relation. Regardless of a loss of self-concept in one subject, such as mathematics, which may even have positive outcomes, students are experiences other non-cognitive and identity developments that may be valuable to them and to their families. The BFLP effect may be irrelevant in comparison; certainly the demonstration of its existence has not stemmed the desire for such elite environments. Here, the idea of habitus and corresponding critical theory can help bring possible explanations to such choices, embedded as they are in a world of competition and social inequalities.

Furthermore, the idea of habitus is particularly timely in the cultural settings being investigated here. In these settings, the existence of stratification, differentiation and class are sometimes ignored. In Finland and Sweden, for example, hidden tracking or research that finds social disparities in school choice, but does not link such findings with causal factors, with the growing social inequality in Finland, for example (Seppänen and

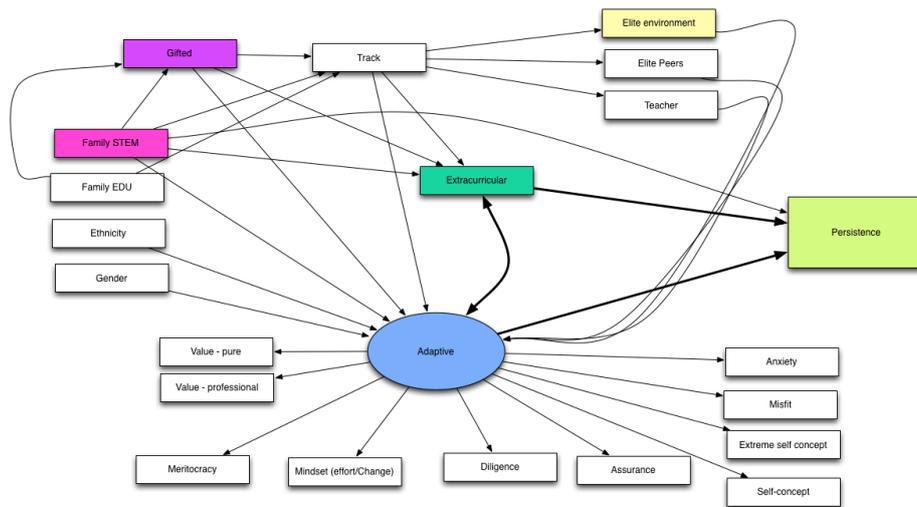
Sairanen, 2011). But again, we must ask about about students who do not have choice. What does self-efficacy mean in such a context, and how would it be generated? Should it be generated? Do schools want self-efficacious disadvantaged students? do many leaders want these students, for that matter? Along with inspiring students to achieve, schools have been used with purpose as ways of gently channeling (limiting) student ambition (Ahola, 1997; Gamoran, 1992). In the related body of research, considering non-cognitive attributes as linked to the notion of habitus opens up unconventional ways of using these attributes in survey research. Furthermore, it leads the way towards considering unconventional groupings of these variables, which are often used in isolation, despite their interdependence. Finally, it can guide the models and their analysis.

My use of *habitus* is based on Bourdieu, of course, but also recognises how others, such as Sayer (2005a), have added to the concept. It is included in this study because it is deemed a useful and convenient way for gathering characteristics that are important for student engagement, and ultimately for persistence. Furthermore, by using this word, I invite the critical viewpoints that ‘habitus theorists’ so importantly bring to educational research. Habitus is arguably a much more descriptive metaphor and tool for understanding than *non-cognitive skills*. As discussed, the term is a wild misnomer. However, I will use the terms interchangeably, acknowledging that they speak to different audiences, and that non-cognitive skills is a limited conception of processes more fully described by habitus.

## **3.2 Indicators of habitus in the PSTEM survey: non-cognitive skills and psychometric scales**

In this section I discuss the psychometric variables commonly included in discussion of non-cognitive traits. I am using slightly different terminology (for example, assurance rather than self-efficacy) because the scales I have used are not exactly as, e.g., self-efficacy researchers would use them. That is, I want to acknowledge I am breaking the rules a little, and so cannot claim the full force of the established terminology. The second is that I want to create this distance to tie the ideas more forcefully with concepts such as character and identity, rather than the psychometric measures from which the original terminology might spring. A discussion of the item validity appears in Section 3.5 later in this chapter.

Finally, I do not claim to be defining habitus with these variables, but do claim that



**Figure 3.1: The theorised path diagram of student persistence, connecting psychometric measures to habitus as described in Chapter 4**

they should be considered as indicators of a student’s habitus, one that has been and will be generated within the context of family, school and society as well as personal choice, and which impacts students’ likelihood of pursuing STEM careers. The following is an introduction to each variable included in this conceptualisation, with the actual questionnaire items and their sources in the corresponding tables.

### **Assurance: Agency and Self-Efficacy**

Self-efficacy is a concept that reflects the individual’s certainty that he or she can accomplish a given task in a particular domain. It is most rigorously measured by fit-for purpose scales that include a range of specific activities of varying degrees of challenge (see Bandura, 2006). Within STEM education and the study of persistence, self-efficacy has also been studied through qualitative research (Zeldin, Britner, and Pajares, 2008). Self-efficacy is most famously an integral part of Bandura’s 2001 social cognitive theory. While focusing on agency, Bandura here acknowledges that self-efficacy beliefs form part of an identity that is influenced by the social structures the individual inhabits. Zimmerman (2000, p. 87) writes that ‘[s]elf-efficacy beliefs also provide students with a sense of agency to motivate their learning through use of such self-regulatory processes as goal setting, self-monitoring, self-evaluation, and strategy use.’ However, it should

be noted that self-efficacy beliefs are evidence of a sense of agency, rather than agency itself. Nevertheless, positive self-efficacy beliefs are predictive of success, regardless of previous performance, and an important facet of resilience. Self-efficacy beliefs regarding self-regulation and science grades for example, have been linked before to other constructs included here, such as Dweck’s (2006) Mindset model (e.g., by Chen and Pajares, 2009). Again, at the time of the questionnaire development, I opted to adapt previously used and translated items if possible. In this case, items were drawn from the Swedish, Finnish, and American versions of the PISA surveys, which in turn, were derived from other scales.

In PISA 2000, a measure for control expectations (a competing construct similar to self-efficacy) and self-efficacy loaded onto a single factor (Adams and Wu, 2002, p. 242). This was the case here as well. The PISA items in turn draw heavily on the Revised Control, Agency, and Means-Ends Interview (Little, Oettingen, and Baltes, 1995). Bandura notes that self-efficacy is domain specific; in my survey, these measures are made for science or mathematics in particular, rather than for general learning, as they were in the PISA surveys. These items can be seen in Table 3.1.

**Table 3.1: Assurance**

<i>Thinking about your [MATH/SCIENCE] classes, how much do you agree or disagree with the statements below?</i>		
CODE	ITEM	SOURCE
SUBSELFEFF2	I am confident I can do an excellent job on assignments and tests	PISA 2000 SELFEF
SUBSELFEFF3	I am certain I can master the skills being taught	PISA 2000 SELFEF
SUBSELFEFF4	When I sit myself down to learn something really hard, I can learn it	PISA 2000 CEXP
SUBSELFEFF5	If I decide not to get any bad grades, I can really do it	PISA 2000 CEXP
SUBSELFEFF6	If I decide not to get any problems wrong, I can really do it	PISA 2000 CEXP
SUBSELFEFF7	If I want to learn something well, I can	PISA 2000 CEXP

The ‘Assurance’ variable in Table 3.1 is of interest because school structures, particularly structures of stratification, might be seen to be sending students signals regarding expectations about their performance and capabilities in math and science. That is, while student and teacher expectations have been shown to influence student outcomes (Eccles,

Futterman, Goff, Kaczala, Meece, and Midgley, 1983; Wigfield and Eccles, 2000), such expectations might be engendered in part by the actors' interpretations of educational structures. This generation of assurance, or lack thereof, is often left out of psychometric models. While Bandura eloquently describes the place of personal choice in the development of identity, personal choice does not always exist. Importantly for educational policy, not all students can choose the contexts in which they learn and develop their identities, as will be seen in the empirical work here.

In educational policy, it is not simply that the opportunity exists, but that it would be psychologically and socially feasible for the student to walk through that open door. Discrimination, whether by class, gender or race can work beneath the level of conscious choice (Bourdieu and Wacquant, 1992, p. 171–172). The distinction between coercion and consent are not always clear. Students are aware of lack of faith that others (teachers and parents) may feel towards them as empirical work both based in psychology (Eccles, Futterman, Goff, Kaczala, Meece, and Midgley, 1983) and sociology Reay (2006) show, and the expectations of others can predict academic outcomes and student choices, regardless of prior performance or measured aptitude (Eccles and Wigfield, 1995; Wigfield and Eccles, 2000).

If persistence in math and science education is a goal, it would be important to look at what structures and environments diminish or increase student assurance, which is closely linked to perseverance. In my model, I proposed assurance in science and mathematics to be predictive of persistence, and impacted by the interaction of family background and school structures.

## **Diligence**

The diligence items in the questionnaires are based on the PISA Effort and Perseverance Index, which in their framework was conceptualised as intrinsic motivation. However, the items in Table 3.2 are better defined as a measurement of student's beliefs about their own effortfulness (diligence) in schoolwork in math or science. This seemed an important variable in preliminary interviews, when students in elite tracks conceptualised themselves as hard working, especially in comparison with peers in other tracks (Saari, 2009). The expectation was that these beliefs would interact with beliefs about agency on one hand, and about the causal power of effort in achievement on the other, discussed in the section on mindsets below.

Work ethic itself, and good behaviour have been considered part of a (mathematics)

habitus (Noyes, 2006). Ultimately, this variable was also of interest since diligence, in the broader sense is necessary for perseverance (Duckworth, Peterson, Matthews, and Kelly, 2007), as is self-control (Duckworth, Tsukayama, and May, 2010). The diligence items can be seen in Table 3.2.

**Table 3.2: Diligence**

<i>Thinking about your [MATH/SCIENCE] classes, how much do you agree or disagree with the statements below?</i>		
SUBEFFPER1	When studying, I work as hard as possible	PISA 2000 EFFPER
SUBEFFPER2	When studying, I keep working even if the material is difficult	PISA 2000 EFFPER
SUBEFFPER3	When studying, I try to do my best to acquire the knowledge and skills taught	PISA 2000 EFFPER
SUBEFFPER4	When studying, I put forth my best effort	PISA 2000 EFFPER
SUBEFFPER5	When I study and I don't understand something, I try to look for additional information to clarify this	PISA 2000 EFFPER
SUBEFFPER6	It's hard for me to really put enough effort in [mathematics/science]	NEW
SUBEFFPER7	I complete my homework on time	PISA 2000 ST32
SUBSELFEFF8	Actually, I rarely ever study for [math/science] class	NEW
GENEFF2*	It is hard for me to really put enough effort in school	NEW

\* Not math or science specific: 'Thinking about yourself as a student in general, across all subjects ...'

### Self-concept

Self-concept has already been shown to be influenced by school structures (see, e.g., Marsh, Trautwein, Lüdtke, Baumert, and Köller, 2007; Marsh and Hau, 2003; Marsh, Chessor, Craven, and Roche, 1995) and family background. Furthermore, self-concept interacts with gender. Eccles et. al., has used the idea of self-concept in the Expectancy-Value Theory to predict students' academic outcomes and persistence. However, they find that the idea of self-concept is empirically '...so directly linked to expectations for success that it is quite difficult to distinguish between these two constructs.' (Eccles,

2009, p. 82). While this sounds similar to self-efficacy, Eccles previously has contrasted her notions with those of self-efficacy researchers. ‘Self-efficacy researchers also tend to focus on individuals beliefs about how confident they are they can complete different tasks rather than asking them to compare their efficacy to that of others.’ (Wigfield and Eccles, 2000, p. 72). Additionally, this comparative aspect is missing in Marsh and colleagues measures of self-concept.

I chose to use measures from three different OECD PISA questionnaires. Part of these are clearly based off of Marsh et al’s SDQII (self-description questionnaire II), and used by Marsh and Hau (2003) in the analysis of the BFLP concept across countries. However, the items used for math, science and general self-concept differed from year to year. I selected items and then used the same questions for general, math and science self-concepts to allow for comparability. These can be seen in Table 3.3.

**Table 3.3: Examples of self-concept items and sources**

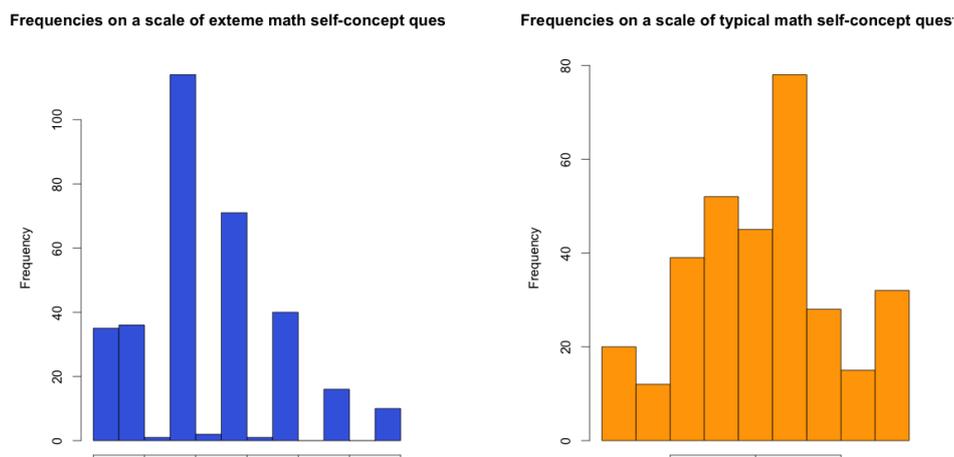
Code	Item	Source
GENASC1	I learn things quickly in most school subjects	PISA 2000
GENASC2	I am good at most school school subjects	PISA 2000
GENASC3	I do well in tests in most school subjects	PISA 2000
GENASC4	I get good grades in most school subjects	
SCISC1/MATHSC1	I am just not good at [science/math]	PISA 2003
SCISC2/MATHSC2	I get good grades in [science/math]	PISA 2003
SCISC3/MATHSC3	In my [science/math] class I understand even the most difficult work	PISA 2003
SCISC4/MATHSC4	I have always believed [science/math] is one of my best subjects	PISA 2003
SCISC5/MATHSC5	I can easily understand new ideas in [science/math]	PISA 2006
SCISC6/MATHSC6	I learn [science/math] topics quickly	PISA 2006

The pilot interviews for this study, particularly with elite students suggested that the ready-made self-concept items, such as those used in the BFLP were limited, as they do not typically included a frame of reference (i.e., ‘I am good at mathematics’ rather than ‘I am good at mathematics in comparison with other students at this school’). Students’ self-concepts in mathematics and science were more complex and answers differed according to frame of reference. Drawing on my preliminary interviews and previous

research literature (e.g., Wigfield and Eccles, 2000) mentioned above, which refers to the importance of frame of reference, I developed two new questions. The goal of these questions is not to fit to the same factor as the standard self-concept questions, but to capture a possible difference between elite students and average students that might be less apparent in typical items. I was looking for items that would increase variance, and distinguish elite students. My new measure was successful in that sense, as can be shown by a quick look at the distributions of these scales, shown in Figure 3.2. The items used to form the scales are given in Table 3.4.

**Table 3.4: Extreme self-concept items**

Code	Item	
SCEXTREME1	I often know about [math/science] topics before we learn them in class	NEW
SCEXTREME2	I am further along in [math/science] than most students	NEW



**Figure 3.2: Frequencies of extreme (left, blue) versus typical (right, orange) measures of mathematics self-concepts; the extreme scale is positively skewed.**

Independent of academic achievement, self-concept has been implicated in students' decisions to continue in mathematics and science (e.g., Eccles, Futterman, Goff, Kaczala, Meece, and Midgley, 1983). As such, it is a candidate for inclusion in the concept of student identities and schemas (habitus) that guides decisions, placing limits on the possible futures (Reay, Davies, David, and Ball, 2001; Archer, DeWitt, Osborne, Dillon,

Willis, and Wong, 2012) that students imagine for themselves. As Eccles and colleagues have shown repeatedly, these self-concepts are not generated by mathematical or science performance alone. They are notably gendered, and clearly linked to social and socio-structural contexts.

### **Mindset: beliefs about effort and ability**

Another belief that has been shown to mediate student learning and educational choices, has less to do with the self, and more to do with the ontology of, or the explanation for, academic achievement itself. While some educational researchers still use *ability* to refer to a static quality of an individual student, research has shown that such a belief on the individual level is maladaptive towards actual learning. Dweck (1999, 2006) identifies two distinct theories of ability: the belief that ability in a given domain can be changed, termed incremental belief or growth mindset and in contrast, the ability that it is impossible to change, termed a fixed mindset by Dweck. Dweck finds that incremental beliefs are correlated with increasing academic performance over time. Furthermore, by working with interventions (in this case regarding mathematics) to increase students' adoption of the incremental theory, student attainment was increased in tandem (Blackwell, Trzesniewski, and Dweck, 2007). This suggests that the causal ordering runs, in part, from the belief to the attainment; belief in the possibility of improvement and change seems to encourage effort and performance. Dweck certainly argues that a disposition towards a growth mindset is conducive to persistence and learning.

Other research supports these results. For example, Stipek and Gralinski (1996, p. 400) use a combination of equivalent items in their study, and use factor analysis to identify two constructs, one they call entity related beliefs, and the other effort beliefs. These mindset scales overlap with scales regarding the importance of effort. Here, the negative items from the short form of Dweck's Mindset Scale (Dweck, 1999, p. 178) load with positive effort-belief items and vice-versa, suggesting the inclusion of both is redundant. In the PSTEM survey, I altered these items to be subject specific for mathematics or science. In addition new items were included. Chen and Pajares (2009) have also used an adapted version of Dweck's scale, but did not share the altered scale. Thus the PSTEM survey represents my own attempt to make the scale domain specific to math and science ability. An example item from the original scale is, 'You have a certain amount of intelligence, and you can't really do much to change it.' My versions for mathematics and science ability can be seen in Table 3.5. I also included items from Stipek and Gralinsky's earlier scale.

**Table 3.5: Mindset: effort vs. ability**

<i>Thinking about [MATHEMATICS/SCIENCE], how much do you agree or disagree with the statements below?</i>		
CODE	Item	Source
TALENTSUB1	You have a certain amount of ability in [math/science], and you can't really do much to change it	Mindset Scale, Dweck (1999)
TALENTSUB2	Ability in [math/science] is something that can't be changed very much	Mindset
TALENTSUB3	To be honest, you can't really change how good you are at it	Mindset
TALENTSUB4	No matter how much ability you have, you can always change it quite a bit	Mindset
TALENTSUB5	You have to have a special talent to do really well in a math class	NEW
EFFORTSUB1	Actually, working hard isn't that important in [math/science], some people are just good at it	NEW
EFFORTSUB2	If you really put time into studying [math/science], you can improve your performance quite a bit	NEW
EFFORTSUB3	The harder you work in math the better you will be at it	Blackwell et al. (2006)
EFFORTSUB4	To tell the truth, when I have to work hard in [math/science] it makes me feel like I'm not very smart	Blackwell
EFFORTSUB5	If you are not good at [math/science], working hard won't make you good	Blackwell
EFFORTSUB6	Everyone can do well in [math/science] if they work hard	Stipek and Gralinsky (1996)
EFFORTSUB7	Anyone who works hard could be one of the smartest in the class	Stipek and Gralinsky

Ultimately, I parcelled these items into two separate scales. One scale gathers the growth mindset and effort beliefs together (MSEFFORTCHANGE), shown in Table 3.5, the other the fixed mindset and negative effort beliefs (MSFIXEDABILITY). The research surrounding the scales these items are based on suggest that a belief in the mutability of intelligence and ability, and the potential of work to effect change in intelligence and ability are adaptive beliefs. That is, they are correlated with positive outcomes for

learners. As such, they are descriptive of an adaptive (school) habitus.<sup>1</sup>

## Meritocratic Beliefs

Beliefs about meritocracy are normally not included in psychometric models of self-efficacy and student achievement. Yet a meritocratic ethos is certainly related to Dweck's mindset framework and ideas of self-efficacy and grit. In meritocratic beliefs, the idea that effort and diligence will be rewarded and are key factors in attaining success is encompassed. Would a lack of belief in meritocracy erode an individual's motivation towards diligence and self-control, not to mention the task-value of learning?

People commonly assume that STEM fields should be more meritocratic than humanities,<sup>2</sup> and thus careers in mathematics and science related disciplines would be likelier sites of upward mobility. Jackson, Luijckx, Pollak, Vallet, and van de Werfhorst (2008) investigated this question of whether the relationship between class origin on class destination differed according to field of study. They found the relationship between class background and ultimate class destination was actually stronger for technical fields in the United Kingdom and France; there was a weak effect in the other direction for the Netherlands (Jackson, Luijckx, Pollak, Vallet, and van de Werfhorst, 2008, p. 383). My own hypothesis is that this counterintuitive relationship is due to the early possibility of tracking in mathematics in the United Kingdom and France, and the relative prestige of those subjects there as opposed to the Netherlands. However, regardless of the cause of this effect, the point here is to highlight how the idea that STEM fields might be particularly meritocratic undergirds common conceptions of these fields, and arguably the support support for increasing STEM education for all students: it is seen as offering the possibility of upward mobility.

In developing the PSTEM, it was interesting to consider whether holding meritocratic beliefs were indeed adaptive in terms of persistence in STEM fields. Meritocracy has lately become less fashionable, and a belief in meritocracy through education has been positioned as a way of stabilising unequal societies (Souto-Otero, 2010). After all, the term meritocracy is relatively new, originating in Young's (1958/2008) dystopic vision of Britain in the year 2034. However, Young's dystopia has never come to pass; Goldthorpe

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<sup>1</sup>A minor questions was whether this belief in the value of effort and hard work would be correlated with a belief in a meritocratic society, since this growth mindset variable is seen as positive, while elsewhere beliefs in meritocracy have been positioned as false or even maladaptive (e.g., Souto-Otero, 2010; McCoy and Major, 2007).

<sup>2</sup>For example, because cultural capital might play a bigger role in the humanities, where the grading is thought to be more subjective

and Jackson (2008) argue there has never been, and possibly never will be, an educational meritocracy. Families are adept at navigating changing educational structures and using them to reproduce class position. Others argue that social mobility must come from other societal structures, such as taxation of wealth, rather than through the educational system (Checchi, 2006).

The idea of meritocratic beliefs is also complicated in the sense that such studies begin on the premise that such beliefs are wrong. Subjects have been primed with meritocratic ideology and been found to blame themselves when they are actually being discriminated against in experimental settings (McCoy and Major, 2007, p. 350). Souto-Otero (2010) contends that such beliefs might be stabilising, while Jost, Pelham, Sheldon, and Sullivan (2003, p. 33) suggest that having an understanding of the world that justifies inequality might provide comfort. Sayer disagrees regarding meritocratic beliefs and educational systems in particular. Sayer states, 'Those who believe that society is basically meritocratic are most vulnerable to shame.' (Sayer, 2005a, p. 959). Sayer suggests that, rather than providing comfort, meritocratic beliefs might be implicated in increasing disadvantage. The question here is to what extent those beliefs are related to adaptive traits. If the development of habitus is influenced by the wider social structure, particularly the future possibilities that the individual can envision, then it seems likely that an individual's conscious and unconscious schema would be tied to such an understanding of the outside world. It is important to note that regardless of these points of view, educational systems are often presented as meritocratic to students; it would be difficult to imagine motivation in the absence of such a belief.

### **Anxiety and Misfit**

The constructs above might be assumed largely to be aspects of positive, adaptive identities to learning, and characteristics that school policies might want to encourage in young people. However, school structures can also provoke negative affect. The problem of exclusion, bullying, and misbehaviour in schools is an acute one (see, e.g., Isaacs, Hodges, and Salmivalli, 2008; Sourander, Jensen, Ronning, Niemela, Helenius, Sillanmaki, Kumpulainen, Piha, Tamminen, Moilanen, and Almqvist, 2007). Here, measures of discomfort (MISFIT) and anxiety (ANXIETY) are seen not only as attributes of the individual, but aspects of the learner's identity that have been developed during their schooling, and which present in part a friction between the individual and their social position and the requirements placed upon them.

**Table 3.6: Meritocratic beliefs**

<i>Thinking about success across all areas of life, how much do you agree or disagree with the statements below?</i>		
Code	Item	Based on:
MERITOCRATIC1	Everyone has the chance to achieve higher status in society	McCoy and Major (2007)
UNEQUAL1	Sometimes individuals are just unable to get ahead in the world, no matter how hard they try	McCoy and Major
MERITOCRATIC2	Anyone who is willing to work hard has a good chance of succeeding	Jost, Pelham and Carvalho (2002)
UNEQUAL2	Individual member of certain groups have difficulty achieving higher status in this country	McCoy and Major
MERITOCRATIC3	If people work hard enough, they can make a good life for themselves	Jost, Pelham and Carvalho

**Table 3.7: Misfit**

<i>Thinking about your current or most recent [MATH/SCIENCE] class, how much do you agree or disagree with the statements below?</i>		
MISFIT1	I feel left out of things	PISA 2000
MISFIT2	I feel awkward and out of place	PISA 2000
MISFIT2	I often don't want to go to class	PISA 2000
CHALLENGESUB5*	I often feel bored	PISA 2000
These items were suggested by the exploratory factor analysis, but is left out of the analysis at this time.		

Importantly, feelings of anxiety and exclusion are also a sign of a lack of agency; if they could be avoided, they would be. Their existence reminds policy makers that students are not always engaged in school out of choice, and that school is not always a positive element in students' lives. The perspective I am arguing for here is that these ideas should be tied to habitus as this connection opens the door to thinking about these traits with more complexity. Rather than simply viewing anxiety and misfit as negative attributes, we can seek to understand why and for what purpose students developed these aspects of their habitus. It is critical that we understand the rational behind such responses,

for there are high rates of medicating students who do not conform to standards at the same time there is general movement towards improving well being in school. From the perspective of a more complex view of the behaviours within their wider social context, the idea of medicating traits dependent in part on social class is problematic (See e.g., Holstein, Hansen, and Due, 2004, for a study of the relationship between social class and the medication for anxiety).

Keeping these difficulties in mind, here anxiety and misfit are conceptualised as maladaptive aspects of a student’s habitus. That is, ways of beings that would make persistence and engagement with math and science, as well as achievement in those subjects, difficult. At the same time, these traits are seen as influenced both by the family background and social context of the student, and by the school structures themselves.

**Table 3.8: Anxiety**

<i>Thinking about your [MATH/SCIENCE] classes, how much do you agree or disagree with the statements below?</i>		
Code	Item	Source
ANXIETY1	I often worry it will be difficult for me	PISA 2003
ANXIETY2	I get very tense when I have to do the homework	PISA 2003
ANXIETY3	I get very nervous doing problems	PISA 2003
ANXIETY4	I worry that I will get bad grades	PISA 2003

### 3.3 Classroom environment measures

Environmental measures are of interest because of their possible relationship to outcomes and to student’s intentions to persist; they are also interesting as outcomes in themselves. For example, what is the level of variation between schools and tracks within schools? What is being gathered in this group of questions, however, is certainly not an objective measure of the classroom environment. Rather, the questions offer a way to measure students’ perceptions of the environment. Predictably, when exploring these variables, it becomes clear that classroom environment variables are closely related to the habitus variables. Indeed, in reality, it must be assumed that they are in part indicating the students’ dispositions towards their classrooms, their teacher, and classmates. This is important in the interpretation: ‘Although student– and teacher– reported measures

such as these elicit important information about the classroom setting, data collected about secondary classrooms from observational measures can offer an added, different perspective of the classroom that is not filtered through the perceptions of a classroom participant.’ (Pianta and Hamre, 2009, p. 112).

The classroom variables (assessing student perceptions) were gathered from a number of sources, and then grouped using an exploratory factor analysis to aid combining them into single variables. Considering the description of different classroom environments in the study by Zevenbergen (2005) and in the pilot studies for this research, there was pattern of higher-strata classrooms being described as more interactive and collegial. Accordingly, measures were investigated that looked at the relationship between the teacher and the students.

While many of the items used were new or adapted, they all drew from a review of instruments. The key instruments included Hoy’s Pupil Control scale (Hoy, 2001), which contains items that can be considered to reflect the collegiality or lack thereof in a classroom. Also consulted was Hoy’s Faculty Trust scale (Hoy, 2002) for similar reasons, as well as Hoy’s Bullying index (Smith and Hoy, 2004). I also reviewed studies to develop a wide view of classroom environments. Among these studies was the framework for evaluating classroom environments set forth by Fisher and Fraser (1983), which considers three domains of importance: the relationship between the teacher and the students, the personal development, and systems maintenance and change. Currently, one of the most prominent tools for evaluating classroom environments is the CLASS, the Classroom Assessment Scoring System (La Paro, Pianta, and Stuhlman, 2004; Pianta and Hamre, 2009). The point of CLASS is really to give an external, objective rating of overall classroom environment than can be done with student or teacher reports. While I was not able to engage in the rigorous observation that is integral to the CLASS system, I drew on this work to conceptualise three key domains to cover regarding classroom environments:

- **Emotional support** For example, are students comfortable asking questions? Are bullied students protected?
- **Classroom organisation** For example, are students engaged and on task or is the teacher talking about random things?
- **Instructional support** For example, does the teacher try different methods to make sure students understand the material?

This is a simplification of the CLASS schema, which is actually a detailed framework

for organising intensive classroom observations. Interestingly, the CLASS domains were echoed in previous research regarding classroom environment measures; I also looked at older models from Trickett and Quinlan (1979) and Trickett and Moos (1974). My items were an attempt to provide coverage for these three main areas.<sup>1</sup>

The most salient items at this point have been grouped into the following variables using exploratory factor analysis. The TEACHER variable gathers together positive items regarding students' perceptions of their teachers. The treatment of the other classroom variables is more ambiguous at this point, because the 'meaningful' sub-scales I predicted either did not load as definitive factors or were not relevant to the models here. Further analysis is ongoing.

**Table 3.9: Teacher**

<i>Thinking about your current or most recent [MATH/SCIENCE] class, how much do you agree or disagree with the statements below?</i>		
Code	Item	Source
TEACHER1	The teacher gives students an opportunity to express opinions	PISA 2003
TEACHER2	The teacher shows an interest in every students' learning	PISA 2003
TEACHER3	The teacher gives extra help when students need it	PISA 2003
TEACHER4	The teacher tries hard to make the material interesting for us	
TEACHER5	I feel comfortable asking my teacher to explain ideas	ISME

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<sup>1</sup>Further instruments that were consulted included the science specific 'Is Science Me?' (ISME) survey (Aschbacher, Li, and Roth, 2010), the Michigan Childhood and Beyond Surveys (Fredricks and Eccles, 2010; Simpkins, Davis-Kean, and Eccles, 2006) as well as the PISA 2000, 2003 and 2006 surveys and the United States National Education Longitudinal Study of 1998 and Education Longitudinal Study of 2002.

**Table 3.10: Elite peers**

<i>Thinking about your current or most recent [MATH/SCIENCE] class, how much do you agree or disagree with the statements below?</i>		
Code	Item	Source
ELITEPEERS1	The best students in my school are in my [math/science] class	NEW
ELITEPEERS2	Students in my math class work harder than most students at this school	NEW
ELITEPEERS3	My classmates inspire me to work harder	NEW
ENCOMPUB1*	Students are very competitive in my [math/science] class	NEW
ENVIELITESUB2*	The teacher has high expectation for our class	Hoy, Student Trust
ENVIELITESUB3*	Students ask more questions than in other classes	NEW
ACTIVECLASS1	Our teacher encourages creativity	NEW
ACTIVECLASS2	We are asked to do investigations or experiments to test out our own ideas	NEW
ACTIVECLASS3	Students are given problems or projects that take several days to complete	NEW
TOOEASY1	Actually, it isn't hard to get a good grade	NEW
TOOEASY2	My [math/science] classes have been easy	NEW
TOOEASY3	I have had to push myself to keep up with the work	NEW
TOOEASY4	I am often challenged during class	NEW

### 3.4 Structure and family background variables

In this section I move on to describe how key elements of educational structures were tackled in the survey. These include transition to upper-secondary mathematics and science, extracurricular involvement, and gifted identification.

## **Transition**

The subject of school transitions arose in the interviews, and in response, I included this topic in the PSTEM survey. Particularly in Finland and Sweden, where some students had been to specialist schools and others denied such schools existed, it was common for students to enter gymnasium with a high self confidence and struggle within a new, better qualified peer group. Previous research has shown, both qualitatively (Noyes, 2006) and quantitatively (Jackson, Erikson, Goldthorpe, and Yaish, 2007), that points of transition are also points where differences are magnified and secondary effects of social class are exaggerated. The negative transition measure sought to indicate whether students had experienced a shock in terms of habitus and a loss of motivation at the point of transition to upper secondary school. Made of novel items, this measure of transition is designed not simply to measure positive or negative aspects of the structure, but to include the idea of change, that lost interest in the new environments they encountered in upper-secondary school.

These survey items are in need of revision. The analysis suggests they might be improved by extending the scale to two scales, one regarding a loss of interest, the other a misfit of performance and peers, that is, a feeling of being behind other students. Their close relationship with the adaptive habitus variables suggests they are worthy of further reflection.

## **Extracurricular activities**

Extracurricular and enrichment activities in mathematics and science are often promoted as ways of engaging students. Activities like robotics competitions draw high-level media and political attention. Extracurricular activities seem to have a positive effect on student interest, but perhaps not strong enough to encourage persistence (Aschbacher, Li, and Roth, 2010). The positive effect of involvement might not be linear, but they do seem to exist across class and gender (Fredricks and Eccles, 2010). Involvement is also dependent on the STEM capital of the family, as discussed in the next section.

Furthermore, I had supposed that involvement would be markedly stronger in schools in the United States, both because of higher prevalence of extracurricular school activities in general, and because of their importance as signifiers for admission to elite tertiary schools. Another goal was to do a survey in a geographic sense to get a better lay of the land, since I had found in many interviews that official enrichment activities were, in

**Table 3.11: Transition to upper-secondary math and science**

<i>For many students, the transition from middle school math courses to high school courses can be challenging. Thinking back to your own experience moving from middle school to high school, how much do you agree or disagree with the statements below?</i>		
TRANSPOS1	[Math/science] is easier for me in high school than in was in middle school	NEW
TRANSNEG1	When I came to high school, other students seemed to know more about [math/science] than I did	NEW
TRANSNEG2	I didn't feel I was prepared for high school math/science classes	NEW
TRANSNEG3	I started high school wanting to take more math/science classes, but changed my mind after I found out what the classes were like	NEW
TRANSPOS2	I am more interested in math/science now than I was before high school	NEW

practice, not available. In a further, open question, I asked for other STEM activities in which the students had participated, both to include in a general measure of involvement and also as a way of gathering a better idea about what opportunities existed for students in each of the three sites.

Finally, participating in mathematics and science extracurricular activities have long half-lives, being used as signifiers and arising in conversations about mathematics and science into tertiary education settings and beyond (if one stays in those fields). This seems particularly true for those studying mathematics, and in that profession, there is a keen interest in the significance of high-profile competitions such as the Mathematics Olympiad (e.g., Andreescu, Gallian, Kane, and Mertz, 2008).

The XSTEM.sum variable is a sum of these, and in addition an open question (p. 10 of the questionnaire) about further STEM activities that might not have been included in the list, which was coded as a binary variable

**Table 3.12: Extracurricular: formal and informal**

<i>Thinking about your [MATH/SCIENCE] classes, how much do you agree or disagree with the statements below?</i>	
Xproject	Entered a research project (related to science, technology engineering or mathematics) in a fair or competition
Xcompetiton	Participated in a math, science, engineering or technology competition
Xonline	Watched math or science videos from the Kahn Academy online
Xpodcast	Watched free math or science videos or podcasts of university lectures
Xoutsidecourse	Taken extra courses in science, technology, engineering or mathematics outside of high school
Xvisit	Visited a science research center (for example, at a university, power plant, hospital or company)
Xtutor	Tutored others in mathematics or science
Xforums	Used online forums to discuss math or science problems
Xfieldlab	Conducted fieldwork or laboratory work for an independent or professional research study
Xprogram	Learned a new programming language, such as Python or C++ or developed new computer programs outside of school
Xtutee	Received tutoring in math or science outside of class
Xhealth	Volunteered in a hospital or healthcare center
Xsummer	Attended summer programs or camps for math or science
Xclub	Participated in science, technology, engineering or math clubs

### Country specific measures

For each field work site, I collected a list of specific STEM related programs available for students. This information was garnered from interviews, informants, and internet

searches. Ultimately, I collected eight additional prompts for Sweden, ten for Oregon, and twelve for Finland. These included math and science competitions, summer programs and access to university courses among other activities. Students were asked to check all in which they had participated.

### **Other extracurricular activities**

I also asked students for their level of involvement in other extracurricular activities, and if (and how much) they were working. These were included as controls, taking into consideration that some students are highly involved, but simply not highly involved in STEM activities (Aschbacher, Li, and Roth, 2010, p. 572). As Aschbacher, Li, and Roth note in the case of American students, students highly involved in other activities might be simply making a decision to focus on other strengths or passions. This was also suggested in the interviews I conducted in Finland and Sweden. As such, they are also distinct from students who with no extracurricular involvement.

### **Gifted Identification**

Here ‘gifted education’ is short hand for programmes that result in differentiation at the primary and lower secondary levels. Some of these programs are officially labelled by their administrators as as ‘enrichment’ programmes. See Chapter 5 for a more elaboration of my intentions and positions on this subject, using illustrations from the interviews. These questions are included for reasons as similar to those regarding extracurricular and enrichment activities. The questions regarding gifted identification are hypothesised to have an explanatory effect on, not the persistence necessarily, but on the adaptive habitus variables.

There was a great deal of stratification in Swedish schools in the primary and lower secondary levels that is not apparent in national-level descriptions of school structures in Sweden, but became apparent during the course of field work for this project. In terms of the relation to family capital and to the school outcomes, many of these structures, such as special classes and special school in Finland and Sweden functioned in very similar ways as with segregated gifted programs (Saari, 2013). In each context, being identified by a teacher seemed to be a powerful experience. Even so, I did not expect this measure to function as well as it did across each of the three contexts. Ultimately, the strong and similar relationship of this variable to key variables in the model, like track placement

**Table 3.13: Gifted Identification**

<i>In elementary school or middle school/junior high, did you experience any of the following?</i>	
Did your teacher give you extra problems or activities in math?	NEW
Did your teacher recommend that you take part in a science competition or science club?	NEW
In mathematics, were you ever asked to help other students?	NEW
Did you work ahead of other students in your class in mathematics?	NEW
Were you ever in a Gifted or Talented program?	NEW
Did a teacher recommend for you to take advanced math or science in high school?	NEW
Did you attend a class or school with a special emphasis on <b>science</b> ? (For example, where you studied science for more hours than an average class)	NEW
Did you attend a class or school with a special emphasis on <b>math</b> ? (For example, where you studied math for more hours than a normal class)	NEW
Did your teacher recommend that you take part in a math competition or math club?	NEW
Did your teacher give you extra problems or activities in science?	NEW

and extracurricular involvement support the existence of stratification in Finland and Sweden that are analogous to gifted education programmes in the United States.

## Track code and rationale

Students were also asked:

1. Current math course
2. Last math course
3. Current science course
4. Last science course
5. Reasons for being/ not being enrolled in mathematics or science.

In addition, in Sweden the questionnaire asked if students were taking the nature science line. In Finland, the questionnaire asked if they were taking long mathematics.

## Parent's STEM capital

STEM capital here refers to parent's education or work in a STEM field, combined with their interest in, and support for their children in pursuing, mathematics and science. As such, it is closely related to what Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012) term *family science habitus*. I developed this measure before that paper was published, and am continuing to use my original terminology here. The idea of a STEM capital measure was meant to be a domain specific adaption of the idea of cultural capital. Broady (2001, p. 50) defines *cultural capital* as '...dominating form of symbolic capital in societies where a centralised school system [is developed]'. Capital is another metaphoric concept for understanding how power and status are transmitted in societies when they are not done so physically (i.e., through wealth, land, property, violence, and so on), but through actions such as concerted cultivation (e.g., Lareau, 2008) of young peoples' educational choices, non-cognitive development, and taste. In many large-scale education-related studies, such as the OECD PISA surveys, measurements of parental education, attendance at cultural events, and number of books in the house are used as proxies for measuring cultural capital. While the size of the effect of cultural capital seems to vary across countries Hampden-Thompson, Guzman, and Lippman (2008, p. 177), effects on educational outcomes are found worldwide.

However, it seemed prudent to create a STEM specific variable for this study. PSTEM interviews suggested that family background was important to students' involvement in extra-curricular activities and on their intentions to pursue STEM careers. However, it was clear that it wasn't cultural capital, or educational capital in general that was at play, but rather what I came to think of as *STEM capital*. Such effects have been reported elsewhere, for example (Aschbacher, Li, and Roth, 2010, p. 577) refer to this as a 'family community of practice in science':

Most of the High Achievers described immediate or extended family members who were doctors, pharmacists, scientists, or engineers who helped shape the family community of practice in science in a variety of ways, such as serving as role models and providing advice, information, and ongoing conversations about what such careers and their pathways entail. Parents also facilitated extracurricular experiences by seeking opportunities, encouraging participation, paying expenses, and providing transportation.

The resources and dispositions towards STEM that Aschbacher, Li, and Roth (2010) describe fit with the metaphors of capital and habitus, for example by Archer, DeWitt,

Osborne, Dillon, Willis, and Wong (2012). These metaphors have the benefit of summarising neatly a complex amalgam of resource and disposition.

Accordingly, in addition to measuring parents' education I also asked four questions, which were a first attempt at creating a quantitative measurement for family STEM capital. The questions were asked separately for each parent or guardian (mother or guardian 1 and father or guardian 2) and a sum was created, both for mother and father independently, and using both together. I also included two items about self-employment and business ownership, as an alternative form of capital to educational capital. These should also be taken into account more widely in studies of student outcomes. It would be interesting to see if and how their effects differ from measures of cultural capital (and parental education); their absence seems to me to reveal an interesting bias of academics, who perhaps value their own accumulated forms of capital over others that might actually be more powerful in market economies, and greatly influence students' educational choices and investments.

**Table 3.14: Examples of family capital items**

<i>This question is about your parents' or guardians' work, education, and involvement in STEM fields. Please check the corresponding box on the right if any of the statements on the left apply to you parents or guardians</i>
Is interested in science, technology engineering or mathematics
Works with science, technology, engineering or mathematics
Studied science, technology, engineering or mathematics
Encourages me to study science and mathematics
Works as a medical or health professional (of example, a nurse or paramedic)
Owns his or her own business
Works for herself or himself (self-employed)

### 3.5 Reliability of the questionnaire

This section is about analysing the validity of the main questionnaire items, including the reliability of the variables discussed in this chapter. This survey was designed to be analysed primarily with structural equation modelling. The primary analysis that was being tested is presented in the next chapter, Chapter 4.

Here I will present some of the processes undertaken to examine the validity of the measures used from a statistical standpoint. First, these analyses included an exploratory factor analysis of the ‘non-cognitive’ measures, as well as scales used for structure and classroom environment. These scales were confirmed, refined, and in some cases defined during that process. Second, using the reliability of these scales was estimated. Third, the process of parcelling was described. Lastly, the main outcome variable, ‘persistence’ was explored by regressing its components on a binary outcome variable of students intentions to persist that was created by coding open ended responses.

## Exploratory factor analysis

An exploratory factor analysis is one way of looking at whether participants’ answers on a group of questions form a common factor, or are rather unrelated, or even perhaps more related to another construct. It allows data to be examined as a whole. While it is possible to go straight to confirmatory factor analysis and look at scale reliability, a factor analysis is useful here because the questionnaire included new items as well as closely-related measures that are not normally included together that might be, statistically speaking, part of the same factor. For the classroom environment items in particular, there was a need for examining if they formed a reliable scale; for those items, the analysis was truly exploratory and used for variable formation.

Here I give detail about the process as it related to checking factors for the non-cognitive variables—those variables that I have argued in this chapter that might be indicative of an adaptive habitus. A similar process was done for the classroom environment measures.

### How many factors?

Exploratory factor analysis works best with a large sample, so I conducted it first and most rigorously with the entire data set, and then separately by country, to see if the results differed. Using pairwise complete observations to handle missing data, I first took a look at the scree plot, which estimates the number of factors, for all the non-cognitive variables. The traditional reading of the scree plot is done by identifying the point of inflection (e.g., Field, 2009, p. 640). This suggested seven or eight factors by my estimation. However, the results of this eyeball method are ambiguous. As a more objective test, I used the VSS function from the *psych* package in **R** (Revelle, In Press), I

calculated the Very Simple Structure (Revelle and Rocklin, 1979) and Velicer's Minimum Average Parcel (MAP) criterion using the varimax rotation, chosen as it is more likely to provide more interpretable loadings (Field, 2009, p. 644). A VSS test with complexity of 1 and 2 returned 1 and 2 factors respectively, while the Velicer MAP criterion returned 8 factors. Because there was such different results from the two tests, I decided to include a third more rigorous test of the number of factors. This was a parallel analysis (Horn, 1965) that calculates the number of factors before the eigenvalues of the factors intersect with those of a randomly generated set of the same size. That is, it can be thought of as finding the point where meaningful statistical explanation is exhausted, and the groupings become no better than randomly generated data points would provide. This test returned 14 factors.

Clearly, much depends on the criteria that one uses to determine the number of factors. For example, for five or less factors, the data set was strongly unidimensional, with most of the the key variables loading to a single factor, as did the visual graphs of the scree plot and Velicer Map criterion also suggest; a single factor explains quite a bit of the data. Furthermore, some tests, including the Very Simple Structure test (Revelle and Rocklin, 1979) imply a single factor. Results were similar by country.

So, there is an argument that one factor explains quite a bit of all these non-cognitive variables. However, by using 14 factors, the key variables were also shown to hold together. That is, at that high level of definition, self-concept for mathematics loaded strongly to a single variable, and so on.

The exploratory factor analysis was further used to clarify certain variables. For example, included in the survey were both the Mindset scale (Dweck, 1999, 2006) and closely related items from a scale about effort (Blackwell, Trzesniewski, and Dweck, 2007). The 'growth mindset' (Dweck, 2006) and positive effort items, both of which imply the belief that one can change one's ability through hard work and effort, loaded to a single variable, whereas the negative items (fixed mindset, talent is immutable) loaded to another. Two different variables were created.

The other variables that were influenced by the factor analysis where the 'assurance' and 'diligence' variables. 'Assurance' is based mostly on items related to self-efficacy and control expectations (Bandura, 2001; Duckworth and Kern, 2011), which are closely related concepts in practice, as Duckworth et. al. show. The confirmatory factor analysis implied to was reasonable to consider these items together. The 'diligence' factor was also developed through the exploratory analysis. It related to items having to do with personal effort and perseverance, and was a combination of OECD PISA items, and new

items. One new item that that have been considered, when making the questionnaire, as part of self-efficacy, ‘Actually, I rarely study’, loaded to this ‘diligence variable’, where I argue, it makes more sense in any case. These variables and their meanings were discussed earlier in this chapter.

A similar analysis was conducted for the classroom environment items, which are a work in progress. In addition, as part of the development of the structural equation models in the next section, factors (as latent variables) were evaluated with confirmatory factor analysis. Using the more stringent Velicer MAP criterion there were estimated to be seven factors. Using that estimate, the exploratory factor analysis a grouping of comfort versus misfit variables, two groupings of challenge versus easy variables, a classroom environment factor, and a separate factor of classroom environment items that focused on the teacher. The classroom environment measures in particular need further analysis and development. As the measures stand, they were not integral to the models reported here, however, they might be useful in further investigations.

## **Testing the reliability of the scales**

A common, simple, and socially accepted but perhaps often abused method of considering reliability in scales is by calculating Cronbach’s alpha coefficient (Cronbach and Shavelson (Ed.), 2004). This coefficient was developed to evaluate the reliability of tests. That is, the idea was to come up with a heuristic for determining how much of the variation is caused by the respondents (the test takers), and how much of the variation would be due to the particular questions asked, drawn from an imaginary universe of equivalent questions. That is, a person’s performance on a test might in part be do to luck? they just happen to have studied a particular part of the examined subject more thoroughly, and that ends up being the focus of the test, for example. Cronbach himself has called the measure a ‘...crude device that does not bring to the surface many subtleties implied by variance components.’ (Cronbach and Shavelson (Ed.), 2004, p. 394). While this idea makes a lot of sense for testing, its use in practice arguably encourages researchers to come up with measurements that are not that interesting, because the object being measured is so narrow that they might as well have used a single item.

However, it is a useful and widely accepted tool for gaining information about how well a scale holds together. There are some cautions to consider; coefficient alpha is a measure of internal consistency, but not homogeneity (Schmitt, 1996). Internal consistency refers to the interrelatedness of a set of items, whereas homogeneity refers rather to the idea

that there is only one factor present in the scale. Thus it is possible to construct a scale that is really made up of two factors but still has an acceptable coefficient alpha, thus calculating the alpha alone is not enough.

Here, this danger has been mitigated in two ways. First, the exploratory factor analysis confirmed that the times used were indeed loading on single factors. Second, the method of calculating Cronbach's Alpha used here, part of the *psych* package in **R** (Revelle, In Press), also calculates other measures, such as the inter-item correlations. Thus as they alphas were calculated, there was an opportunity to see if the measure was reliable as a single construct.

The Cronbach Alpha's, calculated with Revelle's (2012) *psych* package, are shown in Table 3.15 for the 'non-cognitive' variables and in Table 3.16 for the structural and environmental variables. The bold values represent scales for which the judgment of reliability varied between the countries.

**Table 3.15: Reliability of of the non-cognitive scales used adaptive habitus indicators: standardised Cronbach  $\alpha$  coefficients for the whole sample and by country**

Variable	TOTAL	Finland	Sweden	USA
Misfit	0.80	0.78	.074	0.83
Anxiety	0.80	0.75	0.83	0.83
Assurance	0.83	0.81	0.86	0.83
Diligence	0.82	0.85	0.83	0.80
Optimism	0.75	0.80	0.75	<b>0.67</b>
Meritocratic ideology	0.76	0.71	0.76	0.78
Extreme self-concept	0.68	0.60	0.62	<b>0.72</b>
Science self-concept	0.92	0.90	0.93	0.92
Mathematics self-concept	0.94	0.84	0.93	0.94
General self-concept	0.86	0.81	0.88	0.81
Growth (Effort) Mindset	0.84	0.72	0.86	0.87
Fixed (Talent) Mindset	0.79	0.72	0.84	0.82
Value Math/Science	0.81	0.79	0.77	0.84
Value Eng/Medicine	0.79	0.74	0.75	0.83

**Table 3.16: Reliability of structure and environment: standardised Cronbach  $\alpha$  coefficients for the whole sample and by country**

Variable	TOTAL	Finland	Sweden	USA
<i>Structure experience</i>				
Gifted ID	0.75	0.75	0.77	0.75
Negative Transition	0.61	0.62	0.64	0.62
<i>Classroom environment</i>				
Teacher	0.80	0.71	0.84	.084
Active class	0.65	0.56	0.49	0.58
Peers	0.65	0.57	0.57	<b>0.73</b>
Elite environment:	0.49	0.47	0.51	0.39
Tooeasy	0.69	0.69	.069	.069
Combined Classroom	0.73	0.70	0.71	0.73
Exploratory Classroom	0.73	0.71	0.69	0.73

## Evaluating the alphas

There is no absolute cut off for acceptable Cronbach alphas, although generally it is considered that the cut off should be 0.65 to 0.70 or above (Girden, 2001). Some researchers have used values as low as 0.59 (e.g., by Mason and Scrivani, 2004). It should also be noted that the reliability can be influenced by the number of items; the longer the test the higher the reliability is likely to be (Cronbach and Shavelson (Ed.), 2004).

All of the non-cognitive, adaptive habitus, measures used here were above this range (Table 3.15), with the exception of ‘optimism’ for the United States version, and ‘extreme self concept’ for the Swedish and Finnish version. The environmental variables (see Table 3.16 ) are more problematic. There was a clear ‘teacher’ variable that performed well across the three settings, as well as a borderline measurement of the lack of challenge( ‘too easy’). The theoretically defined measures for peers, elite environment and active class did not perform well (although the peers items did with the United States, and interesting exception). However, a gross measure of classroom variables ‘combined classroom’ did reach an acceptable level across all three settings, as did a more parsimonious ‘exploratory classroom’ scale, that was drawn directly from the exploratory factor analysis. The reliability of these measures is better, and although the exploratory environment variable is borderline for Sweden, the combined classroom scale may have a higher reliability because

it is simply includes more items. A further consideration of these variables is needed.

### **The validity of the instruments across the three different settings**

Apart from those exceptions, the analysis supports the validity of the questionnaire items for Finland, Sweden and the United States. Furthermore, the internal validity of the main variables suggests that parcelling is allowable.

### **Parcelling and summing**

Some of the variables included a large numbers of indicators, for example ‘Assurance’ and ‘Diligence’. Particularly because some of the sample sizes here are so small, it is preferable to have fewer indicators. One way of doing this is by parcelling indicators together, and then using these parcels as indicators of a latent variable. Another way of doing this is to simply parcel all the items together and in effect create a score for that scale.

Parcelling has several drawbacks, including a loss of information and error estimation. However, it also has several advantages. Drawing from Little, Cunningham, Shahar, and Widaman (2002) and Holt (2004) these include: (1) creating more normal data (data that approximates a Gaussian distribution) by combining items that were measured on short Likert scales, as in this survey; (2) reducing the estimations made by the model, and thus the sample size necessary to compute it; (3) better model identification. One of the tricks of doing structural equation models, as described in the next section, is that these models work best when there are three indicators. This simply has to do with the mathematics involved in assessing the model; it has nothing whatsoever to do with meaning. Parcelling allows for several indicators to be collapsed into three, for easier use in structural equation modelling.

Holt (2004) recommends always parcelling when uni-dimensionality can be ascertained. The factor analysis and coefficient alpha confirm this for the variables here, with the noted exception of the negative transition variable, but is still generally interpretable, and comes in above the cut of used by some researchers in practice (e.g., Mason and Scrivani, 2004). This scale needs further refining.

## **Parcelling procedure**

Little, Cunningham, Shahar, and Widaman (2002, p. 165) give several suggestions for parcelling, one of which is to assign items to be parcelled together randomly. This seemed preferably to me, because otherwise there seemed a danger of incorrectly inflating reliability. For identical items across domains (for example, self-concept for general academics, mathematics and science) random assignment was used once, and then the same parcelling structures were used for the other domains. That is, self-concept items that were identical across math and science were parcelled identically, so the structural similarity between those variables would be preserved.

The random placement of the variables into parcels was calculated using a random number generator in R. Sum variables were also computed and used in the analyses.

## **Validity of the persistence variable**

Students' intentions to persist in STEM fields were the key dependent variable in this survey. Accordingly, built into the questionnaire design were two measures. One was composed of scales, the other of an open-ended question that was then coded as a binary variable. This allowed for testing the relationship between the two measures, giving additional assurance that the measures had some consistency.

### **Scale for Persistence: Not a simple sum variable!**

For the scale persistence variable, students were asked how likely they were to study a particular STEM related field in the future. To interpret this as a summed scale over different fields, it was necessary to consider carefully how student's answers would be scored. I created a new variable, by recoding as one point for likely and 2 points for very likely, and 0 for against.

This was not a simple sum. A simple sum of these would have obscured students who were very interested in one subject, and not at all interest in another. For example, there were three subjects, biology, mathematics and health, and Student One gives a 2 for biology, 3 for mathematics and 2 for health, and Student 2 who really wanted to be a biologist, for example, gives a 4 for biology, 1 for mathematics and 1 for health. The first student would have a score of 7, the second of 6. Yet, it is likely that the second student would be more likely to persist.

Instead, I recoded these variables, so that no points were given for being inclined against the field, 1 point was given for being likely, and 2 points given for being very likely. This gives Student One a score of 1 and Student Two a score of 2, arguably a much more meaningful reflection of their level of passion.

### **Checking for validity**

To test the validity of this measure, I used a binary outcome variable that I had made from students' answers to open ended questions about their future plans. If there was a significant problem with the continuous measure's validity, then it would likely not explain, or not explain much of student persistence. However, they were highly correlated. I also regressed this variable on the binary outcome of each persistence component. In order to do this, it was necessary to do some preparatory work, namely a multiple imputation. A quick outline of this and the results of the logistic regressions can be found in Appendix C. The results suggested validity by confirming a strong relationship between these two very different measurements.

## **3.6 Summary**

In this chapter I have given a theoretical argument for the inclusion and framing of the main variables used in the PSTEM questionnaire. I have also given a brief analysis of the statistical validity of the corresponding questionnaire items and measures. I have laid bare the items used in the analyses presented in the next chapter, Chapter 4, and the validation of the items used. There are many faults in the six questionnaires that were ultimately produced, and some of the variables here need further exploration.

Any interpretation of statistical findings based on survey research must acknowledge that '... variables are standing as a simple, miserable proxy for vast and complexly interwoven social institutions.' (Marsh, 1979, p. 300). Likewise, it is not claimed that the adaptive habitus variable, which will be described at length in the next chapter, would be '... reducible to the regularities in which it manifests itself' (Bourdieu, 1977, p. 85) even if it can explain them. Moving to the next chapter, I use these variables to give models of student persistence in Finland, Sweden and the United States for both the science and mathematics domains.

# Chapter 4

## Structural equation models

This chapter describes the process, and discusses the results, of the structural equation modelling used to analyse the PSTEM survey. After a brief introduction to the method of structural equation modelling, I elaborate upon the technical aspects of the process, and describe the six resulting models relating students' intentions to persist to school structures, adaptive habitus indicated by a latent variable as discussed in the last chapter, and student background. These six models of persistence are fit to samples that represent greatly disparate settings and structures. Yet, there are common themes across the models; both these common themes and important differences are highlighted here. Finally, I briefly pinpoint directions that I would like to pursue further arising from these models.

A preliminary, over-saturated model for student persistence animated the survey design. In each of the six samples, this model was fit first. Regressions that were both of small magnitude and not statistically significant were then removed where the removal did not alter the relationships of other variables, allowing for better model fit. Chen and Pajares (2009) inspired this trimming of models. Individual schools were included in the model, and retained where they influenced the model fit. School effects are significant in several of the models, particularly schools with a mathematics or science focus, which emphasises the importance of local context, and local school structures to these student outcomes.

These exploratory models suggest that the concept of adaptive habitus has explanatory potential for persistence in STEM fields, and that this is stronger across countries for science than mathematics. The models support Noyes's (2006) contention that transfer to a more stratified educational structure is a key moment in the development of habitus

in mathematics (and also, the models suggest, science). The models further support the recent research of Aschbacher, Li, and Roth (2010) and Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012) suggesting the importance of family STEM resources and disposition (measured here by a simple, new, scale described in the previous chapter) on student persistence and engagement in mathematics.

Admittedly, this is a small-scale study, and weak in terms of its justification to generalise statistical outcomes. While secondary data analysis may have been able to offer generalisation, it would have missed the targeted questions of the survey used here, as well as the contextual understanding of each of the participating schools that adds to the analysis here. In each section, there is an attempt to briefly contextualise these models, and thus take advantage of the eccentricities of the data collection.

## 4.1 Structural equation modelling (SEM)

Proponents of structural equation modelling position it as an overarching framework for complex correlative models that can, even in cross-sectional studies, help demonstrate causality (Pearl, 2009). More importantly here, structural equation modelling (SEM) can be used as a disconfirmatory technique (Kline, 2011, pp. 220, 374). For example, confirmatory factor analysis and structural equation modelling could have suggested that it was not valid to construct a latent variable gathering together adaptive non-cognitive skills, or that such a variable was not related to students' intentions to persist. On the other hand, SEM was attractive because of the combination of path diagrams and latent variables for understanding the interplay of educational structures, affective variables, and student persistence. Both are techniques are used for dealing with complexity, and can improve the calculation of errors when multiple estimations are made simultaneously. Path diagrams are particularly useful when, as is the cue here, variables are conceptualised as having multiple effects, and where some variables, like family capital, are theorised to be working on persistence *through* other variables, such as track placement or participation in extracurricular activities.

Furthermore, many of the psychometric measures used here, such as self-concept, were developed for use in SEM models, albeit more traditional ones. In doing so, I am linking an analytic method (SEM) associated with psychometric research to the critical analytical tools that are being developed by researchers who draw upon Bourdieu's conceptualisations of capital and habitus.

Both perspectives are useful tools in thinking about the effects of school policies on student retention and persistence in education. The models here are first used as a disconfirmatory technique. That is, it was possible for example that the new measures I created would not relate to persistence, or that the latent variable created to represent the adaptive habitus was not statistically valid according to common guidelines. However, the modelling described in this chapter was also in part unabashedly exploratory. I was interested in the possibility of visualising a difference in the interplay of the variables and their relationships with persistence. Patterns and differences between the national settings were interesting, of course, but also between the science-oriented survey and the mathematics-oriented survey. There is a sense in which these models seek to be qualitatively descriptive—a way of visually mapping the differences in the ecologies of educational structures for better understanding. An overview of the key patterns across the models can be seen in Table 4.1.

## **Thinking critically about the choice of SEM**

The benefits of SEM are, among other things, the ability to consider unobserved (latent) variables as part of a path analysis of multiple regression equations that are estimated simultaneously. However, the choice of modelling techniques is not itself value neutral. Statistical modelling is not separate from social structures that encourage researchers to value one technique above another. Thus, their selection deserves a critical reflection. Gigerenzer (1991), for example, discusses the potential of statistical tools to influence, and perhaps limit, the metaphors that scientists use to study the workings of the human mind. That is, sometimes a model of the data is made to fit the statistical tool, rather than the tool made to fit the reality of the data. One must, then, be cautious of how these tools limit the conceptualisation of research problems, and acknowledge that they are themselves situated within social structures, and embedded within particular ideologies (Lawson, 2009, p. 169) that limit their validity.

Latent variables seemed a particularly apt tool for attempting to measure the affective traits associated with adaptive student identities relating to educational structures and persistence, discussed further below. However, the type of SEM models here and SEM in general are not the only valid way of examining this data. At the end of this section, I give suggestions for further directions in which to take this analysis.

I have found the process of SEM to be perilous given the subjectivity of mathematical models. Training for social scientists in SEM provides us with a set of tools and rules

to follow, even tricks for producing better-fitting models. Yet these can muddy the theoretical work as well as the complexity of data. That is, a reductionist approach is often encouraged. For example, while on one hand there are warnings about focusing on indices of model fit (e.g., Kline, 2011), there is also a demand for good model fit from editors. Tricks for improving model fit include having no more or less than three indicators per variable, correlating error terms, and keeping models simple. Notably, this suggests that we leave out as many variables as possible.

While attempting to base the model in theory, I have also been mindful of both significance and effect sizes of variables in deciding whether or not to remove variables, or predicted regression from the model. Since the data set includes many interrelated variables, it is clear that other models would be possible, including far more complex ones, if the sample sizes had been large enough to support those estimations. Indeed, in these analyses, I limited the number of variables included. In acknowledgement of the small sample sizes, I also used summed scales for some variables that could also have been represented as latent variables. The process of creating these summed scales is discussed in the previous chapter.

One of the norms of structural equation models is that latent variables should ideally have three indicators. Often, latent variables are used to measure with more precision a scale that is already reliable, such as self-concept scales that are composed of similar, highly correlated items. My adaptive habitus variables disregard this advice. I see such usage as pedestrian, because if the underlying items are too similar, then the model is really not taking full advantage of the possibilities of latent variable modelling. Rather than using latent variables to measure a reduced, narrowly defined trait, here they are used to reveal a common dimensionality within a network of different affective traits and beliefs. This is a more interesting way of using the power of latent variables, the danger being that it is more difficult to produce acceptable model fits, and that the labelling of what is being captured is more open to debate. However, the latent variables included in these models do pass the normal guidelines for viability. Their interpretation rests on the idea that they show an underlying uni-dimensionality to the adaptive non-cognitive skills used as indicators, and that this uni-dimensionality is indicative of what I call adaptive habitus; that is, a collection of non-cognitive traits that have generally been considered to be adaptive to positive educational and work outcomes.

## 4.2 The preliminary model for persistence

Figure 4.1 illustrates the preliminary model that served as a starting point to the six models presented in this chapter. It is a simplified model of the theoretical mapping of factors influencing student persistence, adapted for what was possible given the possibilities afforded by, and outcomes of, the survey. Included in these models are several new measures. The key novel measures are for adaptive habitus, STEM family capital, extracurricular involvement, gifted identification, and negative transfer. These were hypothesised to be important in understanding the patterns and dissimilarities of student persistence across the different samples. That is, these measures were developed to reveal similarities and differences across the samples.

The main themes of this model are the relationship between structure, family background, and adaptive habitus, and students' aspirations to persist in STEM fields, and how these patterns differ across subject and country. Below is a short overview of these constructs, which are described with greater detail in the previous chapter.

### Key educational structures

In these models, structure is approached by the variables relating to gifted identification, mathematics track, and extracurricular involvement. The model underlying the questionnaire hypothesises that extracurricular involvement and gifted identification will be related to persistence and adaptive habitus.

Noyes (2006) and Jackson, Erikson, Goldthorpe, and Yaish (2007) also pinpoint moments of transition as key points where secondary effects of students' backgrounds come into play. Nora (2004) also relates these effects directly to habitus. Here, transfer is captured by questions that relate to a decrease in interest, or a feeling of being unprepared for upper-secondary (high school, lukio, gymnasium) level studies in mathematics and science in comparison to one's peers, thus signalling that for some students there is a structural break from the lower secondary environment in mathematics and science. This measure is new to this study.

## Family background

Family background is measured by a combined score of the mother and father's education, as well as a new scale relating to STEM capital. This scale was described in the previous chapter, and relates to the importance suggested by Aschbacher, Li, and Roth (2010). The scale also overlaps with the conceptualisation of family STEM habitus, as proposed by Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012).

## Adaptive habitus as a latent variable

As discussed in the previous chapter, habitus is a useful tool for considering the interaction of individuals within societal structures. Statistical models using the framework of habitus can benefit educational policy analyses by providing a tool for a critical reflection on the meaning of psychometric variables, which are increasingly being recognised as important to educational and life-long outcomes (e.g., Heckman, 2008; Borghans, Duckworth, Heckman, and ter Weel, 2008; Duckworth, Peterson, Matthews, and Kelly, 2007), and can capture the conscious and unconscious, embodied aspects of habitus. Adaptive habitus here refers to a disposition that is well-adapted, to borrow the understanding of the term from biology, to the particular environment of mathematics or science education. This includes attributes like self-confidence in as well as diligence and interest toward those subjects, attributes that are also considered positive non-cognitive skills.

These attributes have been linked to persistence in other models, but usually treated separately. Using a latent variable, it can be tested whether they meet the criteria for loading to a single dimension. Then there would be an argument, statistically, for the existence of an underlying factor that in part explains each of the disparate variables. Here, that underlying construct is adaptive habitus. This does not mean that these variables all move completely in concert together. Rather, it means that there is an element, an adaptive habitus if you will, that undergirds these attributes of which they are partial indicators, which partially explains them, and that does, statistically speaking, move in concert in relation to other variables.

It should also be noted that this use of latent variables falls in contrast with models such as those given by Dumais (2002) and Vaisey (2010). Dumais relates to future occupations, and Vaisey to educational aspirations through single questions which are predictive of future choices. In the models here, the main endogenous variable, persistence in STEM fields, is then closer to the variables used by Dumais and Vaisey. Using their framework,

these models might be interestingly considered as models of STEM habitus. However, these unidimensional indicators have also been criticised as discussed in the previous chapter; Reay (2004, p. 439) calls us to acknowledge the ‘aspects of circularity inherent in habitus’, and the fluidity of the concept, which should be ‘...viewed more fluidly as both method and theory; a way of understanding the world’ rather than a fixed object. Certainly, structural equation models are used to deal with multidimensionality and circular causality. Thus such modelling seems a promising way to incorporate these powerful metaphors into quantitative analysis.

Certainly, conscious aspirations are only one part of habitus, as the concept is used here. It is also used as a metaphor for a dynamic, embodied identity developed in relation to school and wider societal structures, an identity that is both consciously and unconsciously performed. Psychometric measures of self-concept and self-efficacy seem obvious candidates for revealing the self-imposed boundaries individual’s place on their aspirations a key aspect in the value of habitus for explaining secondary effects of class, gender, and race. Furthermore, as developed in the previous chapter, the object here is not simply to measure habitus, but to make use of that metaphor to provide another interpretation of these psychometric variables that are becoming so influential to educational policy. Drawing on Bourdieu’s conceptualisation of habitus, these psychometric variables are thus knitted within and to the social environments and structures, rather than being simply individual traits.

This is the idea underlying the models in the chapter. The next section describes the technical background of the modelling process presented in this chapter.

### 4.3 Overview of the modelling process

This section gives an overview of the modelling process. The software I used to run the structural equation models was **lavaan** (Rosseel, 2012) a package for the **R** statistics programming language. Missing data was handled by case-wise maximum likelihood estimation (Rosseel, 2012, p. 30).

#### Normality assumptions

SEM assumes the normality of variables, error distributions and linear relationships between variables. As seen previously, variables that were oriented towards assessing levels

of involvement and identification, such as XSTEM, the measurement of involvement in enrichment and extracurricular activities, were highly positively skewed; that is, most responses were close to zero. These variables, including the outcome variable about students' intentions to persist, were handled with a simple log transformation. Although survey data in the form of Likert-type scales usually violate true assumptions of normality, they are commonly used as indicators in SEM models, often with the assumption that they approximate continuous variables (Hox and Bechger, 1998). Since the approximation of normality tends to increase with the length of the scale, parceling is also one way to achieve more normal indicators. Parceling data is a non-trivial procedure Kline (2011, pp. 196, 363). Accordingly, procedures were undertaken to improve the validity of the parceling here as discussed in the last chapter.

After parceling and transformations, the data was reasonably normal, after examining the skewedness of each variable. While using a weighted least squares (WLS) estimator is considered the best method for non-normal data, it requires very large data sets. Instead, I used the maximum likelihood estimation with robust standard errors and the Satorra-Bentler scaled test statistic (Tomarken and Waller, 2005, p. 41), a conservative measure of validity.

### **The hierarchical nature of the data set**

The data analysed here is highly structured, consisting of students within schools within countries. However, the small number of countries and schools precluded the use of standard hierarchical modelling. Gelman and Hill (2007, p. 247) state that with less than five groups, it is difficult to estimate group level variation. Indeed, hierarchical models that were tested here had unstable estimates at the group level. Another way of handling such structures would be with multiple groups analysis in SEM; however this sort of analysis focuses on mean structures, which were not part of the original research questions. That is, it was of greater interest to my research to understand the relationships between variables, rather than to draw a conclusion about whether self-concept in Finland is higher than in Sweden for example.

I handled country variation by producing a separate model for each country, what Gelman and Hill (2007, p. 270) term a 'no-pooling estimate.' At the school level, I used schools as simple binary indicators (dummy variables), a primitive way of looking at group differences, commonly used for gender and ethnicity. Here, these variables are included in the model if they had a significant effect, changed the relationship of other variables, or

if taking them out resulted in a worse model fit.

### **Model fit indices: CFI, RMSEA, and SRMR**

Methods for establishing a good fitting model within the SEM framework are constantly in development. The appropriateness of fit indices varies according the estimators and sample sized used (Tomarken and Waller, 2005). Tomarken and Waller (2005, p. 54) recommend using more than simple rules of thumb to accept a model, agreeing with Marsh, Hau, and Wen (2004) that finding a best fit involves proper research design as well as subjectivity.

While the **R** statistical computing package **lavaan** offers multiple goodness of fit measures, here three are reported. The first is the Comparative Fit Index (CFI). Typically CFI is above .90 for accepting model, and ideally above .95 (Hox and Bechger, 1998). The second is Root Mean Square Error of Approximation (RMSEA), a more modern measure. Tomarken and Waller (2005) describe RMSEA as being appropriately sensitive to misspecification, but underreported (Tomarken and Waller, 2005, p. 54). This is no longer the case; it seems now to be a standard in reporting models. Typical standards are for the RMSEA to be below .05. Finally the Standardised Root Mean Square Residual (SRMR) is reported. The standard cut off for that measure is .08, although this is criticised by Kline (2011, p. 209) as being too lenient.

Kline (2011, p. 197) also notes that the original rules of thumb proposed by Hu and Bentler were not intended to become absolute rules, and yet there are certain cut-offs that are now presented as standard within research communities, although these points seem to differ according to discipline. A further issue is that model fit indices are measured against a null model, which may not be appropriate, and some measures, such as  $\chi^2$ , are difficult to interpret when robust estimation methods are used, as they are here. In advance, I chose to use three measures I learned to interpret and understand: CFI, SRMR, and RMSEA. While it is possible to explore the data arbitrarily to attain better model fits, the primary concern was to fit a model that made sense and was grounded in the original proposed model. The models and fit indices here robust standard errors and the Yuan-Bentler scaling correction.

## The preliminary model

One aim of the models described in this chapter is simply to see if the variables being used work in the six different contexts, each providing an independent testing ground. This is a methodological issue. Second, the models are used to explore the connections between family background, educational structures, and intentions to persist proposing that some of these interactions will move through the adaptive habitus variable. Confirmation of the general model would imply a model that explains a latent variable representing habitus by school structures (such as extracurricular involvement, gifted and specialist programs, school transitions and track) as well as by family background and gender, and in turn has an effect on student intentions to persist. If such a model were to hold in general, it is then of interest to look at how it differs according to context and school subject domain (science or mathematics).

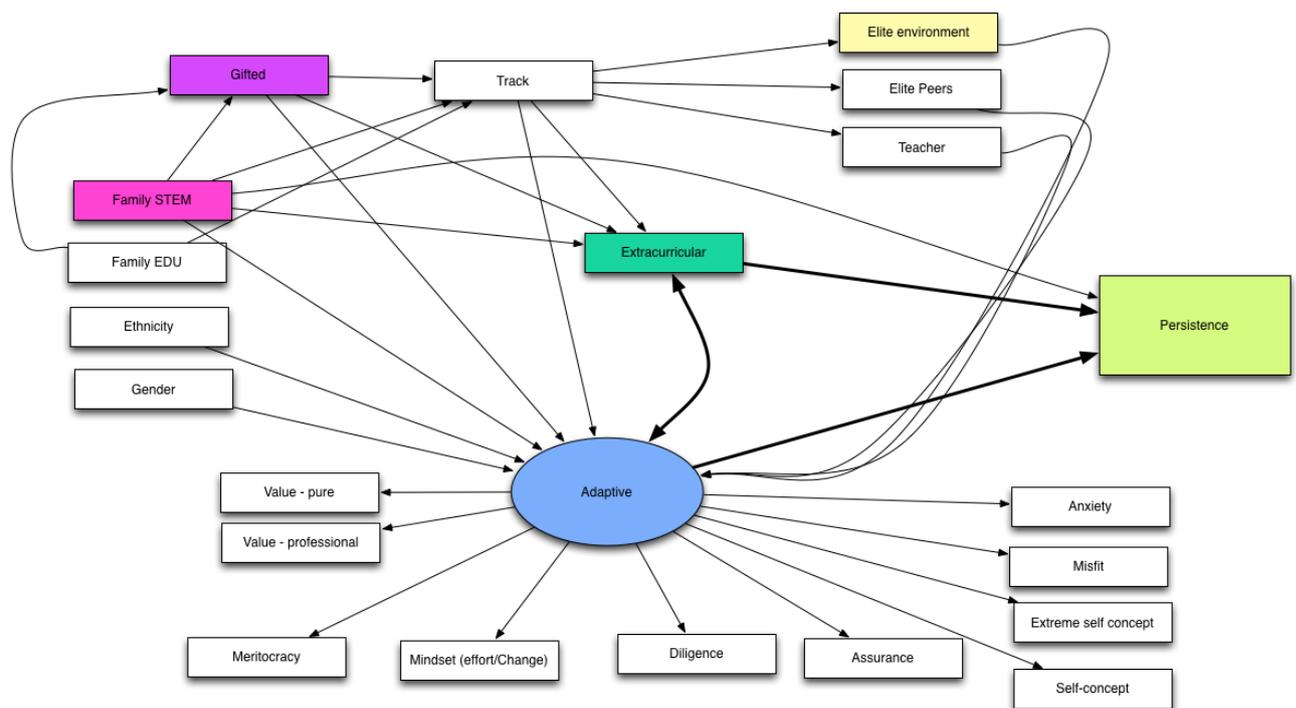


Figure 4.1: The preliminary with proposed paths

This basic model was adapted for six different cases, that is, for each of the six versions of the questionnaire, developed with the consideration that the established research of

variables such as self-efficacy suggests that the domain specificity (see, e.g., Zimmerman, 2000; Bandura, 2006) of the questions is important. Thus, one of hypotheses of this research design is that the affective habitus variable(s) for mathematics, for example, would function differently than the variables for science. In addition to the variables shown here, I also included dummy variables for the schools in each model. This basic model was then fit for each of the six different samples.

### **Confirmatory Factor Analyses**

Prior to running a full SEM model, I conducted a confirmatory factor analysis with two competing hypotheses. The first was that the variables used as indicators would load to a single latent factor. The second hypothetical model for representing adaptive habitus as latent variables resided within two factors. One of these was personal, focusing on the respondent's self-beliefs. The second was external and ontological, reflecting the nature of ability, society, and the value of mathematics, science, and related disciplines.

More specifically, the personal variable includes the following aspects:

- MATH/SCISC (subject self-concept)
- ASSURANCE (subject self-efficacy/agency)
- SCEXTREME (extreme self-concept)
- MISFIT (subject environment exclusion)
- DILIGENCE (subject self-control)
- ANXIETY (subject anxiety)

The external or ontological variable includes these aspects:

- VALUEPURE (value of math or science)
- VALUEPROF (value of engineering or medical science)
- MERITOCRATIC (beliefs about meritocratic societal structure)
- MINDSET (effort/change) (beliefs about the potential of improving ability in math or science)

The other option would include these aspects in a single variable. The two-variable model fit better for the American samples, where meritocratic beliefs were active. However, meritocratic beliefs did not load well in any scenario for Finnish or Swedish models.

While the distribution of beliefs between samples is not dramatic (see Figure 4.2), preliminary regressions suggested that the meritocratic beliefs do not seem to have as strong interaction with adaptive beliefs in the Finnish and Swedish contexts.

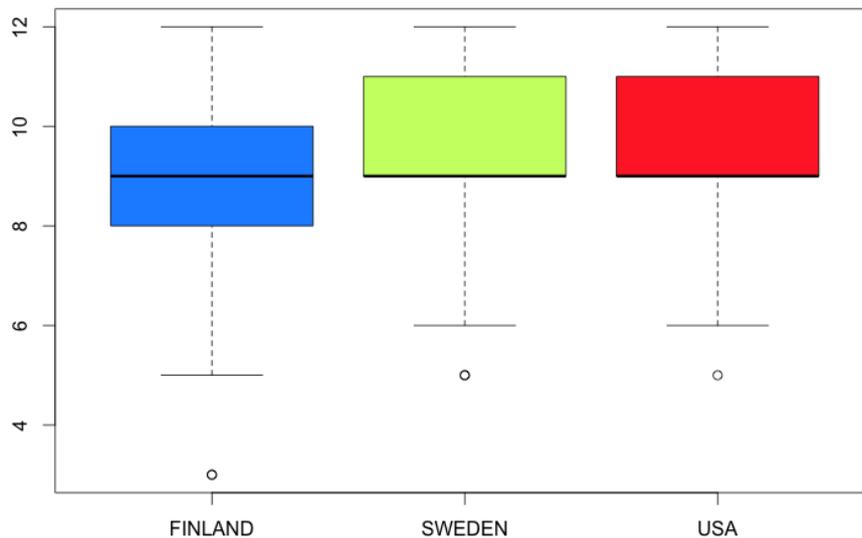


Figure 4.2: Box plots of the distribution on the meritocratic beliefs scale by country, on a scale of 4 to 12, with 12 being highly meritocratic. The items used can be seen in Table 3.6 and in the surveys in Appendix B

Likewise, optimism did not load well with the other beliefs, and was left out of the analysis entirely for the time being. Nevertheless, there are intriguing differences between countries (see Figure 4.3), which deserve further scrutiny.

### Predictions for the model

In addition to predicting that it would be possible to form a latent variable from the disparate affective indicators, and that such a variable would be related to both structural indicators and persistence, the following hypotheses informed the modelling of the data:

1. Affective measures can be grouped into a latent variable or variables representing an adaptive habitus that will impact students' persistence.

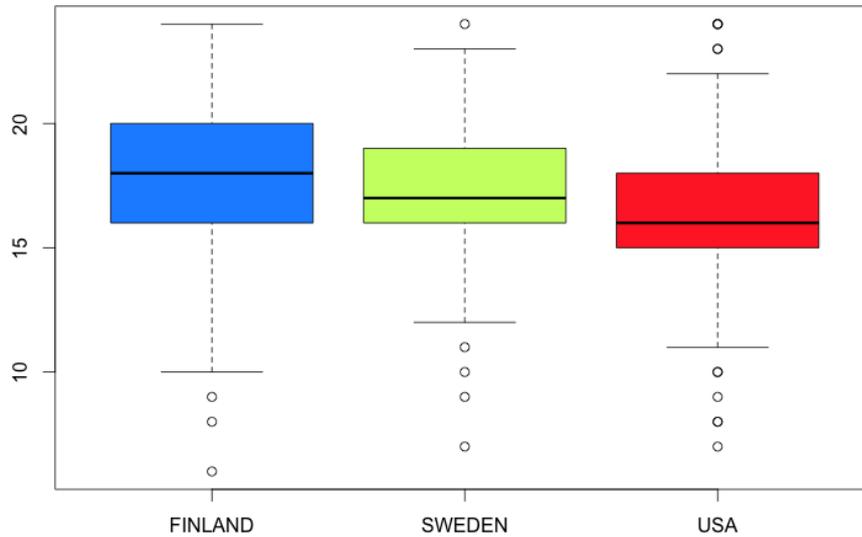


Figure 4.3: Box plots of the distribution on the optimism scale by country, on a scale of 4 to 24, with 24 being highly optimistic. The items used can be seen in surveys in Appendix B.

2. This adaptive habitus will be affected by formal and informal educational structures represented by mathematics track, gifted identification, and extracurricular involvement, as well as school choice
3. Family STEM capital will have a different effect from educational capital on students' persistence in STEM fields.
4. Family capital, as well as gender, and ethnicity will be mediated through structural variables and the adaptive habitus.
5. Finally, gifted education and extracurriculars will have less of an impact in Finland and Sweden, but that the track choice will have a greater relationship with persistence.

In the next section, the final models will be displayed. Detailed tables presenting the regression estimates, confidence intervals, point estimates and R2 for each model can be found in Appendix E.

## 4.4 Models by country and subject

In this section, a model for each sample and a short description of the model is provided. Tables representing these models can be found in Appendix E. Here, the models are given in graphical form, with standardised coefficients. The red lines correspond to negative relationships. Line thickness is reflective of the effect size, or the strength of the correlation. Statistically non-significant, but model-significant estimates are represented by dashed lines. The point of this representation is to aid the visualisation of patterns and differences across the models. The key patterns arising from the model comparison are outlined in Table 4.1. Detailed tables containing the outputs used to make the path diagrams in this chapter can be found as an appendix.

After presenting each model, there will be a discussion of the general themes highlighted by the models, as well as to in what contexts the predicted relationships held, or did not hold, and what the models reveal about general structures, and country specific contrasts. As mentioned above, data collection involved interaction with each participating school, and school context is revealed to be important, something that is particularly emphasised in the interview data that will be discussed in the following chapters. Thus, the school context is briefly mentioned here as well. The opportunity to recognise the factors of school environment that might be contributing to model effects is one positive outcome of the limited nature of the survey data reported here.

Before beginning, it might be helpful to point out some of the themes that arise in these models:

- Across countries, adaptive habitus towards science was more strongly related to students' intentions to persist in STEM fields in general.
- The new Family STEM Capital measure is more active in the models than family education.
- Gender had large effects in Sweden and Finland, but not in the United States.
- Across the models, transition was most the educational structure most closely linked with the reporting of adaptive non-cognitive skills.
- Overall, the models for the domain of science produced more convincing model fits, suggesting that the relationship of mathematics to general STEM persistence is complicated. This is supported by the interview data to be discussed in successive chapters.

An overview of the patterns of paths (correlations) between key variables can be seen in Table 4.1. This table is meant to be used a reference for looking at patterns across each of the different, complex models reported in this chapter. The correlations noted in the model all have a  $p$  value greater than 0.10, and a standardised effect size greater than 0.10, except for the correlation between extracurricular involvement and persistence in the Swedish model for mathematics. There was an effect (0.15) but it is not approaching significance. It was retained because of the small sample size, and because the smaller variation at the specialist schools included implies that the estimate would be conservative. Further studies would be needed to confirm this pattern, as well as the other patterns illustrated in Table 4.1.

Each of the models will be discussed individually in this chapter. Models will be discussed by country (Finland, Sweden and then the United States), first mathematics, and then science. The details of the models can be found in Appendix E.

**Table 4.1: Patterns of relations in the SEM models, by country and subject.**

Variables	FI Science	FI Math	SE Science	SE Math	US Science	US Math
1.Negative Transition and Habitus	No	Yes	Yes	Yes	Yes	Yes
2.Habitus and Persistence	Yes	No	Yes	Yes	Yes	Yes
3.Extracurricular involvement and persistence	Yes	Yes	Yes	Yes*	Yes	Yes
4.Extracurricular involvement and habitus	Yes	No	Yes	No	Yes	No
5.Gifted Identification and Habitus	Yes	Yes	No	Yes	No	Yes
6.Gender and habitus	Yes	Yes	Yes	Yes	Yes	No

Yes indicates a notable effect size,  $p < 0.10$ , exceptions are noted by (\*). No indicates no demonstrated relation.

### 4.4.1 Finland, Mathematics

The Finnish sample for mathematics differs from that of science as it includes a large number of participants from a single, high performing school. That school (FI1B) had a direct and significant relationship (.20,  $p < .01$ ) on persistence. Including variation among schools in extracurricular involvement also greatly improved the model fit. One aspect of this model is that the adaptive habitus variable does not have a significant direct effect on persistence (and even a possible negative relationship with the persistence variable). Otherwise, the model is rather similar to that of science; family STEM capital has more direct relationships, with the students' interaction in the educational structures (through gifted identification, track choice and extracurricular involvement, and a significant (.21,  $p < .01$ ) effect on the adaptive habitus variable.

Being female and having a negative experience in the transition to lukio (upper-secondary) level courses (in this case mathematics) have a strong negative relationship with adaptive habitus. Here, the inclusion of a large sample of students from a high performing school that, according to the staff there, is strong in math and science influences the model. This school, FI1B has a direct relationship with persistence. Choice of that school also is related to family STEM capital. What is surprising here is that the track (long vs. short mathematics), has only a small effect (and is a highly unstable estimate) on persistence and the adaptive habitus when family STEM capital is included in the model. Combined with the lack of importance of the adaptive habitus on persistence, unlike in the science domain, this suggests that mathematics is perhaps both less of a signifier or gatekeeper for future science ambitions in Finland,<sup>1</sup> and thus is less important to future STEM ambitions, particularly in the presence of more closely linked variables.

#### Structure and STEM capital (Finland, Mathematics)

In this model, gifted identification, track, and involvement in extracurricular activities are closely related, and extracurricular activities have a direct relationship with persistence. Gifted identification actually has a negative and non-significant direct relationship with persistence when included in the model.

Family STEM capital, but not family education, has a positive relationship with all of these variables. School choice also matters in the case of school FI1B, a prestigious school

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<sup>1</sup>Perhaps also due in part to the relatively recently relaxed mathematical standards for university entrance via the matriculation exam

strong in mathematics and science. These relationships are actually underestimated as I had to regress the binary variables of track and school on the family STEM capital variable. The results in the mathematics domain sample shows strong relationships between structure and family STEM capital, and in this model they are part of a path that is strongly related to intentions to persist in STEM fields. The relationship between structure and family STEM capital in mathematics is similar to the model for the science domain, discussed next.

### **Model fit (Finland, Mathematics)**

Model fit indices for this model (Finland, mathematics) where CFI 0.891 with RMSEA = 0.048 (0.029, 0.064) and SRMR = 0.060, indicating a good fit. The model is shown in Figure 4.4.

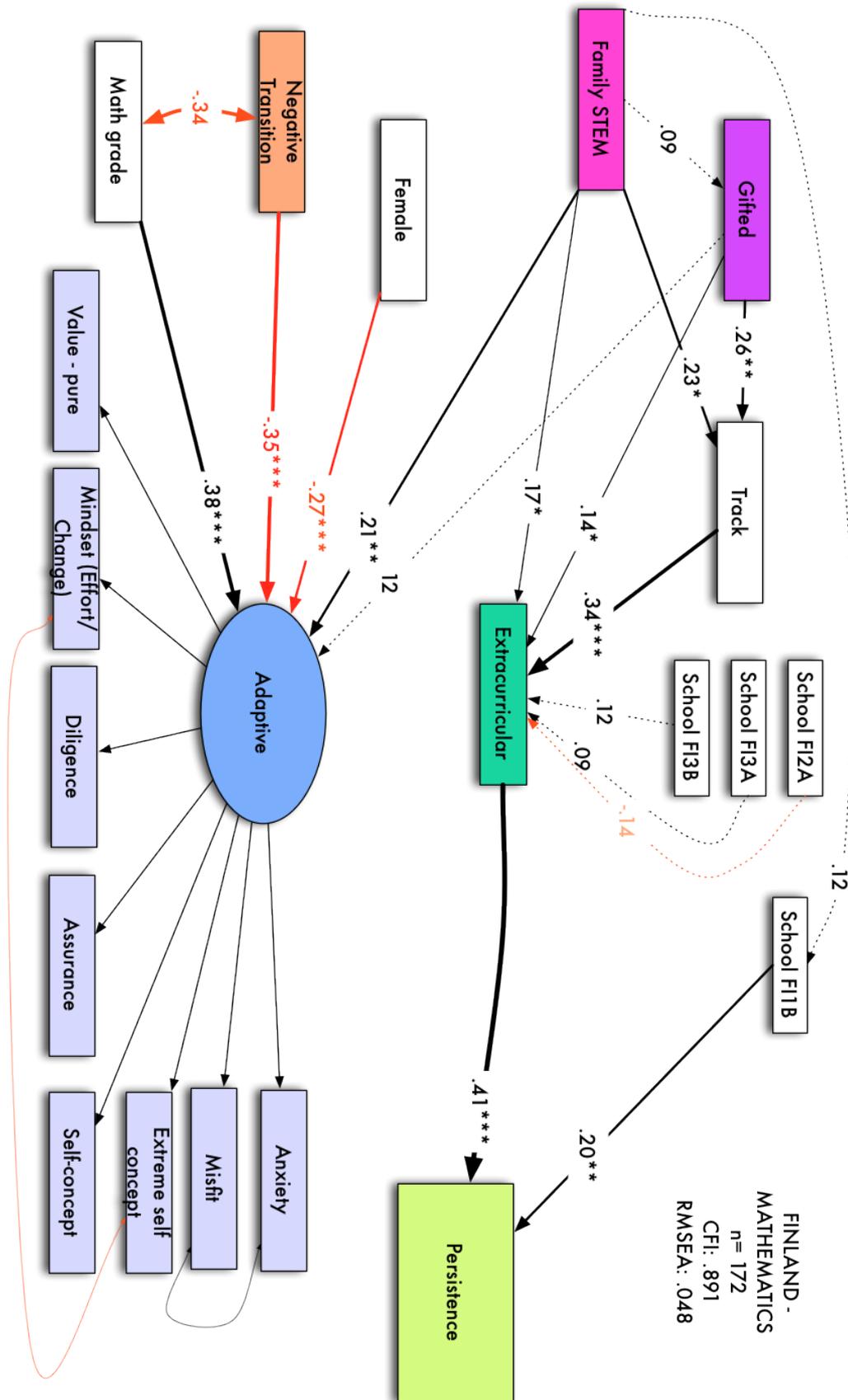


Figure 4.4: Finland, mathematics, with standardised coefficients

#### 4.4.2 Finland, Science

The science domain model for Finland can be seen in Figure 4.5. This sample does not include the FI1B school. Again, for Finland, the meritocratic beliefs measure was excluded from the latent variable due to the confirmatory factor analysis. The resulting Finnish adaptive habitus variable has a strong relationship both to persistence (.29,  $p < .05$ ) and extracurricular involvement (.36,  $p < 0.001$ ). However, in this model, the relationship of extracurricular involvement and intentions to persist becomes insignificant if a direct effect of family STEM capital is added.

In this model, the transition variable was specific to science. In contrast with the mathematics transition measure, it did not have a significant effect on the adaptive habitus, or on the persistence variable. This suggests that transition in science is not a key point of selection within the Finnish school system, perhaps reflecting relatively equal provision of science education during compulsory school.

There are several surprises in this model. First, the largest effect is a negative effect of being female on the adaptive habitus variable. There is also a surprisingly strong connection between gifted identification, mathematics track, and extracurricular involvement. While effort was made to make variables that captured these structures in the Finnish context, it was still surprising to see the strength of the connections in a system where gifted identification, in its most literal sense, does not formally exist. It was supposed that these connections would be weaker in the Finnish system, which is generally considered more flat.

#### Structure and STEM capital (Finland, Science)

When compared with educational capital, STEM capital has stronger relationships with gifted identification, track choice, and a larger (but not statistically significant) effect on adaptive habitus throughout the model. Family education did have significant relationships with the adaptive habitus variable, and a similar sized, but not significant, relationship with extracurricular involvement. Combined with the strong effects of family STEM capital, this suggests that family capital is at play in the Finnish educational system in similar ways to that in the school structures in the United States, see below, and England even though the structures appear very different.

The mathematics track does not have a significant effect here on intentions to persist, but relates closely to students' involvement in STEM extracurricular activities. This also

comes as a surprise.

### **Model fit (Finland, Science)**

The CFI for this model is 0.952, with RMSEA = 0.041, with 90 percent confidence interval (0.000, 0.074) and SRMR of 0.072, indicating a good fit. The model can be seen in Figure 4.5

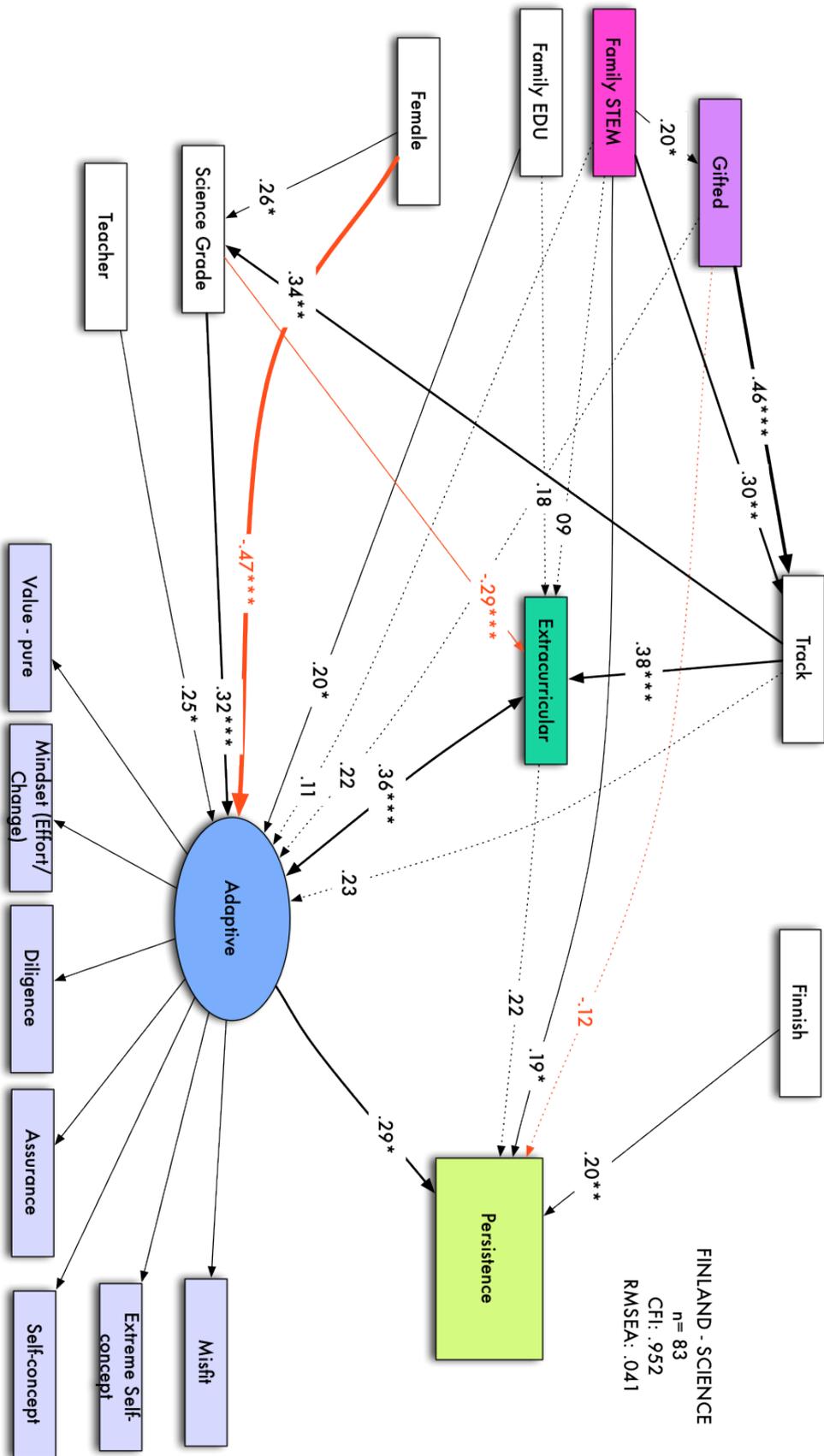


Figure 4.5: Finland, science, with standardised coefficients

### 4.4.3 Sweden, Mathematics

The model for the mathematics domain in the Swedish sample can be seen in Figure 4.6. The Swedish samples are much smaller, coming from only two schools, one of which has a science focus, and the other a vocationally oriented technology focus. The first is situated in a wealthy area of the municipality, but draws on students from all over the region. The second situation is a less-advantaged area. Both STEM capital and educational capital are positively related to the more selective school, SW2A, an award winning school within its metropolitan area, as well as located on one of the region's most affluent areas. This context, as well as the small sample size, is important to keep in mind, particularly in this, the worst fitting model of the six.

As with the Finnish models, meritocracy did not load well during the confirmatory factor analysis, and was left out. Here there is a respectable and significant relationship ( $.35, p < .05$ ) between the adaptive habitus variable for mathematics and persistence, suggesting that mathematics as a signifier of ability has stronger currency in Sweden than in Finland, but perhaps more that there is more hidden differentiation in Sweden than in Finland. Analysis of the interviews, discussed in further chapters, suggests that this hidden differentiation can increase the negative impact of encountering accelerated peers at the transition to the more stratified upper-secondary school in mathematics in particular, thus increasing the saliency of mathematics habitus in students' estimations of their future possibilities. Similar to other models, there is a strong relationship with negative transition ( $-.37, p < .001$ ) and being female ( $-.19, p < .01$ ). There is also a negative relationship (although not statistically significant) between the adaptive habitus variable and extracurricular involvement.

#### **Structure and STEM capital (Sweden, mathematics)**

In this sample, the school is the primary differentiator. One of the schools is more selective than the other, and had a higher average STEM capital and education level among parents. However, the school was not a significant correlate with persistence. While the math track did not have a statistically significant correlation with persistence, the effect size suggests that if the trend were to continue with a larger sample that it would have a direct connection to students' intentions.

Similar to other models, family STEM capital is active, although the effect sizes are not large and mostly not statistically significant. In contrast to Finnish and American

models, in this sample of specialist schools, track (measured here by mathematics course, since everyone participating had a science concentration).<sup>1</sup> However, here, students' perception of their environment was important, having a significant relationship with the adaptive habitus variable. The relationship between gifted identification and extracurricular involvement is also strong. The connection would be surprising without the context of the interview data, which reveals the prevalence of gifted-like programmes, particularly for more privileged young people.

Again, in the novel Swedish context, STEM capital is a useful construct, partly mediated through school choice. Extracurricular involvement is closely linked to gifted identification, but not to persistence, in contrast with other samples. Also, unlike in the Finnish case, in this Swedish sample, the mathematics domain adaptive habitus is strongly related to persistence.

### **Model fit indices (Sweden, mathematics)**

For this model, the fit indices are not great, which is not surprising given the sample size. A simpler model would likely need to be fit in order to get better numbers. CFI is 0.877, RMSEA is .072 (0.039, 0.099), and SRMR is .083, which its approaching a good fit. The model can be seen in Figure 4.6.

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<sup>1</sup>I had originally planned on comparing science and non-science tracks, but ultimately coded students according to their mathematics course, as they were coded in Finland and the United States

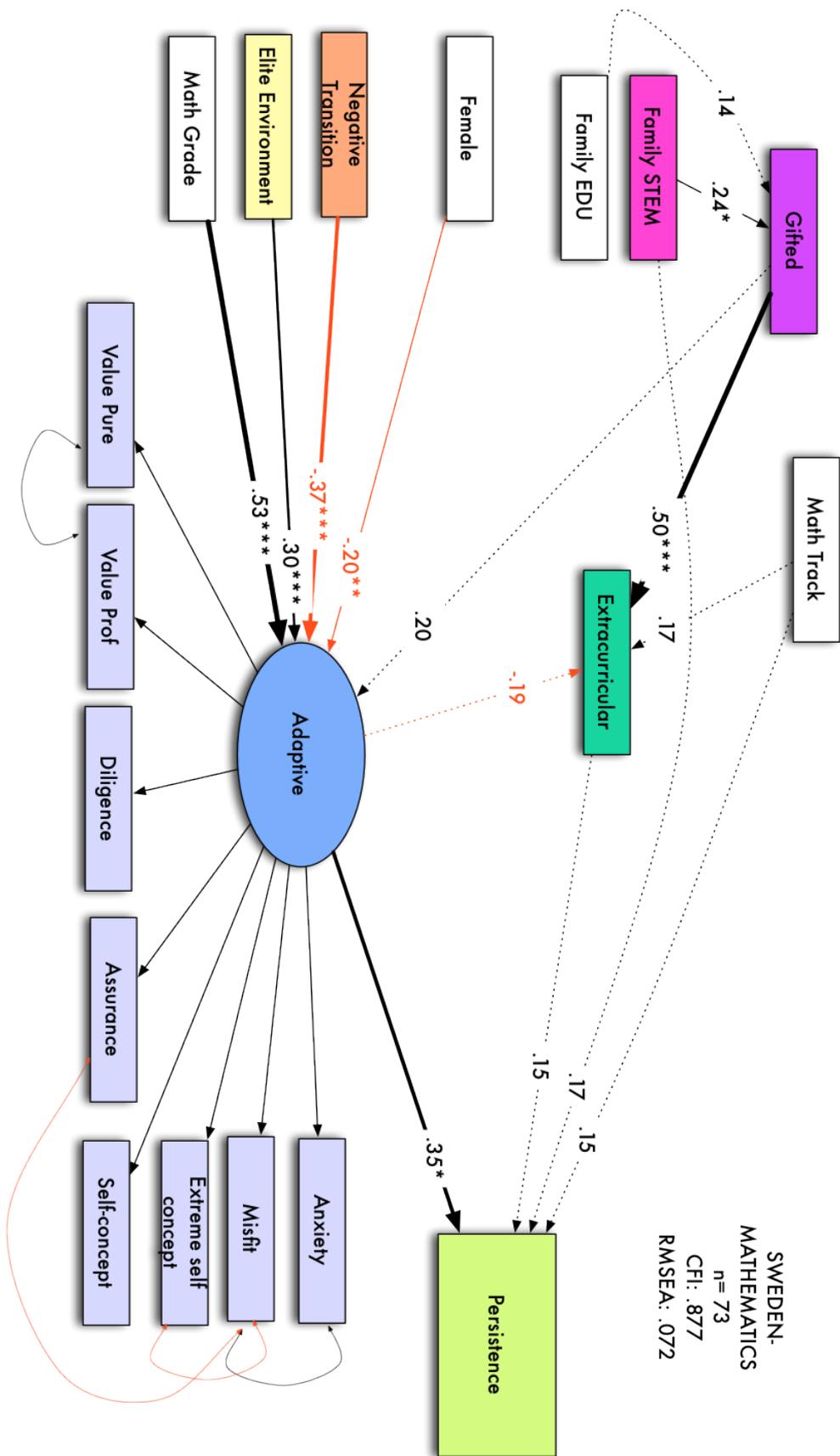


Figure 4.6: Sweden, mathematics, with standardised coefficients

#### 4.4.4 Sweden, Science

In contrast to the ill-fitting model for mathematics, the model for the Swedish science domain is eerily well fitting. Indeed, across all three national contexts, the model for science fits better than the model for mathematics, suggesting that students' general disposition towards pursuing STEM is fuelled on average by interest in science more so than school mathematics. The model can be seen in Figure 4.7

The factor analysis did not support the inclusion of value or diligence variables as indicators for adaptive habitus. However, as these are of particular interest, they were retained in the model as separate exogenous variables. As it turns out, these variables are independently related and significant (diligence in science: 0.28,  $p < .05$  and value for science, 0.29,  $p < .001$ ). They are also strongly related to the adaptive habitus variable. With a larger sample, it would have been possible to model these within the latent variable of adaptive habitus. However, here, the adaptive habitus in science, diligence, and value for science are all positively related to persistence, suggesting again that they can be considered, in this sample, to move in concert to a significant degree.

#### Structure and STEM capital (Sweden, Science)

As in the other models, STEM capital has more positive relationships with other important variables. However, given the extremely small sample, these are not estimated to be significant. In contrast, the educational background variable has an extremely strong relationship with gifted identification, which in this model is less related to extracurricular involvement. The basic connection between family background, gifted identification and extracurricular involvement is similar in both models, but the magnitudes of the relationships are completely different. Furthermore, in this science model, the science domain adaptive habitus variable is significantly, and positively associated with extracurricular involvement.

Again, in this context of STEM oriented programs, track was not important, as there was little variation in it. However, transition to gymnasium-level science is important in the model, as it is in all models here. A unique feature of this model is that the student perception of their science course environment as elite also had a significant connection with the adaptive habitus variable. There are several possible explanations for this; the students' positive perceptions were related to their habitus, for example, but another possibility is that there is differentiation in science courses at play that is captured by

this variable. In contrast, the mathematics track did not have a significant correlation with the main variables in this model.

### **Model fit indices (Sweden, science)**

Using the robust estimates, this model had a CFI of 0.971, RMSEA = .040 (0.000, 0.089) and SRMR of 0.074, all of which indicate good fit. However,  $\chi^2$  was not significant due to the small sample size. Regardless, these are shockingly good numbers implying despite the small sample size, and provides support for the idea that science adaptive habitus is more predictive of intentions to persist than mathematics adaptive habitus.

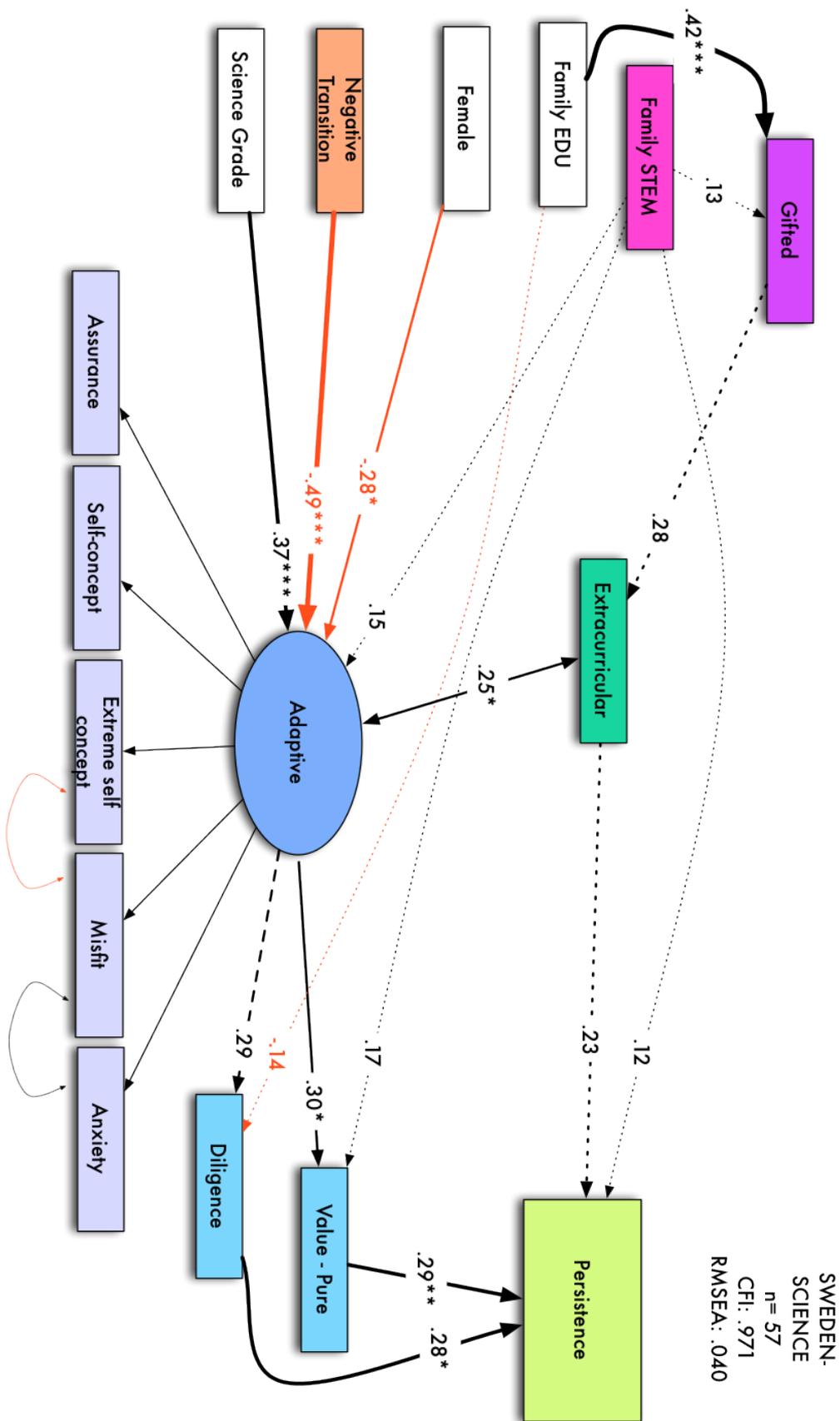


Figure 4.7: Sweden, science, with standardised coefficients

#### 4.4.5 United States, Mathematics

Separating the adaptive habitus variable into two latent variables (Ontological and Personal) produced a better fit for the United States model. Contrary to the hypothesised relationships, in the mathematics domain model for the United States, there is no connection between extra-curricular activity, or gender, and mathematics adaptive habitus. The model can be seen in Figure 4.8

Surprisingly, when both Ontological and Personal latent variables are in the model there is no direct effect from the Personal variable on students' intentions to persist. However, the Ontological variable had a strong relationship (.52,  $p < .001$ ) with the Persistence variable. Again, this coincides with the overall pattern more than the mathematics habitus, which focuses primarily on personal attributes and is less related to general intentions to persist in STEM fields when compared with the science domain.

Gifted identification had a negative direct relationship with Persistence, but a positive relationship with the Personal mathematics variable, and participation in extracurricular activities, which is unsurprising. Extracurricular STEM activities had a strong positive relationship (.39,  $p < .001$ ) with persistence.

The education level of parents did not have a significant effect on the model. In contrast, the measurement for parents' STEM capital had significant direct relationships with gifted identification, the schools students' attended and extracurricular involvement. Perhaps most surprisingly, there was not a significant gender effect in the model. This can be perhaps explained in part by the nature of the sample. In this sample, attending a particular school that specialised in science and health science (US3A), had a positive relationship with extracurricular involvement and the ontological part of the adaptive habitus, both of which related strongly with persistence. In this sample, young women in the United States (but not Finland or Sweden) had a stronger preference for health sciences than young men. However, it might also be the case that gender effects are a larger issue in Finland and Sweden, perhaps because of the older age of the sample. It is important to note that contrary to popular conception, Nordic countries tend to have higher rates of labour market segregation according to gender, and of these, Finland is the most gender-segregated country (European Commission, 2009).

In this model, the ontological aspect of the adaptive habitus dominated the relationship with student persistence. That is, positive beliefs about the value of mathematics and engineering, the meritocratic nature of the country in general, and the belief in the potential to change one's ability in mathematics were strongly associated with enthusiasm

for persisting in STEM fields. In contrast, students' self-ratings in the domain of mathematics were not directly related to persistence. This may suggest that students' choices to persist at these schools occurred despite their lower self-ratings in mathematics. As such, it might be considered as a reflection of success in schools that were focused on less-advantaged and more average performing students. It also suggests that some students, who have perhaps not had access to supportive enrichment or acceleration, may also value STEM fields and desire to continue in them, despite having modest self-evaluations of their own potential.

### **Structure and STEM capital (United States, Mathematics)**

Here, gifted identification was most closely linked with parents' STEM capital, and the personal component of the adaptive habitus. It was also linked with mathematics track placement and extracurricular involvement. As in all the models here, a negative transition to high school mathematics (importantly, phrased as a loss of interest, rather than simply not liking it), had an important negative relationship with the personal adaptive habitus variable ( $-.34, p < .01$ ).

Context, of course, is also important for further interpretation of this survey. The schools in this sample are not affluent. However, in this context STEM family capital is also important. Family capital is most strongly mobilised through pre-high school gifted involvement, school choice, and extracurricular activities, rather than by mathematics track.

Extracurricular involvement and the adaptive habitus are both seen to have significant effects on the persistence variable. Again, STEM capital is a more pervasive indicator than parents' education. Negative transition is also important, having a strong negative relationship to the adaptive mathematics habitus.

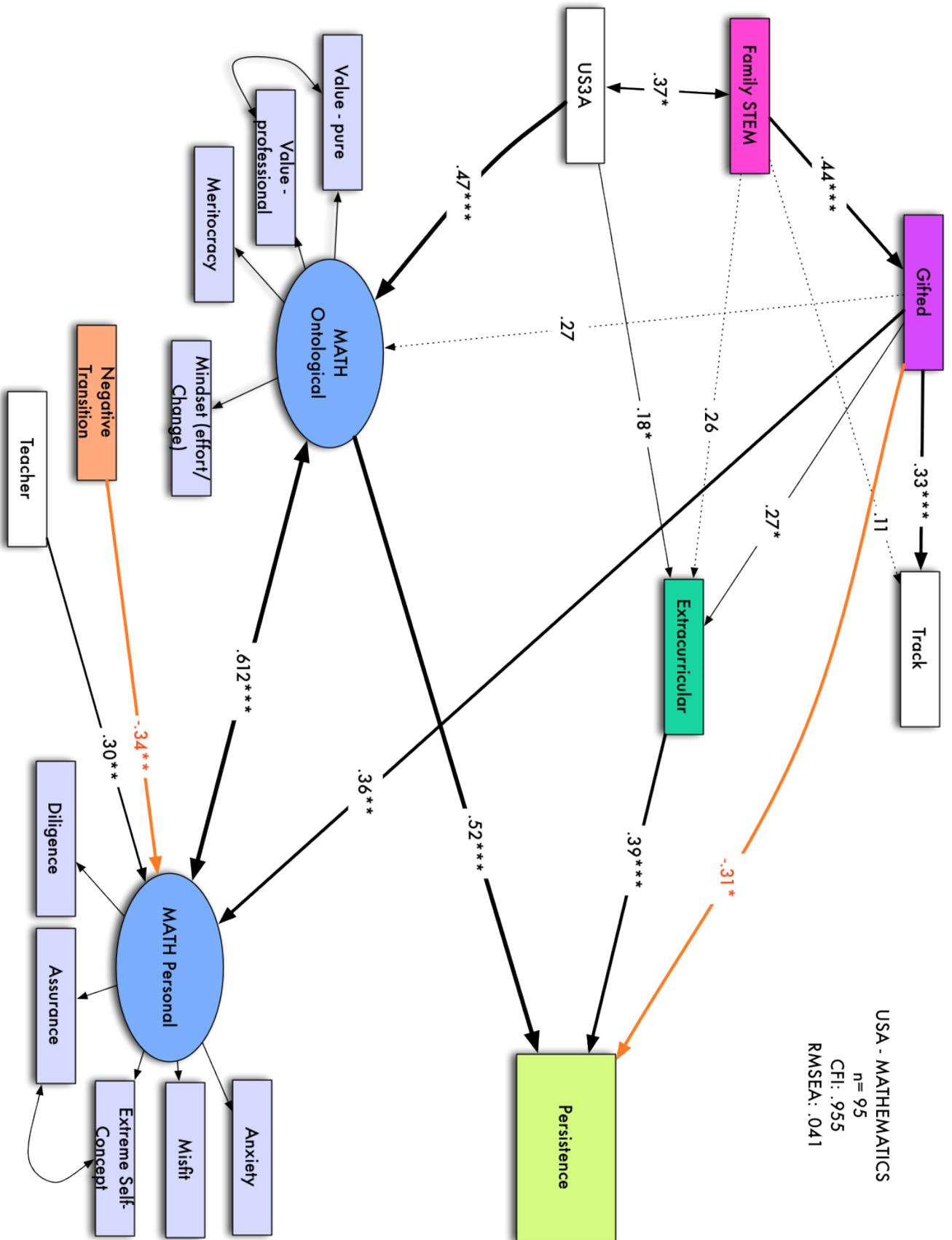


Figure 4.8: United States, mathematics, with standardised coefficients.

### Model fit indices (United States, Mathematics)

For this model, CFI is 0.955 and RMSEA of 0.041 (90 percent confidence interval: 0.000, 0.068), whereas SRMR is 0.088. The CFI and RMSEA indicate a good model fit. The SRMR suggest there are unexplained correlations, which, looking at the modification indices is probably due to not being able to handle the binary regressions in this model at this time, due to software constraints. The connections that this implied, between track, gifted identification, school and family capital are visible in the model as it stands. Since the other fit indices are very good, this model was accepted.

#### 4.4.6 United States, Science

The science domain model for the United States sample can be seen in Figure 4.9. As with the model for mathematics, splitting the adaptive habitus variable into two gives a better fit with the science domain questionnaire data, and a better description of the effects of habitus in the model. Within this model, however, the personal variable of adaptive habitus had a significant (although much smaller) relationship with persistence, and membership at the specialist school (US3A) had a direct positive relationship with persistence.

Again, family STEM capital was more predictive than family educational capital, with the effects occurring again through school choice and gifted identification. Here, negative transition in science has a large affect on both the ontological and personal aspects of the adaptive habitus. This is surprising, as it would have been supposed that the negative effect would be more strongly connected with personal attributes than general ones.

Also notable is the large effect (.48,  $p < .001$ ) of gifted identification on reported extracurricular involvement. This suggests that access to extracurriculars is mediated by access to gifted programs. That is, the extracurricular activity takes place within the auspices of a gifted program, or that the mechanisms by which students access such programs is similar, a result that is not surprising.

It is surprising, however, that in this model there is little connection between the extracurricular involvement and the adaptive habitus variable. They seem to have common sources of development, but no direct relationship, which is contrary to my hypothesis. However, this does resonate with the interview data where participation in some activities (robotics, field work) was described as students as important to the development of their interest in STEM, whereas other activities, notably mathematics competitions,

were not. This idea, though, would also hold true in Sweden and Finland where there is a connection to persistence. What I surmise is that the lack of effect is due in part to higher rates of access to enrichment, and more varied, and perhaps less effective, forms of enrichment available in the United States, but this supposition would require further investigation. Modelling the variables with a single adaptive habitus variable, however, produce a modest but significant effect. This does not fit the overall data, however.

In total, this model explains less of the persistence variable than the previous model for mathematics; the effect sizes are smaller. The relationship of the adaptive habitus variables is also markedly different from that of the mathematics model, affirming the idea that these beliefs are functioning differently for mathematics and science.

The sample here is different as well; it draws more heavily upon a school that has mixed ability science courses. Students from that school are also, on average, younger and less enthusiastic about science than the other schools, which also had science focused programs. Thus, the school context is important to the interpretation.

### **Structure and STEM capital (United States, Science)**

There are several main themes of this model. First, family STEM capital is more important than family education capital and particularly related to pre-high school gifted identification, which in turn was strongly related to extracurricular involvement. Second, the adaptive habitus and extracurricular involvement have a significant and direct relationship with persistence. Finally, the negative transition to high school mathematics has a negative impact throughout the model.

### **Model fit (United States, Science)**

For this model, the CFI is 0.920, RMSEA .045 (90 percent confidence interval: (0.029, 0.060) and the SRMR  $\hat{=}$  0.61, indicating good fit. The model is shown in Figure 4.9. A very good fit can also be produced for this model, by creating a latent variable of latent variables, where Personal and Ontological are complemented by a science self-concept, so the structure or division of these variables is ambiguous.

Such a model, however would emphasise self-concept as an element of the adaptive habitus, which is not something I am prepared to argue for at this point. This does reveal how knowing about the tricks of a given statistical method (in this case, that three indicators

per latent variable are ideal from the standpoint of calculations) can influence modelling as well as theory development, albeit not necessarily in a positive (useful) way.

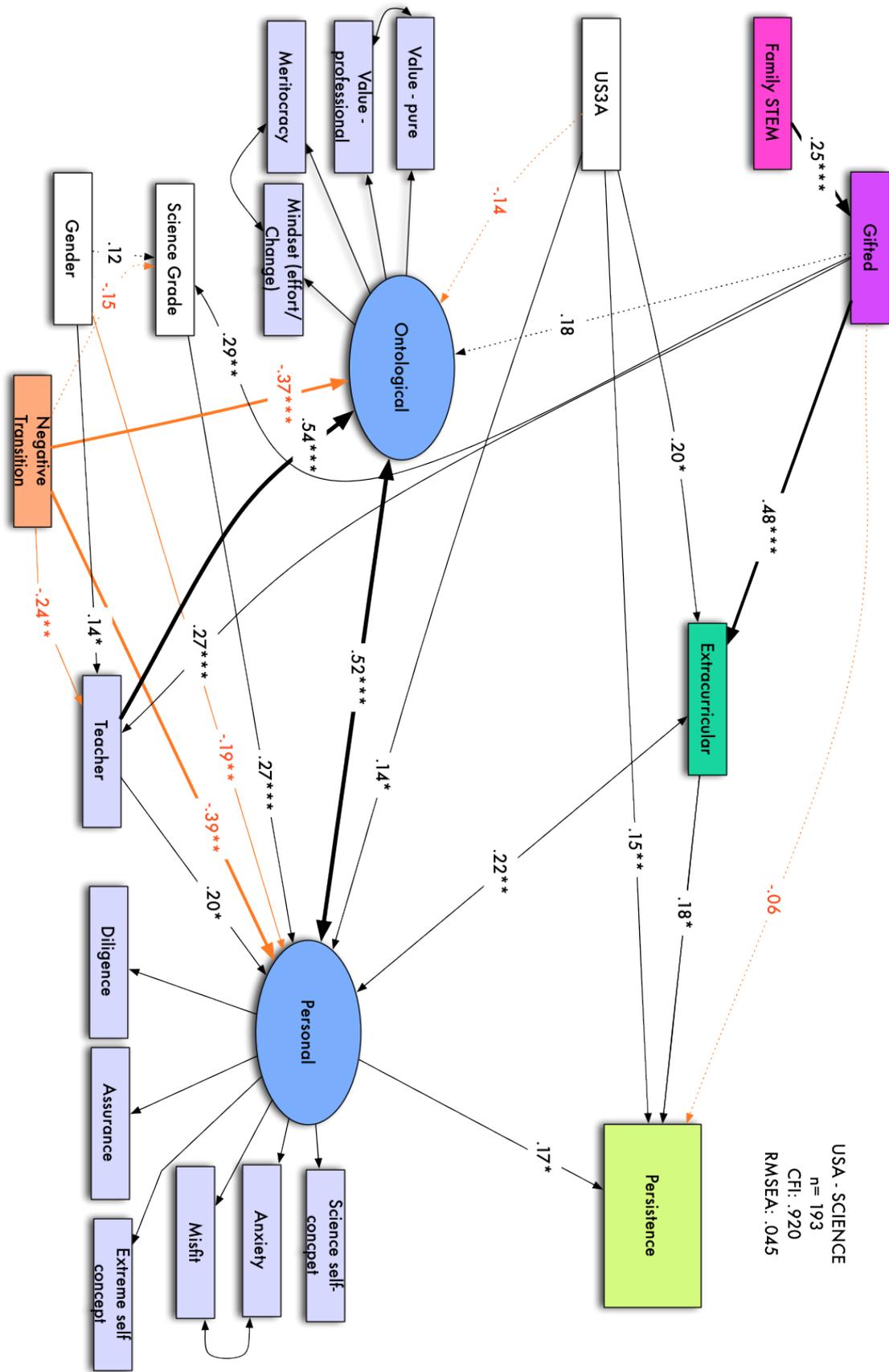


Figure 4.9: United States, science, with standardised coefficients

## 4.5 Reflecting on the predicted model

In this section, I revisit five predictions for the model using the analysis provided above in Section 4.3.

### Predictions for the model revisited

1. *Affective measures can be grouped in to a latent variable or variables representing an adaptive habitus that will impact students' persistence..*

That such a variable can be formed was affirmed for each of the six contexts, but the shape it took was particular to each country. While part of this might be due to the variability of sample size, the process revealed that meritocratic beliefs were interwoven, that is, they are statistically significantly related to adaptive affective variables in both the United States sample, but had little relationship with the Finnish and Swedish samples. This suggests an important difference in the centrality of such an attribute in the United States contexts.

Five of the six models supported a significant, positive relationship between the adaptive habitus and aspirations to persist in STEM fields. It was not significant in the case of Finland for mathematics. Similarly, for Sweden, the science adaptive habitus had a stronger relationship than the mathematics habitus. However, it was the opposite case in the United States. There, the personal adaptive habitus variable had the strongest relation to persistence, coinciding with the relative prominence of mathematics as a 'weeder' and sorter for further STEM studies in the United States relative to Finland and Sweden. That mathematics is simply less of an indicator of ability to proceed in STEM fields, a hypothesis that is supported by the interviews, deserves further exploration in relation to persistence.

Overall, the models confirm that the adaptive latent variable is related to persistence in STEM fields. The models also suggest that the science domain might be more important than the mathematics domain, and that students' might be choosing to pursue STEM careers despite not enjoying or feeling successful in mathematics. This is something to reflect upon when considering educational policies that use mathematics in gatekeeping functions, or inflexibly link various mathematics and science subjects together, which also arises in the analysis of the interviews.

2. *The adaptive habitus will be affected by formal and informal educational structures*

*represented by mathematics track, gifted identification, and extracurricular involvement, as well as school choice.*

In all of the models for the science domain, the adaptive habitus was positively related to extracurricular involvement. This relationship will be discussed further in the interview analysis. However, for some students, the interview data suggests that involvement serves to spark interest, or to magnify interest and grow commitment to STEM fields.

In every model, experiencing a negative transition, defined as a decrease in interest, being unprepared especially in relation to peers had a notable negative relationship with adaptive habitus. This negative connection tended to be stronger across countries than the positive connections to gifted identification and extracurricular involvement. Surprisingly, it was much more important than mathematics track. The main structural relationships are through extracurricular involvement and school transition.

3. *Family STEM capital will have a different effect from educational capital on students' persistence in STEM fields.*

In every model, STEM capital (measured for parents or guardians) had more relationships with the main variables in the model. In the United States, perhaps because the sample was less affluent, including this variable completely washed out effects of parents' education. STEM capital had a uniformly positive effect on students' intention to persist, as well on extracurricular involvement. In Finland, for the smaller science sample, parents' education was also significant and positively associated with those variables, but STEM capital was more predictive of track choice and had a direct effect on persistence.

In the (small) Swedish samples, STEM capital did not reach significance in most relationships, but was positively related to adaptive habitus variables and persistence. In both models, parents' education, however, had a positive relationship with gifted identification, a relationship that was quite strong in the smaller mathematics sample. This suggests that gifted identification in the Swedish context is likely explained at least as much by other family background variables. The models suggest that STEM capital is more important in extracurricular involvement, persistence and adaptive habitus across three very different contexts, and that it is more predictive than parent's education on student aspirations.

4. *Family capital, gender, and ethnicity will be mediated through structural variables*

*and the adaptive habitus.*

In each of the models, family background was connected with gifted identification, track choice, school choice and extracurricular involvement. Direct effects on adaptive habitus vary. The model for the United States in mathematics suggests strongly that STEM capital had a strong indirect effect through students accessing gifted and enrichment programs, as well as school choice.

Gender, was negatively related to adaptive habitus variables, and associated with negative transition. However, this effect is not present in all models. Surprisingly, the negative relationship between being female and adaptive habitus was present in every Finnish and Swedish model, and stronger than the effects in the United States models, where it was not significant in the mathematics model. As mentioned above, this might be due to the different national contexts, but also relate to the particular schools involved, where there was an emphasis on health science in the United States, and where young women in the sample had a preference for health related subjects in comparison with the young men in the sample. The models did not support the idea that there were differences in ethnicity mediated through these variables, although the particulars of the samples mean make it impossible to generalise on this point.

5. *Gifted and extracurricular education will have less of an impact in Finland and Sweden than in the United States, but track choice will have a greater relationship with persistence.*

These last predictions did not hold. Track choice was of little importance directly on persistence, in any model, surprisingly. Also surprising, in Finland, the mathematics track had a strong relationship with extracurricular involvement in both samples. The importance of extracurricular involvement varies greatly from sample to sample within country, however the models in no way suggest it is less related to persistence in Finland than the United States. It does seem to be in Swedish sample. However, the sample represents two specialist schools, which are ultimately very particular contexts. Perhaps most surprisingly, the variable representing gifted identification was active and significant in each model. While some effort when into conceptualising a variable that would capture gifted identification as it is embodied in each of the educational structures, it was still expected to be less prevalent in Sweden and Finland. However, the variable had similar connections (particularly to track and extracurricular activities, as well as parents' background) in each setting. As with the composite variable for extracurricular involvement, this new measure

deserves further exploration.

Across the models, gifted identification was more closely linked with the adaptive habitus variables, suggesting that in Sweden and United States, early mathematics performance plays a bigger role in developing students' identities. For Finland, gifted identification had a relationship with habitus for both mathematics and science, albeit a weak one.

## 4.6 Main themes

In addition to reflecting on the predicted relationships, there are four main themes arising from the comparison of the six models:

**The newly conceived adaptive habitus latent variable formed part of interpretable and viable models that were significantly related to student persistence.**

These models show that disparate beliefs and ways of being that one might predict to be caused by mathematics and science habitus do indeed form reasonable latent variables that have significant effects in modelling student persistence. Alternately, from the perspective of Dumais and Vaisey's conceptualisation of habitus as aspiration, these models also show how aspirations in STEM fields are related to these effective variables and educational structures, as well as family STEM capital, and possibly formed through extracurricular involvement. In three models, this variable was significantly related to a teacher variable describing positive teaching practices, supporting a contention based on Zevenbergen (2005) that a mathematics habitus develops in part in relation to the environment and interactions between the student and mathematics teacher.

**Transition to upper-secondary emerged as a key point in the development of habitus across all models.**

One durable effect that is evident across all models is the effect of a negative transition on the adaptive habitus variable. This strongly supports the characterisation of Noyes (2006, p. 59) that transition 'acts like a prism, diffracting the social and academic trajectories of the children as they pass across it.' This seems to be the case also in

systems such as Finland and Sweden, which seem less stratified from the outside. The effect is vitally important here, and is directed onto the mathematics (and according to these models science) habitus in each of the very different settings. This reflects Noyes' discussion of the British educational system, and strongly suggests the need for further investigation.

The importance of gender in the transition in Finland and Sweden reflects Noyes's (2006, p. 60) suggestion that '[r]esearchers and policymakers need to bear in mind the highly complex nature of school transfer points, and how much school transfer is affected by social factors that cannot be seen in schools.' Despite equitable gender achievement in compulsory schooling, the transition to upper-secondary has a negative impact on young women in these countries. These models show there is a loss of interest and confidence at the point of transition both in science and mathematics, a loss that could be modelled as having a direct effect on student persistence. The models also pinpoint a key structural moment where policy might better support students in becoming empowered and engaged learners and users of mathematics and science. In Finland and Sweden, this may be a key point where young women scale back their ambitions in these areas.

### **Family STEM capital was a more salient predictor of STEM related variables than family education.**

In recent science education research, the importance of family background has been called to the fore. Aschbacher, Li, and Roth (2010) in the United States find that family expectations and support for extracurricular involvement are key to student engagement in STEM fields. Researching younger children in England, Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012) define a STEM family habitus, which includes both dispositions and resources, and seems to foster positive dispositions towards science in the children interviewed.

In this study, Family STEM capital was a simple measure, encompassing both resources and dispositions (having worked or studied in a STEM field, encouraging or being interested in STEM ), and thus indicated also what Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012) refer to as habitus and Aschbacher, Li, and Roth (2010) as expectations and identity. This simple variable was pervasive and positively correlated with key variables and directly with intentions to persist, as predicted by Archer et al. and Aschbacher et al., in this case in three different national contexts, as well as different school contexts.

**Extracurricular involvement was closely linked with student persistence, and in turn was influenced by students' backgrounds and placement within the school structures.**

In these models, extracurricular involvement is mediated by track and school, as well as by family background. It is closely associated with gifted identification. Extracurricular involvement as it relates to student persistence will be explored further in the following chapters. Analysis of interviews show how for some students, schools offering greater access to extracurricular activities and exposure to information about science careers are more than 'holding pens' for students' ambitions; they also serve to amplify and direct ambition during a period in which many students are otherwise losing interest and confidence in math and science. The interviews also show how extracurricular activities not related to school or family can impact students' intentions to persist in STEM fields. These themes will be further discussed in light of the interview and policy analysis in throughout the following chapters.

## **4.7 Directions for further analysis and study**

These models suggest several interesting points for further investigation and analysis. In this last section, some of these will be discussed. First, the models highlight the importance of the interaction of gender and structure, which was not a main focus of this research, but arose as significant in the models nonetheless. Second, transition emerged as a key variable and needs further exploration considering the contrasts between settings. Third, several new measures were created that were salient to STEM persistence and may be worthy of further development. Lastly, this research suggests new directions for modelling habitus, and interweaving the use of that metaphor with the understanding of non-cognitive skills in practical education policy research.

**Gender presented a puzzling pattern that needs further clarification.**

Gender presents one of the more curious patterns across the six models. There was a stronger negative relationship between being female and having an adaptive habitus towards mathematics or science in Finland and Sweden than in the United States. There was also more of a connection between being female and having a negative transition to upper secondary in Finland and Sweden than in the United States. Such a difference was

unexpected and may have to do with the sampling, but it might also be an effect of other factors at play in the Finnish and Swedish systems, as well as the difference in timing of the transition, and the increased amount of choice in Finnish and Sweden. As will be discussed further in later chapters, the Finnish and Swedish systems are both more permeable at the point of transition, and this pattern brings into question of whether the increased permeability might decrease the retention of young women. However, that questions needs further investigation.

**Transition, arising as an important variable needs further exploration, including into possible interventions.**

Also pressing is further exploration of the importance of transition to upper secondary schools. While some environmental variables, regarding the teacher and the elite classroom were significant in these models, these variables deserve further exploration elsewhere. Drawing more directly on the variables here, a clearer understanding of what aspects of extracurricular involvement are important, and how they are accessed is needed. Would there be an interaction between such involvement and negative transition? Individual interviews, discussed in upcoming chapters, suggest that this is the case.

**Family STEM capital (or habitus) and Gifted ID are promising scales across the three settings; more targeted measures of enrichment are needed.**

While the measure of extracurricular involvement was extensive, and showed a strong relationship with persistence across countries, a more target variable is needed to distinguish the relative value of different forms of enrichment. This is discussed further in Chapter 7, which develops a characterisation of effective enrichment for STEM persistence.

**Implications regarding use of habitus in future quantitative research.**

While many quantitative researchers seem hesitant to use the word, ‘habitus,’ many researchers such as Aschbacher, Li, and Roth (2010) have used the word in relation to math and science identity (see also Eccles, 2009). One way this is being approached is to identify and characterise groups of students and patterns of beliefs in latent class analysis (e.g., for interesting examples see Chow and Salmela-Aro, 2011; Malmberg and Little, 2007; Dumais, 2005). This type of analysis would be a particularly interesting way to explore the data here, and to see if how different latent classes relate to track, school, and

nationality and gender, and linking these with educational policies, particularly given the differently gendered labour context into which these students will be emerging.

The discourse surrounding 21st century skills, as well as research finding that so-called ‘non-cognitive skills’ are important to lifetime outcomes (Cunha and Heckman, 2009) suggest that these variables are worthy of consideration. Chen and Pajares (2009) offer a path diagram of a complex array of beliefs and indicators, relating them to self-efficacy and academic attainment. Using the metaphor of habitus takes such connections further. One can draw upon that banquet of highly validated psychometric variables, but at the same time invite a critical examination of how family background and school structures mediate the development of such traits as part of students’ identities. Such a viewpoint also invites the notion that the development of different psychometric traits might be intertwined rather than independent. As schools seek to foster adaptive affective traits, policy makers must also think critically about how, and with what frames, and to which purposes such adaptive traits, and the habitus that they form part of, are developed.

In addition, part of the point of these models is to argue that adaptive habitus can be represented as an underlying factor to many of the affective variables that are so important to mathematics and science outcomes. For example, an excellent longitudinal study by Duckworth, Tsukayama, and May (2010) reported established causality from self-control to students’ academic results. The results, however, are not related to the school structure and environment, which was a selective public magnet school. As they state, ‘What our analysis did not rule out, however, is the possibility of an unmeasured time-varying third variable that changes in sync with self-control and causally determines subsequent academic performance’ (Duckworth, Tsukayama, and May, 2010, p. 316). Perhaps adaptive habitus could be considered such a variable. Chapter 8 in this dissertation examines the potential of magnet schools to shape the development of students’ adaptive habitus in particular. As the research discussed above implies, many of these adaptive traits are connected developed and weakened in concert, concentrated in the same individuals, and related to the schools and schools structures that students inhabit.



# Chapter 5

## Practical uses of stratification

Stratification in mathematics and science education is often assumed to encourage and promote students with exceptional ability. The stated goal of programs for elite enrichment, whether formal school structures or enrichment programmes, is often exactly to promote retention of (exceptional) students in STEM fields. Nagel (1991), for example understands the goal as important and worthy for differentiation in education systems:

A society should try to foster the creation and preservation of what is best, or as good as it possibly can be and this is just as important as the widespread dissemination of what is merely good enough. Such an aim can be pursued only by recognising and exploiting the natural inequalities between persons, encouraging specialization and distinction of levels in education, and accepting the variation in accomplishment which results (p. 135).

Like Nagel, a number of researchers point out the merits of stratification (e.g. Benbow and Stanley, 1996; Schofield and Hotulainen, 2004; Fredricks, Alfeld, and Eccles, 2010). However, the question of aptness arises when assessing the outcomes of such programmes. In other words, if the goal of a given structure is to increase the future production of high levels of expertise in mathematics and science, do they actually succeed? Drawing on the interviews in Finland, Sweden, and the United States, I suggest that there are three additional ways that such structures are *used in practice* that are important to consider.<sup>1</sup>

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<sup>1</sup>The ways in which they truly do foster the development of talent and expertise are examined further in Chapter 8.

## DISTINCTION

Stratification becomes a signifier of intelligence in school systems that conceive of mathematics and natural science as ‘difficult’. This perception is used both socially and academically, even if a student does not ultimately move on to pursue STEM fields. This is the case in Sweden, where the academic concentration of mathematics and natural science also serves as a sort of credential (Labaree, 2007) that is valuable in the educational market. In the United States, because tertiary education is entered primarily by overall distinction and competitiveness and not primarily by subject interest, accelerated classes and extracurricular involvement fall clearly into this category. However, in Finland, where anyone can try, at least, to take Long Mathematics, the distinction of the subject is lessened considerably.

In this section, I look at each country separately, examining the Natural Science Line in Sweden, Advanced Placement/Honours tracks in the United States, and the Long Mathematics Line in Finland.

## ESCAPE

As discussed in Chapter 1, selective tracks can also serve as a way of escaping to a more enjoyable academic experience. They provide environments that are more enjoyable because students and parents feel them to be a better ‘fit’, where students’ have similar interests and dispositions towards school, and where the academic level is more rewarding. Such feelings of comfort and belonging, can be described as relating to a students’ habitus towards school, and ultimately to family background and resources (e.g., Reay, Crozier, and Clayton, 2009; Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2010). In American schools, finding this comfortable fit is commonly achieved through enrolment in Advanced Placement and International Baccalaureate programmes (Hertberg-Davis and Callahan, 2008; Fredricks, Alfeld, and Eccles, 2010). However, if anything, this effect is more pronounced in Finland and Sweden, where entrance into upper-secondary schools is competitive. In Sweden, where the Natural Science track is often separated within a school, such environmental effects occur within the school as well, with the Natural Science students being perceived as more studious, as will be discussed in this chapter.

## PROTECTION

A related, but more extreme use of stratification for escape is that for some interviewed students, elite programmes in mathematics and science (and other domains) were ways of escaping bullying and social exclusion. This challenges the narrative of programmatic status due to excellence that is part of Nagel’s (1991, p. 136) justification of inequality:

‘What cannot be done is to separate the pursuit of excellence from the creation of inequalities to of status, and it must be acknowledged that such inequalities can cause a good deal of pain.’ I find that parents and students may only activate meritocratic structures or school choice when bullying or mistreatment from peers or teachers threatens them. That is, structures that purportedly discover and encourage academic strength are also ways in which vulnerable students escape situations of violence in schools. I think this is absolutely crucial to consider when discussing stratification, to really understand how it benefits students, and why it is so difficult from a policy perspective to change these educational structures, something that advocates in the United States have struggled with for decades (Oakes, 2008). For some vulnerable students with the family and personal resources to navigate the system, this is a powerful motive both for using these structures and maintaining them.

In the remainder of this chapter, I examine how each of these themes plays out in the context of Finland, Sweden and the United States. Notably, the different structures examined result in social separation. This segregation is not the necessarily an actively, *consciously* articulated goal of educational choices. However, if a policy goal would be to reduce social and racial segregation, for example, it is useful to understand how actor’s conceptualise the use of stratification in education. It is striking that across three different very different structures, these uses have common themes. The first is by providing a general distinction between students that has little to do with eventual STEM persistence. The second is by providing educational spaces that feel more comfortable and engaging for some students. The third is by providing a refuge for (some) vulnerable and excluded students. The first, I argue, likely is prohibitive to STEM persistence overall in a system. The second and third may increase persistence for those students able to use the system for escape and protection. None of these uses is in line with discourse commonly used in support of such structures in mathematics and science learning, the production of elite STEM experts.

## 5.1 Distinction

As educational access expands, student and families find new ways of distinguishing themselves. In addition, employers and universities find new ways of distinguishing between applicants. Gamoran (2008, p. 172) writes that, ‘...when most students reach a given level of schooling, inequality re-emerges through differentiation within that level’. Broccolichi (1999, p. 441) describes, in France, the use of mathematics and science as signifiers

for access to further study, regardless of future subject, where the students interviewed: ‘... were knocked down a peg in their discovery of a more clearly hierarchized [sic] world where students not on the “royal road of the sciences” are looked down on... and where the students come to learn that the science track is ... the only sure thing in this period of generalised access to the baccalauréat and of uncertainty in the job market.’. The Swedish Natural Science line fulfills a similar function.

## **The use of the Natural Science line in Sweden**

In Sweden, as in Finland, competitive entry into school is key moment of differentiation, as is the school choice. Some students, for example, made a point of explaining their choice of an elite state school as being in direct political opposition to the spread of private schooling in Sweden. In terms of distinctions within schools, and certainly in terms of interactions with policies selecting students for further education, the Natural Science tracks at gymnasiums in Sweden, and the mathematics courses taken there, serve as an important point of distinction. Students apply to a particular track within a particular school, and entry into a Natural Science programme seems to be commonly more selective.

The choice of this track for many students had nothing to do with interest, but rather the assumption that this was something they should do as ‘good’ students. One interviewee, Josefina, attending an elite state school and focusing on natural science, demonstrated this :

Josefina: ... And also because I was a great student in my [lower secondary] it was like an expectation that I would choose the Natural Science because that’s the hardest programme. I don’t know. It’s like, everybody expects you to do it because they are like you are a great student and if you choose the natural science program you will get—you can choose whatever you like after that because you can have all doors open as you say here... And so just like... .

JS: Was that teachers who were telling you... .

Josefina: Yeah; its like teachers and friends and parents. I don’t know—it’s like this—this idea that if you are a great student you should read French and go to the Natural Science programme. I don’t know, it’s like everywhere (laughing). For me it was good because I liked it, but I know other student in

my class that are really more interested in like the social sciences (...) They are like, 'Now I really don't fit here but I chose it because I had good grades.'

Josefina outlines the social and structural expectations in Sweden: good students, diligent students, choose natural science, regardless of their interests. The other side of distinction, from her point of view, is that the Social Science line is seen as an easier choice during gymnasium, something chosen not so much by interest as it is for those who 'can't manage' the Natural Science line:

Josefina: ... I think that's because the social science has this reputation that it's like, the easier way out. And you don't learn as much and you don't have the— all the doors open. But I think that it could be as hard as the Natural Science so it wouldn't depend on how good student you are but it would depend on— it should depend on what you are interested in and not how hard it is.

Josefina notes that the distinction is arbitrary—it goes against her sense of what is right—and yet it was a strong force in her own decisions, which were almost automatic with regards to applying to Natural Science. It is simply what one does as a strong, ambitious student.

The view is not limited to students from elite schools. Similar views were also expressed by Alonso, a student with an immigrant background and attending the Suburban Gymnasium. Though their schools are very different, Alonso's understanding about the function and choice of the Natural Science line are very similar:

Alonso: I got good grades, and it has become—how can you say it?— a normal thing: if you get good grades you go to [the Natural Sciences programme] and you study the sciences. If you get bad grades, you go and do Social Studies. And so it becomes a bit more like that. I don't know why but... if you look at this gymnasium, it's like two different schools. If you go up to the social science area, you can see people don't really care about their studies, and if you like, take a look around here, in the Natural Science level, then you see the opposite.<sup>1</sup>

Like Josefina, for Alonso the choice is automatic. This automatic choice is governed by a disposition that seemed to be absorbed from all sides. However, this choice is not automatic for all students. For example, another student at the Suburban Gymnasium,

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<sup>1</sup>In this school, all the classes for the Natural Science line were in a ground or basement level (all of their classes, including non-science subjects) and the Social Science track studied on the floor above.

Belen, was aware that the Natural Science line would provide more opportunities for further education, and she had done well in her lower secondary mathematics and science, the choice seemed to risky for her:

Belen: But at the same time not because like I said earlier because my grades wouldn't be as good, as they would be if I chose Social Science, so if my grades aren't good then a lot of the doors automatically close because they want high grades.

In the end, entry to university is often determined automatically by a point system involving students' marks. Thus, for less confident students, the Social Science line looks like a safer choice en route to *some* sort of university education. Belen was further dissuaded by the idea that most students choosing Natural Sciences, '... after a year most of them change. So they have to go a year again.' when they move to the Social Science track. This had happened to another interview participant (Björn) from the Suburban Gymnasium.

This is one example of impermeability in the Swedish structure. By creating tracks of math and science that are bundled together, the students have to go 'all in' or not at all. Furthermore, there is a high cost if they don't make it, that of repeating a year of school. All of these increase the threshold of self-concept and assurance that a student must have in order to make that selections.

From the point of view of students and families, the choice of the Natural Science track was to some degree automatic if the student was strong academically. During the time of the interviews, various university programmes, notably at the prestigious Stockholm School of Economics were increasing their requirements for mathematics, increasing also the likelihood that even for these non-STEM courses, a Natural Science student would be more likely to qualify. Again, this is a use of mathematics and science not as a step in a future career in STEM fields, but as a signifier of intelligence, diligence, and ambition.

Teachers interviewed also agreed that the Natural Science line was used as a gateway to higher education, but not necessarily STEM education:

Teacher: There's no education that you can't choose from the natural sciences and some economics course or programs at university level they sort of try to adapt their entry--this is my guess--but they are quite good guesses I think--they try to adapt their standards for students to come in to get more Natural Science students like they put 'We require this high math course' even though

maybe you don't really need that to cope with it, but they want students who are good at math.

JS: (...) Is there a sense that the students who are in the natural sciences program are going to continue on in science or that they're trying to keep as many options open as possible...

Teacher: I think the latter. I wouldn't bet on a percentage but its not sort of at all, I think, evident for more than a few of them that, 'Yeah I'm going to natural science higher education.' I think its more 'Oh yes, some kind of higher education'.

The Natural Science programme is ingrained in the Swedish structures and consciousness not as a pathway for persistence in STEM, but as a signifier of general academic potential.

It is interesting to note, and not unique to Sweden, that mathematics and science opened up all disciplines, were as social sciences and languages limited future possibilities. If the programme is used primarily to signifying academic prowess, rather than as a way of producing future STEM talent, this has implications about the efficiency of such a programme. In the Swedish sample, there were several interested students like Belen, who did not dare take it, and those who change their mind, see Chapter 9, have a difficult road ahead.

## **Long Mathematics in Finnish lukios**

As in Sweden, for some students, mastery of mathematics and science is also seen as a more challenging choice. Students in Long Mathematics in particular considered Short Mathematics as easy, a choice for students who are 'just not interested' or who find mathematics difficult. Contrary to the Swedish structure, however, students could still apply for science programs at the university without having taken Long Mathematics or the advanced courses in physics. This is the case with Juha, attending the Large Magnet School, who is very keen on biology, and enrolled in a natural science specialist programme. He was able to take Short Mathematics, but continue taking advanced biology. This contrasts with Björn at the Suburban Gymnasium in Sweden, who also loved biology, but was not able to focus on that science without also taking mathematics and physics. Indeed, the place of Long Mathematics was noticeably less distinguished than the Natural Science Programme in Sweden, or elite tracks in the United States.

First of all, everyone can try to take it, and many do. The downside of this is that many drop out as well, and there did not seem to be an effort to retain students. They were free to come, but free to go as well.

Mathematics is not a distinguished subject in Finland, but that did not stop Soila, also enrolled in the science programme at the Science Lukio, from expressing a growing interest in mathematics and computer science. In her interview, she expressed how the science programme could be easy for her to try out:

Soila: I just really don't know what I want to do and that's— like you know those two things are the things that interest me right now and I think, you know, I can try because its—the maths department in Helsinki university is like the easiest place to get in nobody wants [to study] there.

In a sense, the Finnish case reaffirms a question raised regarding credential inflation: if everyone can enter, certainly it loses some of its value as a marker of distinction (Labaree, 1997). In the model, the adaptive habitus variable for mathematics was not related to persistence, though it was for science. I argue that this has to do with school structures that make participation in mathematics learning less of an issue of distinction and more an issue of choice. Unlike the Swedish system, where students must apply to study a programme at Gymnasium, or the American system, where students might not be able to change their track assignment, in the lukio students have free choice of courses, even within specialist programs, as evidenced by Juha who maintains a specialist biology program without Long Mathematics. This is an important difference from Sweden, where science and mathematics subjects are bundled together, which functioned similarly to the French system as described by Broccolichi (1999).

## **AP, IB and Honors tracks within U.S. High schools**

Stratification within schools is more an issue in Oregon and Washington, where not all students have access to school choice. To prepare for entry into elite schools, regardless of intended subject of study, students need to aim for mathematics and science courses that are designated as Advanced Placement, International Baccalaureate<sup>1</sup>, or similar. For example, in preliminary research for this project (Saari, 2008), Katherine, a student about to graduate from Olympus High, struggled with getting her school, which was low

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<sup>1</sup>These are private corporations, which makes their ubiquity in the American public education system particularly interesting. Students have to pay a fee to take the exams associated with these course, but some schools cover these fees.

performing for the region, to understand the importance of these courses. Counsellors at the school had tried to advise her to take fewer AP courses, a decision she successfully fought. She was hopeful the attitude of the school will change now they have better information:

Katherine: I was talking to one of our teachers, and the one thing about Olympus is that the counselling department isn't as strong as it should be. And they just sent (...) the head counsellor, went down to the College Board training in Houston and she came back and she was really shocked at how many—how much these Ivy League schools wanted from you. And I think that at Olympus that will help a lot because when I was signing up for my classes senior year they told me not to take four AP classes [slight laugh]. And I was like 'I want to go to *these* schools, I need to take *these* classes'.

These elite courses are very important for university admittance; the subject is a secondary issue. At other high schools, students in elite courses, even those heavily involved in STEM enrichment may have had ideas about what universities they were aiming for, but were not necessarily planning to pursue STEM fields. Since admission to university is based in part on qualitative criteria, like involvement in extracurricular activities, STEM related enrichment is attractive to students looking to enter selective universities, even if their ultimate plan is to study liberal arts or social science. Furthermore, access to these valuable enrichment experiences was often offered or advertised only to students already in advanced courses.

The mentors of the Robotics Team interviewed contrasted their open policy of accepting team members with that of elite schools in the region:

Team Mentor: You're interviewed, you take a test, you have to build a robot that meets their criteria and then if you've passed all of that then the team gets to decide whether or not you're good enough to be on. And they charge you almost 60 bucks<sup>1</sup> to be a member of their team. We don't charge our kids we take anybody who comes in who's willing to do their best whatever that is and the team at [the high school] that they started, ah they build little tiny robots but they picked the kids, the administration picked the kids the administration picked the kids that were going to be on their team.

According to the Robotics Team mentor, their inclusive policy was one of the reasons that the team was frozen out of the school by the administration. The students involved were

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<sup>1</sup>United States dollars

aware of the distinction that involvement might provide for university entrance, and the college scholarships offered by the program, though there was a stark contrast between their self-driven involvement and the concerted cultivation (e.g., Lareau, 2008) evident by parents in earlier interviews with elite students (Saari, 2008). In contrast, the students involved in the Robotics Team are from less advantaged backgrounds, and none of them are enrolled in Elite courses. When Alex tried to be moved to a higher-level course after his grades improved, he was denied the opportunity as outlined in Chapter 9.

Hertberg-Davis and Callahan (2008, p. 210), in a study of elite students, were taken aback by those students motivations' for taking AP and IB courses. Students were not enrolling in the advanced courses because of interest or passion for the subject matter. Rather, they were enrolling because they understood how the classes benefited them during university admissions:

... The AP and IB labels were educational brand names, symbols with cache guaranteed to bring them future benefits such as increased chances of being accepted by the colleges of their choice ... The promise of future benefits combined with the relief of escape from general education classrooms may very well be the primary reasons that AP and IB students expressed satisfaction with these courses.

Again, in addition to the distinction that the classes give, which is the primary motivator for savvy students who aim at competing for spots in elite universities, the IB and AP classrooms were also valued because of their exclusive environment, which provided 'relief of escape' from the general school population.<sup>1</sup>

That such uses are the primary consideration should not surprise school leadership, policy makers, or researchers. This is simply a reflection of how these courses are used in practice: as a form of academic distinction for many students who might have access only with considerable family support. For students like Alex from the Robotics Team who lack support but express passion, interest, and improved performance, entry is frequently denied (see Chapter 9). Thus, these programs are not structured in such away as to that students are allocated to them due to interest or passion. By linking high level learning in mathematics and science to a cadre of academically elite courses in other subjects, it is likely a similar effect happens as in Sweden; interested and passionate students are kept out of courses they would be qualified to take because they do not want, or cannot manage, to take the full retinue.

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<sup>1</sup>This was noted even though the research described fell within the general gifted education paradigm, as described in Section 3.13.

## Summary: the impact of ‘distinction’ on efficiency

Distinction by track is a particular issue in Sweden where the impact relates most directly to STEM education, since the prestigious track is the Natural Science Line. As discussed above, in Sweden, the Natural Science track serves a very similar purpose to the science tracks described in France by Broccolichi (1999); that is, their functional use is largely about weeding out students and selecting for further academic work, not about encouraging persistence in STEM fields. Some students outside Natural Science track plan to persist, and struggle to do so, students inside the track have no desire to persist in STEM fields. Rather, these programmes are seen as challenging and a way of distinguishing the intelligent, ambitious and hard working from the ordinary.

This has two implications for policy:

1. **Natural science programmes do not focus on retention.** Since a more elite cohort is chosen for these programmes they are free to act as ‘weeder’ courses and ‘filter’ courses, thus making them even more risky for students who are unsure.
2. **Natural science programmes are inefficient.** Many interested but unsure students fail to enter into Natural Science programs and must seek remedial education before entering further education, particularly because the stakes are high.

One of the compensatory strengths, in terms of fairness and retention in the Swedish system is that remediation of this choice is possible to some extent; universities offer a base year in natural sciences for interested students to catch up. This is an important feature of permeability in the Swedish system, and worthy of future research.

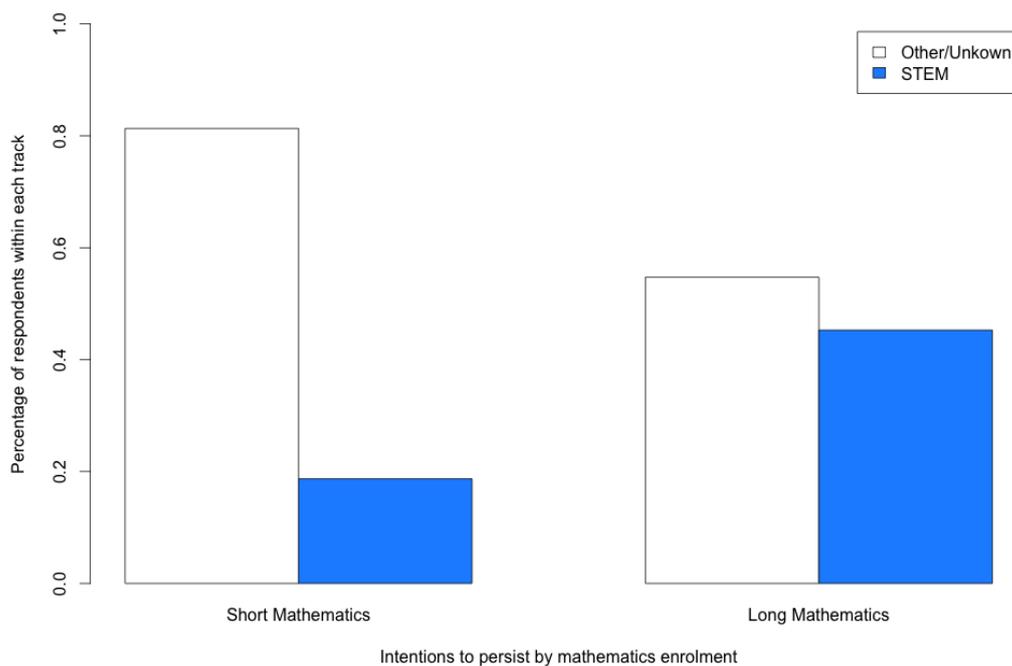
Who are the students who take these courses, and how do they actually fare? In Finland, there is some distinction given to the Long Mathematics track, but by in large, it is less than the differences of perception in Sweden and the United States. Furthermore, students aspired to continue in STEM related areas even when they were not taking Long Mathematics or physics courses, for example.

In contrast, in the American case, elite courses in particular are usually accessed together across all subjects. For example, students often take several Advanced Placement courses together (forming, for example, what two interviewees, Elizabeth and Nicole, called ‘the AP Squad’ a small group that traveled together within a larger, diverse high school).

These courses are more important in terms of general academic position. Access is dependent on family background, as illustrated in Chapter 9. Again, the distinction may

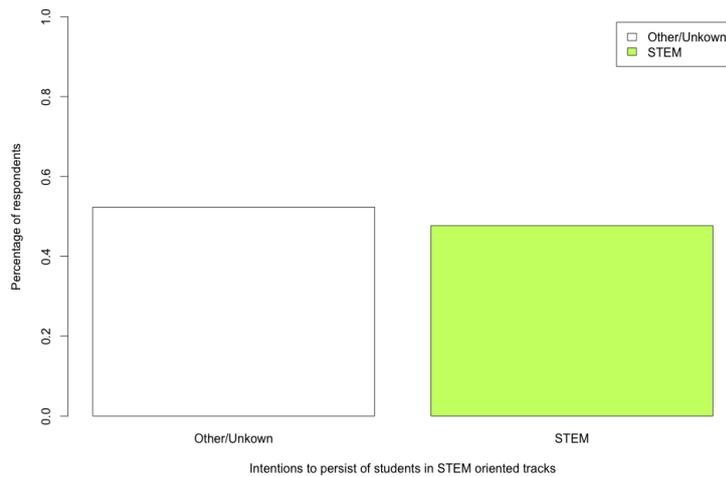
have a cost in terms of efficiency in the sense of providing access to high quality STEM education to the students most interested and committed to persisting.

These differences can be seen in the survey data as well. In Finland, the track (Long versus Short mathematics) is more closely aligned with persistence in STEM fields. That is, in Finland, advanced tuition in mathematics is reaching a higher proportion of students in the sample who are intending to pursue STEM careers, see Figure 5.1. This is shown for both outcome variables.



**Figure 5.1: In the Finnish sample, there is alignment between enrolment in Long Mathematics and intentions to pursue STEM fields after graduation. Here the binary coded, open response regarding students' future plans was used to assess intentions to persist.**

In Sweden, due to the peculiarities of the sample, basically all the students were in science and technology related programmes. However, less than half of the students overall intended to pursue STEM fields (see Figure 5.2). This fits with the use of natural science programmes as described by participants in the interviews. However, in examining advanced mathematics course participation of Mathematics D and higher, there exists an alignment similar to that in Finland (see Figure 5.3).

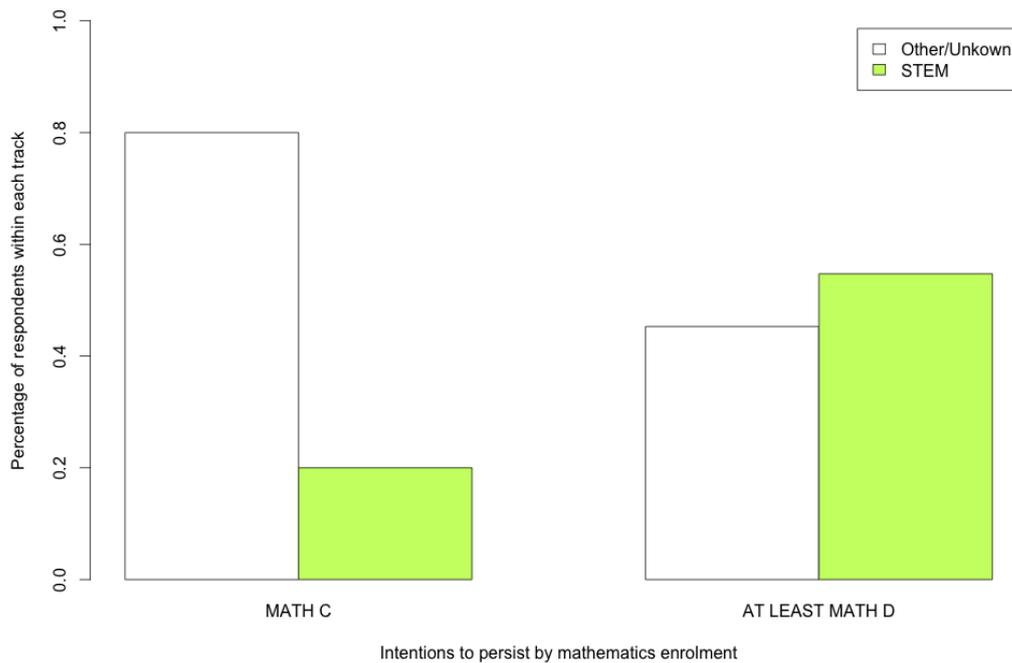


**Figure 5.2: In Sweden, the survey data supported the interview analysis in suggesting that STEM oriented tracks are not aligned with intentions to pursue STEM fields after graduation**

In the United States sample, however, an alignment with high track mathematics and persistence is not visible. Students are in those tracks because they are college bound, the advanced tuition they are given in mathematics is not related to persistence (see Figure 5.4)

The effect of using advanced mathematics and science courses primarily for general academic distinction is that it makes it more difficult for less confident or well-informed students to access advanced work, even if they have the desire and drive to do so. In contrast, the Finnish system is more flexible; students can advance in sciences or mathematics individually, unlike the Swedish system. In the samples involved in this study, it also mean that tuition in STEM subjects was more efficient, since advanced tuition was more likely to be aimed at students who were actually intending to pursue STEM careers.

Furthermore, the lesser distinction (relative to Sweden and the United States) of taking advanced courses, and the ease at which students can recover after trying a difficult course and moving down to an easier one, and their free ability to choose to study Long Mathematics, is in sharp contrast with the other structures. Particularly in the United States, students who aspire to STEM careers but fail to receive the requisite tuition during secondary school face will have to bare heavy financial burdens to make up courses later.



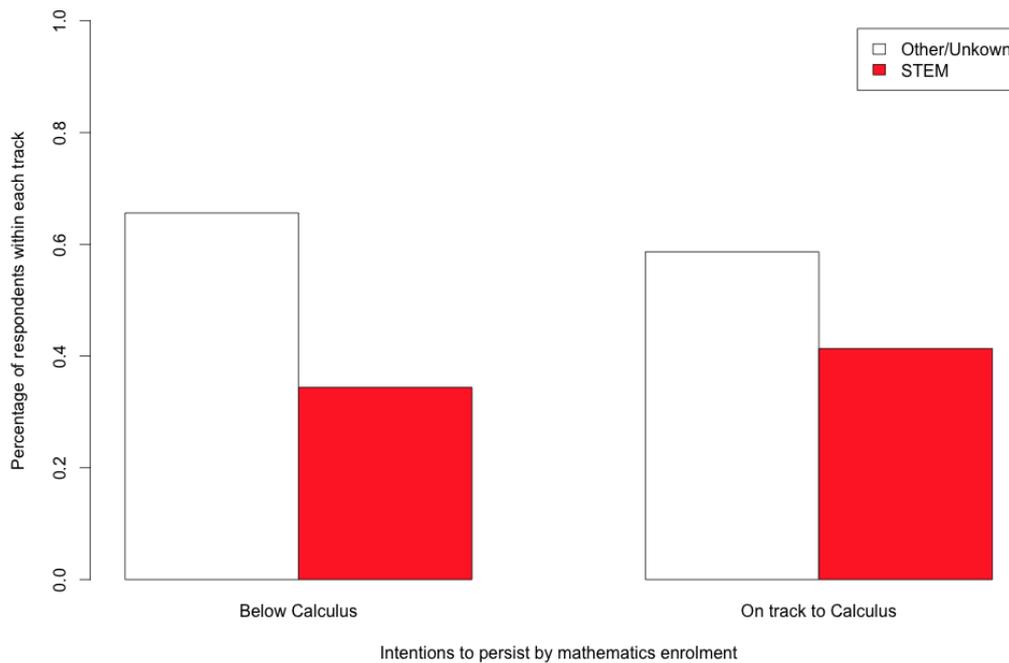
**Figure 5.3:** In the Swedish sample, in contrast with Figure 5.2, there is greater alignment between mathematics course and intentions to persist in STEM fields. Here the binary coded, open response regarding students’ future plans was used to assess intentions to persist.

## 5.2 Escape

Hertberg-Davis and Callahan (2008, p. 210) note that one of the attractions of the elite AP and IB courses in American high schools is the ‘the relief of escape from general education classrooms.’. In all sites, the environment created by exclusivity was seen as positive by the students. In Finland and Sweden, this was particularly manifested by different environment between schools (and schools within schools).

In Finland choice of specialist lower secondary schools by educated parents is accelerating (Seppänen and Sairanen, 2011). This is occurring at the same time inequality in Finland is rising, particularly among children (Naumanen and Silvennoinen, 2011). However, parents are not directing their children towards these schools because of interest in mathematics and science (if that is the school’s concentration). Rather, special classes and schools are known for providing quieter environments with fewer disruptions.

Charles, a student at the Historical Lukio was thankful for the environment the special



**Figure 5.4: In the United States sample, there is little alignment between mathematics track and intentions to pursue STEM fields. As with the other figures, here the binary coded, open response regarding students' future plans was used to assess intentions to persist.**

track in his lower secondary provided him:

Charles: Well in the other classes I remember there were lots of problems so in a way I was lucky well the class itself it wasn't filled with people who just love maths and by the end of the second year I think no one no one thought of us as a mathematics class we were just we didn't we didn't do that much extra maths compared to the others. But it was just that thing because it had the entrance exam and because it required a bit higher grades the friends that I got were a bit, well I didn't get into trouble— there were lots of people who got into trouble for drug use or started smoking at age 14 and well if I would have –If I were... If I would have been with them the peer pressure would have been obviously geared to go into those things so I think I was in a way lucky to be with the more, well more I don't know, perhaps calmer or in a word, people who are not into that kind of things so, yeah I think that was perhaps the biggest influence that the decision had on me that I grew

up with this group of people who were in many ways similar to myself and appreciated the same things that I do.

For students who can pass the test and parents who are involved enough to know the opportunity exists, access to specialist schools provides a way of accessing what is seen to be a better learning environment. Perhaps just as important is Charles's observation that 'I grew up with this group of people who were in many ways similar to myself and appreciated the same things that I do.'. That is, he was then likely with students from families with similar class background, similar taste, similar habitus. This is very similar to the narratives of American students in elite programmes (Bleske-Rechek, Lubinski, and Benbow, 2004; Fredricks, Alfeld, and Eccles, 2010; Hertberg-Davis and Callahan, 2008).

In Sweden, particularly at the Historical Gymnasium, the environment provided by exclusivity was regarded as a positive revelation. One interviewee, Inga, described her admission to the Historical Gymnasium as inclusionary, one that welcomed her into an environment of '*people like me.*' Her thoughts are similar to Charles' description of acceptance into a selective school in Finland:

JS: How was that transition to where you were before to here? Can you talk a little bit more about that?

Inga: Well, I have said that it was hard to be surrounded by the very good students when I hadn't [been] before, but it was also like... they helped me to engage more in the school and everything. So I don't know. I mean I didn't feel like I was a part of my old class. It wasn't- I mean I didn't like any of them actually [laughs] because we were so much different. But here I am surrounded by people with the same- you know we want the same things for our lives so...

JS: So what was it that was different between you and the other students before?

Inga: Yeah-they didn't want to learn and they were disrespectful to the teachers and to each other. And they were a bit childish and ... Yeah, that sort of thing, I'm not sure actually.

For Inga's classmate, Frederick, the choice of the school was with the particular objective of finding people like himself: 'I wanted to be with people who agree with me on a lot of- I mean who think like me. There are other very good schools like [names two

gymnasiums, both well known and selective] but they are both a little bit more to the right so I couldn't really go there.' For Frederick, the choice went past academic habitus to political identity.

For many students, it is the feeling of the school, rather than the actual academic programmes that make the elite environment desirable. This echoes the narratives of students in gifted programmes in the United States mentioned earlier (e.g., Bleske-Rechek, Lubinski, and Benbow, 2004; Hertberg-Davis and Callahan, 2008). For example, for Josefina, a student at an elite gymnasium, the peer environment was described as a key benefit of the school, and the importance of academics and school resources dismissed:

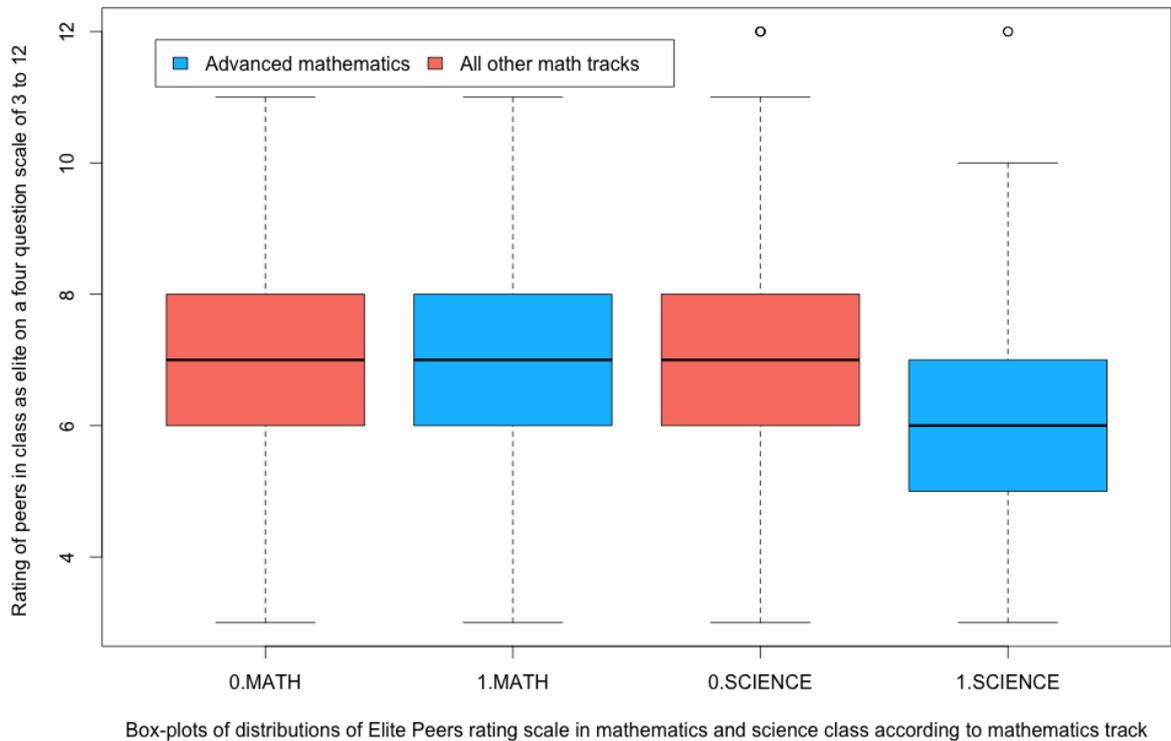
Josefina: If it wasn't for the students, this school would be like any other school, so I don't think the teachers are particularly good or I don't think the equipment is particularly good; it is just like the students have this energy and [are] eager to learn...

This is similar to state schools in the United States, where these sorts of groupings happen primarily through access to elite tracks. Students in elite tracks have described their peers as 'the smartest people; good honours students' while students in other tracks are 'troublemakers' (Saari, 2008). In the survey data, a large number of the United States students had tracked mathematics, but mixed ability science classes. The high-track mathematics students (blue in Figure 5.5) did not rate their mathematics peers any better than did the respondents from other levels. However, they did rate their peers in the mixed ability class lower. In the United States, there seems to be a possible effect of stratification in increasing out-group bias (Jost, Pelham, and Carvallo, 2002). Their distinction has taught them to be critical of the shortcomings of their 'average' (as indicated by the school structure) peers. This is, however, just a suggestion for the interpretation of this survey and needs further exploration.

## Effects on persistence

These peer groups can be important for establishing persistence, however. Olli is a student at the Small Magnet Lukio. He compared himself to other students he had met while training for mathematics competitions:

Olli: ... Even though they weren't in a special lukio so its also possible somewhere else but they don't have such, they don't have people who are also



**Figure 5.5: In the United States sample, advanced mathematics students did not rate their peers in mathematics courses higher, but they did seem to rate their peers in mixed-ability science courses lower.**

interested in mathematics around them, so it's possible but it's not so fun  
[laughs]

The use, by some educational consumers, of stratification of a way of accessing more pleasing learning environments might seem frivolous, or unworthy of sympathy. However the narratives of students across settings in this study and elsewhere suggest that this is a powerful motivator for both students and parents in school choice. The risk, in comparison, of a noisy, poorly-run environment with peers who are not oriented towards academics can seem like a threatening one. Students transferred to more elite schools to escape environments that were not, for them, conducive to learning. Anyone interested in education should have sympathy with that reason. However, students also transferred from, or avoided elite schools and programs because of the environment, looking for a place that fit their 'academic disposition' (Reay, Crozier, and Clayton, 2009, p. 1115).

The reasons behind students' need to switch schools is something that deserves further consideration.

The next section takes the idea of positive environments in a little different direction. Here we examine how students use selective STEM environments to escape emotional violence and social exclusion.

## 5.3 Protection

In the last section, '... the relief of escape from general education classrooms...' (Hertberg-Davis and Callahan, 2008, p. 210), did not perhaps seem particularly urgent. Students were accessing better environments with more academically habituated peers. However, sometimes stratification is indeed a way for students to escape threatening or damaging environments.

### Using differentiation to escaping bullying

For some students, the difference between being in a 'normal' or 'ordinary' tract and a specialty programme was also a difference between being socially excluded and bullied and being part of a community that allowed them to grow. Antti, for example, is an exceptionally high-performing student at the Small Magnet Lukio in Finland. However, before lukio he describes himself as a mediocre student.

JS: I'm interested, though, about the fact you are doing better in this in Lukio, at least grade-wise than you were doing in ylä-aste. Obviously you must have been learning something in ylä-aste, too? But I mean now so—

Antti: Yeah, well maybe I just was more motivated because I think this is a really great school and I wasn't that motivated in ylä-aste.

JS: So tell about what was so motivating about this school from the very beginning?

Antti: Well... It has a lot to do with it being math school because I really like math and maybe it was kind of like 'I finally get to do something that I'm good at'. And in ylä-aste I really wasn't, um, that good at anything else than math. And well, maybe in ylä-aste I had some other problems also. Like, I didn't have many friends or something.

In the specialty school, however, Antti is one of the strongest students. He also has close friends and is perceived as open and social. In this case, the special environment allowed for his growth and flourishing as a student in away his previous school, outside the city centre, likely could not have.

It isn't just for science students that this effect of specialist schools arose in the interviews. Erik, attending the Historical Gymnasium was switched to a specialist lower secondary that focused on arts: 'Because, partly because I was being bullied and it was... And I didn't find it- I didn't find it- I couldn't grow there as a person. And it was so far away in the suburbs.' Like Antti, Erik is perceived as a prominent figure among his peers. He is actively involved in his schools activities, and by all accounts, is flourishing. Other interview subjects enrolled in the specialist programmes repeat this story. Eva, a student in Sweden, switched schools after being bullied 'at my first one for a long time'. The change gave her a respite, and she finished compulsory school well and continued to the Small Magnet Gymnasium, about which she was very enthusiastic: '... I can talk with my friends now and talk about physics science chemistry in a way that I couldn't in grundskolan [primary school].'

For Antti, Erik, and Eva, switching is about finding a place where they are able to be themselves, and to escape a kind of violence to which they were exposed in previous schools. All three end up as strong students, having successfully used the potential of school choice to ensure themselves a better environment.

## **Feeling free to be a 'geek'**

Inga attends the Historical Gymnasium and the Natural Science programme. Like others interviewed at the school, she is very positive about her peer environment, contrasting it with her previous school where she 'didn't like any of them.' For Inga, the difference is that at the Historical Gymnasium, she is also free to express her interest in science in mathematics-those 'dorky things':

Inga: I mean in the class that I came from, it was considered a bit dorky to be interested in natural science things. So, I mean then it wasn't something that I was especially proud of-that I was interested in those subjects. I was proud of me being a good student, but maybe not that I was good at physics or chemistry. I mean it wasn't something very big. But now I feel more proud of knowing how the world works and how- yeah, I think that's the most biggest thing that has changed.

In Finland, Sonia, a Swedish speaking Finn picked the Historical Lukio after hearing about it from a family friend. It was appealing because no one at her previous school where 'I didn't fit in very well' would be going there, she could start 'completely fresh'.

For Sonia, the improved social environment is a function of the selectivity of the school:

JS: Do you think the academic environment at this school is different from the school you attended before?

Sonia: Yeah I think it's a lot better here because well since everyone has had to have pretty good grades just to get in, people here accept people for who they are. Like you are allowed to be a geek and you are allowed to know stuff and it's like a nice thing. While at my old school where you would have the whole scale from those barely passing to those getting excellent grades usually if you were at the top you would be seen as a bit of a nerd and that in a negative sense.

JS: So, um, is it if somebody was doing well at your previous school they might get picked on or can you tell me a little bit?

Sonia: Yeah quite a lot usually. You weren't supposed to do all that well.

JS: So... so how was that manifested like what— can you give me an example like did this happen to you or...

Sonia: Well, yeah, at times... it's mainly like they won't take you — like you won't get invited to parties and you usually won't have that many friends because they're like, you're not cool enough.

In the IB programme at the elite Historical Lukio in Finland, Birgitta contrasts her feeling of belonging with exclusion she felt in previous schools:

Birgitta: I was fed up of being like, because previously if you were smart it was kind of like embarrassing in my previous schools because, like, all my other friends were like, then they were like: 'oh what a geek!' or like—and then I would usually not tell my grades to them or anything. But then I wanted to not have to hide like how good you are but then here definitely no you don't have to like feel bad if you're smart because—or like here I feel bad if I'm not smart enough kind of.

Through the choice of specialist programmes students, student families, and schools are engaged in a sorting that is not simply about test taking, it is also about disposition envi-

ronment fit. Again, the students repeatedly praise environments where they are allowed to be ‘dorks’ and ‘geeks,’ that is, academically ambitious or interested in mathematics and science. However, the Large Magnet School, which also had a less selective general line, shows that it is possible to provide that environment without the same degree of selectivity as the elite schools (Historical Lukio and Historical Gymnasium).

The allowance for student self-expression occurs even at less elite schools than the Historical Lukio. Minna for example is a student in the general line at the Large Magnet School. She was taking Short Mathematics, but the maximum possible number of courses she can take in that line. Ultimately, Minna is interested in pursuing further education in economics<sup>1</sup>, because she sees it as related to mathematics. She chose the school because she wanted to escape where she was, a school that had been recommended to her by teachers because of its concentration on Finnish language. Her brother, now a Fireman, had attended the school and said the teachers were great:

JS: Is that kind of being focused on going to university, is that different from the other lukio where you were?

Minna: Yes, yes it is. Here people want to succeed and they, like, point higher – they have bigger goals. They want to achieve. In the other school they didn’t want to study, they didn’t want to work. All they were thinking and talking about was just drinking and it was kind of sad. That was—I think that that was the biggest reason that I wanted to get out from there because there in my old one it was so...it was so not good for me. I just got upset there and I didn’t have anything to talk about with the people because I didn’t want to compare the alcohol percents<sup>2</sup> with the different things, like, they were doing. And then they were asking of me—asking from me why I am so quiet in there. [laughs] I just didn’t, I wasn’t—I was so different from people.

For Minna, the new environment has been supportive of her academic ambitions. The anti-academic environments they report escaping from are exactly those that Benbow and Stanley (1996) use to justify stratification on behalf of gifted students. The difference is that these students have survived, at least, with this point of stratification coming much later, at age 16. Furthermore, students such as Minna, who was originally placed in a

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<sup>1</sup>Despite lack of encouragement and even disapproval from her parents

<sup>2</sup>For example, beer in Finland is sold by the alcohol percentage, higher percentage beers are not allowed to be sold in normal groceries. Students in lukio in Finland are 17–19 and the age of alcohol consumption is 18.

lower set and guided towards a less selective school, also benefited from the ability to choose a more supportive and engaged academic environment.

## Escaping downwards

As noted in the discussion of escape, students might also move to less selective environments to find the right fit, or to escape bullying. This was markedly the case with two student participants. Soila, in Finland, found her (very elite) previous school uncomfortable. She described the environment as being too elitist for her, and reported teachers sending the message that ‘you are better than the others’:

Soila: Pretty much there are only the best students in there and the teachers always told us how we were better– better people than others and I didn’t like that. And there were some bullying at the school and I had a bit rough time there.

Soila, then, paints a different picture of an elite school. Inclusion does not seem a function of the exclusivity, but something else in the school environment. Perhaps the inclusion is exclusive itself, only felt by those students whose dispositions, whose habitus was already in line with ethos of the school. Soila left the selective schools— one of the most selective in Finland— despite her family’s objections:

Soila: I don’t think that some people are better than others and I didn’t think that if you go to that school you are better than somebody else cause you know I thought maybe we are better at school but we aren’t like better persons or something like that and I just, you know, I hated the fact that we were told that we are better than the others and we shouldn’t be with other people because they are stupid or something.

Solia’s experience reminds us that the elite environment does not fit everyone. Further, students from less advantaged backgrounds are at risk in foregoing the opportunities such schools might provide (Reay, Crozier, and Clayton, 2009). This situation has the potential to exacerbate inequalities. Alonso, a young man of immigrant background in Sweden, first attended a significantly more selective school, before transferring to the majority immigrant Suburban Gymnasium, even though it is further from his home:

‘I didn’t feel comfortable there [in the more selective school] as a– I didn’t have a lot of friends as a– So, yeah I had some friends who were going to [the Suburban Gymnasium] so I just I started here...’

This experience contrasts with students who ‘recognised themselves’ in more selective programmes or schools. For Alonso, the social difference was prohibitive, even though he had the academic background and performance to succeed at the more elite school.

In the United States, Nicole, a successful young Hispanic woman was at the point of graduating from high school. After taking a full load of AP courses, she was headed to a well-regarded private university with hopes of becoming a lawyer or an engineer. Interviewed with her friend Elizabeth outside of school, she recalled counting as the number of Hispanic students decreased year by year in the elite track at their school. The two wondered if ‘racism is really gone.’ Nicole had found a supportive community in her elite classes, but mostly white students attended those classes whereas Hispanics made up the majority of the school’s student body:

Nicole: I get called ‘white washed’, because I have so many Caucasian friends. And, most of the people in my classes are Caucasian. So it’s kind of hard for me to be like– to go to a completely different group.

Unlike Alonso in Sweden, Nicole persists in the elite environment, taking the opportunity provided by the stratification as stratification gave her access to elite courses in mathematics and science. However, she pays a social cost. She has to choose, just like Alonso or Soila, a way of being aligns her with the advantaged programmes. These programmes are often the only way of accessing serious mathematics and science preparation at the secondary level.

## Summary

For some students, specialist programmes or elite schools focused on mathematics and science are viewed as an escape from a threatening, vulnerable, or tenuous social position, or from having to hide their academic performance and ambitions. However, these functions do not perform the same way for all students. Nevertheless, the use of stratification by vulnerable students as a way of protecting themselves is noteworthy.

The lack of distinction of mathematics resonated with the outcomes of the models in Chapter 4; mathematics is not a big signifier for Finnish students. Because of this, students like Vera, discussed in the next chapter, and Sakari, discussed in Chapter 9, are able to ‘scale up’ their participation and interest. The uses of escape and protection are visible across all three systems, and seem to have mixed effects on persistence. For some students, educational stratification presents access safer, more supportive environments,

and is likely key to their academic and social well-being. However, for other students, such uses, without adequate support for students coming from underrepresented backgrounds, might add to increased self-selection out of prestigious tracks.

Recent research by Radford (2013) and Hoxby and Avery (2012) has pointed to a prevalence of high-achieving students from less advantaged families or underrepresented rural areas as applying to elite universities in lower numbers. It is suggested that this might be due in part because of ignorance, as they suggest. It may also be that such students worry about their ability to survive in those elite environments, as research from England suggests (i.e., Reay, Crozier, and Clayton, 2009). Such effects might be particularly insidious when they are not acknowledged.

## 5.4 Policy implications

In this chapter, the idea that school structures are used for more complicated and ambiguous aims was presented. Elite programmes in mathematics and science (in addition to selective schools and extracurricular activities) are used as a form of distinction. They help students accumulated status that may or may not be used to help them persist in STEM careers. In both the United States and Sweden, forms of stratification led to inefficiencies in the sense that elite tuition was being expended on students who were not interested in persisting, but using the education for distinction. However, stratification is, perhaps most importantly, used to create better environments for some students. And this use, whether it is simply a matter of having more positive study mates, or the more urgent need to escape bullying and harassment, is one that demands compassion from policy makers.

Furthermore, this use of, especially elite STEM tuition, is particularly interesting, because it contradicts the idea that stratification performs what (Nagel, 1991, p. 135) terms *maximalism*, developing the ‘...the maximum levels of excellence possible’ in contrast with school systems that would ‘...iron out distinctions...’ creating ‘...waste from failure to exploit talent to the fullest...’. Because, these structures are being discovered not simply by raw ability and capability, but by possibly vulnerable students who are escaping a difficult situation and have the resources and the disposition to take advantage of these structures.

For STEM education policy, these ways that structures are used in practice have important implications.

1. **Distinction and ‘weeding’:** Using science and mathematics courses as ‘weeder subjects’, or as indicators of intelligence and ability, does not seem to encourage general persistence. This is not to say that the courses should not be rigorous, but rather to consider that if many students involved in advanced courses have no plans to continue, and other students who do persist, or would like to persist, do not have access, there is inefficiency in the system.
2. **Environment:** Students in Finland, Sweden, and the United States all experienced classroom environments that were negative towards academics, and many reported one of the benefits of specialist environments was being free to be a ‘geek’. Reviewing the research literature, this is a key benefit for stratification. But what about the students left behind? Students interviewed for the robotics team, for example, reported negative environments in their mathematics courses, but they did not have the opportunity to escape them. Perhaps it is not enough to be satisfied with providing excellent environments for some students rather than considering how they might be created for all students, acknowledging that this would be a challenge.

The bullying that students experienced, whatever their class backgrounds and academic abilities, is simply not acceptable. There are many ways that students can be disadvantaged, and lack of economic and social capital are not necessarily more important than lack of family support, emotional or psychological well-being. Again, I worry about the students who were not able to use stratification to escape damaging environments. This motivation, though, is also important to consider in terms of being able to enact policy changes. The importance of, and attachment to, a structure will be more visceral if it is felt to be necessary for escaping social exclusion and violence.

This use of school choice is compelling, and one that challenges some of the assumptions made about the motivations and needs of school choice participants. The challenges presented here also open up the idea that school and programme choice might hold great value for some students and families because of the potential for ‘escape’ and ‘protection’. However, can supportive environments be created without creating exclusion for other students? The distinction between school environments that might encourage the idea of being ‘better people’ is troubling, a possible foundation of a belief in the ‘moral well-orderdness’ (Sayer, 2005a, p. 233) of the world, where: ‘...[T]he extent to which individuals’ lives go well or badly is believed to be a simple reflection of their virtues and vices. It refuses to acknowledge the contingency and moral luck which disrupt such

relations arbitrarily.'

In Chapter 8, this issue is explored further. There the focus is primarily on two specialist schools where school leadership has used contrasting strategies to create supportive environments. These examples perhaps shed further light on this issue. The urgency students and parents feel about their environments cannot be ignored at a time when education is an act of consumption and pressure is exerted on policy '... through individual consumer actions, such as by attending school or not, going to this school not that one, enrolling in this program not some other program. It is also exerted by political actions, such as by supporting expansion of educational opportunity and preserving advantage in the midst of wide access.' (Labaree, 2010, p. 18). It should be remembered that actions of students and parents are not necessarily always motivated by the conscious seeking of advantage, but also by the desire for safety and comfort. STEM programmes may be used also for this purpose. While I consider this to be a less efficient use of such programmes, the need for students to escape certain school environments is worthy of further consideration, and certainly of compassion.



## Chapter 6

# Differentiation on the ground: focusing on Sweden and Finland

This chapter explores the ways in which structures of differentiation such as ability grouping, special schools and acceleration are expressed in Swedish and Finnish schools. As acknowledged in the previous chapter, the claim that differentiation takes place in these countries' school systems is controversial. Yet, as I demonstrate here, differentiation can be expressed in analogous structures in subtle forms despite the apparent lack of gifted programmes in those countries. Such structures may in fact be problematic because of their lack of visibility.

This chapter was motivated in part by the results of the survey analysis, reported in Chapter 4. I had originally supposed that in the Swedish and Finnish models relationships between the Gifted ID variables and other outcomes would be less or non-existent. This was not the case; these variables were also active in the Swedish and Finnish models. It was clear from the interviews that students, particularly in Sweden, had experienced dramatic forms of differentiation that were functionally isomorphic to students' experiences of gifted education in the United States, though they may not have been explicitly labelled in that way. Because of this, it made sense to model a variable across the three countries relating to the idea of early differentiation, and to explore how these different structures affected students. The finding that differentiation exists in systems that have no formal differentiation policy echoes the work of Benbow and Stanley (1996) who noted first how differentiation occurs in Swedish schools.

Structures of differentiation in Sweden and Finland are hidden, and are often denied. For example, when I asked Anna, a student at the Magnet Gymnasium in Sweden if she

had ever had the chance to be accelerated in mathematics and she was adamant ‘No, the Swedish school doesn’t work like that!’ However, as I will demonstrate, for many of her peers the school system did indeed function in that way. This chapter draws primarily on interviews with students and teachers. Despite the purported absence of such structures in common discourse on these educational systems, I argue, differentiation does exist and it makes sense to include a measure of ‘gifted identification’ in each country,

This research project began with the naive assumption that differentiation in Finnish and Swedish schools before the end of compulsory schooling would be insignificant. This impression is strong and widespread; I have encountered educators from the United States in Helsinki, seeking professional advice as to how non-differentiating policies might be implemented in American schools. The general impression of non-differentiated Finnish and Swedish schools is often used to argue for increased equality in American schools (Oakes, 2008), and I hesitate to disabuse people of it. However, this impression is increasingly false.

It is now widely accepted that at least half of Swedish compulsory schools engage in ability grouping (Skolverket, 2006, p. 30). Despite the laws prohibiting ability grouping in Finland, I argue that an increasing number of students experience if not ability grouping per se, equivalent stratification according to similar criteria. In addition to in-class and in-school differentiation, differentiation increasingly occurs through the mechanism of compulsory schooling as this policy has extended in Sweden and Finland. Increasingly, then, students in Sweden and Finland are experiencing differential access to mathematics and science learning before upper-secondary school, and accordingly, they are developing different dispositions towards mathematics and science learning.

## 6.1 Stratification in Sweden

Originally, stratification in Sweden was the simple structural contrast provided by the choice of natural science or social science tracks. However, as research progressed, it was soon impossible to ignore other forms of differentiation that were arising as important to student trajectories. The first was differentiation before upper-secondary. This was occurring both through ability grouping and acceleration, opportunities for which were intertwined with between-school stratification. Indeed, increasing inequality of provision between schools due to extensive school choice and rapid expansion of publicly funded private schools is a rising issue for educational policy in Sweden today. A second issue was

the lack of transparency in how courses were named, allocated and graded, particularly at the upper-secondary school level.

In this section, examples of ability grouping and acceleration during compulsory school will be given, followed by a discussion of differential access between schools, and finally hidden forms of differentiation at the upper-secondary school level.

### **Ability grouping in compulsory school**

Rather surprisingly, many of the students interviewed in Sweden had experienced explicit ability grouping during compulsory school. For Belen, a first generation Swede attending a suburban school, differentiation began in Year 6:

Belen: They gave me extra work—it wasn't just me, we were a bunch of students and they divided our class in three parts in three groups after how good you are in all of the subjects. Because we were, like, my group most of us were good at all the subjects so we got harder tasks than the rest of them and the ones that needed extra help they got it and so.

For Belen, being placed in the high-performing group was a positive experience. A confident and ambitious student, she was continuing on to study law at the university. In Belen's case, the ability grouping was more or less transparent. However, many students in Sweden reported that there was an attempt to obfuscate the hierarchy of the ability groups by labelling the groups according to colour, for example. Separating groups according to colour, as was reported by many of the students, did not prevent them from recognising immediately the different levels.<sup>1</sup> For example, in Göran's experience, brought the following up when I asked about whether he had been able to visit his previous, prominent private school's observatory (which he hadn't):

Göran: But we did have, interestingly enough some kinds of lectures you could say and for math it was divided into four groups or something. Like, the blue ones—that was what you would call G level and the red ones that's VG and the black ones—that's MVG and I was, I was transferred to the black groups and I mean that kind of sparked, that was a huge motivation for me because actually I started out in the blue group actually in seventh grade and then I actually worked my way up to the red group and then the black group.

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<sup>1</sup>Students also mentioned the use of different colours as a scheme for publishing books for different levels.

However, as research in other contexts has amply supported, ability grouping in Sweden also created negative experiences for other students. When I interviewed Maj, she was attending a prominent private school in Sweden and enrolled in the social science track. Maj was actually very interested in mathematics and science, but told me that she did not dare to select the natural science programme because she considered herself too weak in mathematics in particular. I asked her what made her think she wasn't good at math:

Maj: Because I've never felt comfortable when I've, like, done maths my teachers— well in school we had like, the first grades we did some tests and then they categorised you in different groups and when I did the tests it showed that, well, you're in this G<sup>1</sup> group then you strive for a G and not that much more (...) I got like categorised into this group and then I thought well that's maybe where I am in maths but I think if they would have had another system then maybe this wouldn't have happened. because when you get categorised, it's maybe hard to get out and develop (...)

Even if I would have wanted to— Of course I studied hard to reach my goals, but I felt that when I got categorised like this that there was no way out or well I was here in the G group and I couldn't develop that had the impact that maybe I didn't put so much effort in maths.

In Maj's case, differentiation by ability grouping occurred early in the first grades of compulsory school. It had a profoundly negative impact on her self-concept in mathematics in particular. This was compounded by the fact that in the Swedish system, all students take the same national exams, whether or not their classes have prepared them for the material. For example, Maj was placed in a class where the access to the curriculum required to get the highest score on the national exam was simply not available.

This issue, of differential access to curriculum between students who are nonetheless required to take the same exam is echoed at the upper-secondary gymnasium level as well, discussed below. Furthermore, Maj's trajectory in mathematics and science is impacted not only by access, but by how her placement shapes her self-concept and ultimately her habitus as a mathematics learner. Maj shares the frustration and anger of the students described by Zevenbergen (2005) in Australia, students who similarly were separated into classes where they simply were not given access to content needed to attain a good score on the national exams. Her experience, while specific to the Swedish context, at the

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<sup>1</sup>The lowest passing grade on the national exam.

same time echoes the experiences of students in systems considered more highly stratified in the United States, England, and Australia (Hallam and Ireson, 2007; Noyes, 2007; Zevenbergen, 2005). The negative outcomes for students' like Maj include discouragement and lessening of motivation are familiar in research that considers those other national contexts.

The similarity between these students' experience in Sweden and other national contexts suggests the durability of this structure across different educational systems. In Sweden, however, while ability grouping might be less standard and certainly less visible, it is thus perhaps more insidious. It should be noted that while somewhat hidden, such ability grouping is so widespread that course books are published at different levels accordingly. Thus, during compulsory school, it seems likely that it is now common-place in Sweden for students to be receiving differentiated curriculum, whether or not it is obvious to the students and their families. As will be discussed further below, part of such differentiation, which continues at the upper-secondary gymnasium level, seems to be in part to a response of perceived between-school differences amongst incoming students. The overall context is one in which between-school differences as well as the importance of socio-economic background have been increasing in Sweden (See, e.g., Yan-Hanson, Rosén, and Gustafsson, 2011) in tandem with the increasing use of school choice and private education.

## **Different schools, different opportunities**

Again, Scandinavian countries are often seen as exceptional, particularly with regards to social mobility and equality, but the situation in Sweden seems to be shifting. In France, Broccolichi (1999) described how the lower secondary schooling impacts the transition and success at upper secondary school in France, and in particular how it is related to the general social origin of the schools students attended prior to upper secondary (p. 442). Students enter upper secondary believing themselves to be strong students, but once confronted with competition from classmates coming from more affluent schools who simply have learned more, and are better adapted to the new setting, they rapidly find their academic ambitions limited.

This is also true for students in Sweden encountered in this study. The transition to upper-secondary made differences in previous school apparent to students. Josefina, for example, a student in the natural sciences programme at a historic, selective school in the city centre, experiences this. Though she had had the opportunity to study ahead

at some points during compulsory school, she experienced a shock when arriving at her elite upper-secondary school. She attributed her discomfort to the disparities between Swedish schools:

Josefina: It is because of the education system because each school has different... they keep there how do you say level, knowledge differently. So I know people from other schools who came here as well and they know a lot more mathematics than I did when I came here. So its like if you go to this [lower secondary] you know this much and if you go to another one you know more so when I came here first it was a level difference between me and my classmates so I had to like do an extra effort to reach up to their level as well as the, as the courses like went on I had to step up to that as well.

JS: So did you ever consider not making the effort, I mean did you consider—

Josefina: No I don't think so, cause I've always been very, ah eager to learn as well as em like competitive and I, I always thought it like a failure to be ah— on the first test I had a G, like the lowest grade but it was still...

JS: It's passing

Josefina: Yeah, and I was like oh my God because even though I had not focused so much on the mathematics in 9th grade, I was still like yeah it went good but when I came here it was like (gasp) oh my god it was a shock to me that I was not that good at math as I used to be, so it was like a personal challenge for me to reach out to the other level.

Josefina has strong resources, including family support, and a positively adapted habitus towards schooling that leads her to increase rather than decrease her investment in mathematics and science in response to the challenge. However, other students did not have the same personal resources as Josefina. The most interesting aspect here, however, is that despite Sweden having relatively equal schools historically, teachers and students recognised significant differences in learning according to the compulsory school that students attended. Part of this was due to the many different programmes of acceleration, which varied greatly between schools.

## Acceleration

Particularly in mathematics, some of the students had had the opportunity to work ahead, but acceleration was one of the least transparent structures in Sweden in that not all students were aware that such options were legally available. Furthermore, not all upper-secondary schools were prepared to handle accelerated students. For example, I asked one student at the Magnet Gymnasium if she had ever been given work or allowed to accelerate in mathematics and she said: ‘No, the Swedish school doesn’t work like that!’ Even schools were confused about what to do with students who had been accelerated, as will be discussed in the following section.

Returning to the example of Josefina, attending the elite Historical School, she was studying Year 6 mathematics in Year 4, but was not able to maintain the acceleration when switching teachers. Ending up at the regular level, by Year 9 she was bored:

I thought mathematics was so boring because it had been easy for me my whole education and I was like screw this I don’t need it [laughs] and I didn’t go to the lessons and I didn’t care for the mathematics. But then when I came here it was very hard for me to catch up with the other students and it was a challenge for me and then my interest for mathematics began to grow again.

Even though her school scrapes together a special class for Year 9, it is poorly organized and Josefina and her classmates stop going. Despite skipping class, she gets into an extremely selective and serious school, and responds well to the challenge it provides. Hers is an example, however, of how the acceleration within the Swedish system is poorly recognised and often, in a sense, ‘wasted’ as students transfer to new environments where the acceleration is not recognised.

Likewise, Bengt, at a small private magnet school, was accelerated early, eventually becoming part of a class that skipped the entire Year 6 of mathematics. When he began upper-secondary, he had already taken the first course of gymnasium level mathematics. As the case with Josefina, not all Swedish schools seem set up to recognise acceleration:

When I started the school did really believe me when I said I had done math. A but after a while I got. . . well I got well—I didn’t have to go through lessons and I read Math B alone did the national test and got a grade and then started reading math C (. . .)

Bengt ends up being accelerated in a solitary fashion, he works ahead of all the students at his school. As a consequence does not ever feel part of the community at his small specialist school, one of the main benefits of the school, as his classmates describe it. In addition, acceleration does not seem to give him reprieve of the boredom; boredom is a common theme in Bengt's interview. He is accelerated despite having imperfect performance. He goes fast, but he is not challenged, as the students at the magnet school in Finland are, discussed in Chapter 8.

The rationale behind the acceleration that students experienced seemed to vary from offering gifted provision, to assisting students in making an easy transfer to upper-secondary. Bengt's example brings into question the value of simple acceleration as enrichment, and his experience combined with others, such as Josefina, highlight how acceleration is not recognised by all schools, thus perhaps making it more difficult for students to recognise the benefits of that form of stratification.

Yet, along with ability grouping, acceleration seemed to be one of the most striking ways in which students were differentiated at the compulsory level in Sweden. In addition to a lack of transparency in the chaotic way it was implemented, the lack of transparency in the existence of such pathways, and the mechanisms of access also seemed to be implicated in increasing inequalities.

### **Inconsistent access to acceleration**

In contrast, Josefina's classmate, Inga, and Bengt's classmate, Stefan, both come from more remote, suburban lower secondaries. They were not allowed to accelerate in mathematics or take exams ahead of other students. Stefan, who was attending a private magnet school, shares a similar story in that he lost interest with mathematics he found too easy during Year 9 and began to skip school:

Stefan: (...) In 9th grade, the last term of 9th grade I didn't have to study at all in math cause it was going to slow and I'd already done everything and I knew everything I had to know to get an MVG in math so I spoke computer games with my teacher because I had nothing to do and he couldn't teach me Math A the gymnasium course so I just walked around doing nothing—

JS: So why couldn't he teach you Mathematics A?

Stefan: Cause - I don't know - he hadn't permission? I didn't ask and I didn't think he could [tell] at that time but then when I got to this school I realised

that one other person had already done Math A and it was a like option for people everywhere to do Math A and so on before gymnasium. But I didn't do math a before and that's why it got so slow that I didn't study at all math and when I got to gymnasium it got harder and because I was like used to, I was used to not studying I didn't study at all then either and then it got harder and harder and harder and I still didn't study because I didn't know how I forgot and so on so I had to settle for a VG instead of an MVG and now I have to pay for that.

Unlike Josefina, Stefan, coming from a notably poorer school, was not allowed to accelerate. Furthermore, he did not have the family support or adaptive habitus that helped her through her transition and while reforming her study habits. Stefan's father was not able to complete his education, and he describes his mother as having a break down ('she went through the wall'), living in a remote area outside of the city, and getting through the day with the help of pills. He avoids contact with her. Stephan also describes himself as the best student in his former compulsory school in mathematics. Like Josefina, he started skipping class in 9th grade because he was bored. In contrast, he describes his standing at his gymnasium, a new private school as: 'I am the least smart person in my class, I can't—I don't know anything so I am low at that. But I manage though...'

However, Stefan isn't managing according to his teachers. He fell in with a rough crowd, once he moved to the city to attend the school and escape his mother, and has spent his final year trying to right his course with a sort of uncomfortable, frantic optimism. Unlike Josefina, he struggles to develop the self-efficacy he needs to accomplish his academic goals. Instead, he asserts that he has 'never had to change my ways,' even as his school work and participation in sports has declined. He elaborates: 'I still look good and so on, so I don't have to train, I don't have to practice kickboxing or anything...I've never had to try, I've never had to change.' According to his teachers, though he has reached the critical point where he does need to change in order to fulfill his professed ambition of studying at university and living abroad. At this writing, he has not made that change.

Stefan experiences differences in school resources as he did when he was younger; the small private school he attends certainly does not have counsellors or nurses the way that larger, traditional state run schools would. One of the teachers notes the lack of even a janitor, despite the school's elite profile. This lack was obvious upon visiting the school, which had an unstructured, chaotic feel to it. This is not to say it wasn't an excellent school for some students; indeed it seemed to be refuge for some as discussed elsewhere.

But for Stefan the combination of lack of structure (the ease of skipping school) and the exposure to elite students encouraged a disposition that valued street smarts and ‘acting cool’, something where he saw himself as having an edge over the others. He identifies his school mates as ‘geeks’ but has an affection for them, too, since they do not exclude him, and welcome him when he tries to return to school: ‘Nobody makes fun of my retarded-ness, so I don’t suffer, not knowing about Abraham Lincoln or whatever.’

In gymnasium, Stefan encounters the reality that his success and the ease with which he passed through school were not easily attained. Unlike Josefina, his response was to distance himself from the school and to create an identity in opposition with it. The effects of a lack of resources and chaotic school environment are compounded by various disappointments and discouragements.

Arguably, an unchallenging compulsory school programme, followed by a challenging gymnasium environment where many of the students had had access to acceleration, fosters Stefan’s struggle to fit in with the educational environment. While others have benefited from acceleration structures, Stefan’s story is an example of how they are failing some students in Sweden. Acceleration seems common in Sweden, and is often combined with ability grouping. It also seems to be done in an informal way the is recognised and used only by certain schools, and not accessible to all students.

In the interviews, acceleration was associated with three main issues in the Swedish school system:

1. **Inefficiency:** A student may be accelerated at one school, but this acceleration is not recognised, continued or supported at subsequent schools. This calls into question the efficiency of the original acceleration.
2. **Equal access:** Clearly, not all students had access to acceleration, even students who were working ahead of their peers. Furthermore, the lack of awareness of this option, and its discovery in the form of peers who have had this advantage, compounds existing differences between students at the beginning of gymnasium, and becomes a further reason for some students to begin to distance themselves from mathematics. The way access was mediated suggested a lack of transparency in the system.
3. **Ineffective:** While acceleration helps some students, perhaps at the expense of their peers, transition easily to gymnasium mathematics, there was little evidence among the other students that acceleration increased engagement, which is surely one of its policy aims. In Bengt’s case, it seemed only to exacerbate his disaffection

and boredom.

While the concept of acceleration is important to engagement and persistence, how it is done matters. For the Swedish students in this study, acceleration was an inconsistent, haphazard structure, like a rickety staircase that didn't seem to lead anywhere. Of all the students I encountered in this study, Bengt was the only student who was able to climb it. He was already taking university courses when I spoke with him, although this ultimately did not assuage his feelings of boredom. On the contrary, he seemed to be an example of the perils of going faster instead of deeper (Horn, 2007), and his acceleration made him content with imperfect grades. His story is similar to the tragedy of child prodigies who do not develop into expert performers as adult; acceleration brings attention and instant status, but these are fleeting. In this way, acceleration can be dangerous if it results in stunted development of other valuable non-cognitive skills.

## **Teacher's perspectives**

The system of differentiation in Sweden is also problematic because of the structures of assessment that take place. Grades are by rule a defining factor in admittance to upper-secondary school and university, yet they are largely decided at the school level. The elite Historical School, for example, gives a diagnostic test at the beginning of the year. One instructor described it thus:

Teacher: ... [Students] write on this [diagnostic test] which school they come from then without being you know— we haven't done anything statistical about it but what you see is what you tend to see is that some schools names come up much more often than others when it comes to the fact that you know that a kid has a very high grade but not very much knowledge.

Amongst teachers, the differences in attainment between compulsory schools are a commonplace problem, and one that often results in additional ability grouping at the upper-secondary school level. In addition, the problems of lack of transparency in grading are also evident in teacher's experiences in upper-secondary schools.

## **At the upper-secondary level**

In Swedish gymnasiums, it looks to the outsider as if all students, regardless of their programme concentration, read the same basic courses. However, this isn't the case.

In practice, common separate courses are given for social science and natural science students. This practice is so established that text book manufacturers cater to teachers by producing different books for different concentrations and levels, even though the students will be taking the same national exam:

Teacher: They don't say that, but usually they would try to tone down the more difficult parts, usually.

JS: Mmm. Okay

Teacher: And some textbooks also have them not specific for a program but like easy medium hard, even if they don't say easy medium hard they say red blue yellow or something. This means that for some students, their mathematics course might be aiming only at passing, whereas for other students, the course is aimed at giving them the tools to achieve the highest grade, an MVG:

Teacher: Everything is the same they have the exact same tests and we grade them, we discuss quite a lot how we grade them to sort of try to ensure that it is the same assessment but obviously [in a more advanced group] I don't go through as many times how you solve linear equations compared to the lowest little group were there's only five or six students maybe, but then we practice more how do you conduct a mathematical proof. Cause that's gonna be more sort of crucial if they are going to get their excellent or very good or MVG very good where in the sort of lower groups, if you say so, they're going to focus more on the passing criteria.

This practice of differentiation echoes the ability grouping that students' described during compulsory school. Some of it is hidden: for example, by the use of colours instead of clear levels. Similarly, students are required to take the same exams, regardless of what whether they have had access to the complete curriculum. This situation led to frustration in the case of Maj, mentioned above, echoing research elsewhere (i.e., Zevenbergen, 2005).

The problem of in-school grading is also active at the upper-secondary school level. Similarly, a teacher at a small private specialist school who described himself as very angry points to the grading system as particularly problematic:

Teacher: They are, it's like a farce really, sometimes we read them and we laugh because its so absurd that anyone could read these criteria and actually use them in the real world its very many nice words but its very abstract and

the Skolverket has a policy not to specify when teachers or other people ask about how to interpret these criteria. Every teacher interprets these criteria how he or she wants. For me that is a nightmare situation.

JS: And yet the grading...?

Teacher: Differs from school to school, yes.

He says: ‘There is something rotten in the state of the Swedish education system.’ Admittedly, there *is* something curious about a structure that uses grades so automatically for entry into schools and universities—grades that are generated largely by the schools themselves as they compete in an open market. Grade inflation is perhaps unsurprisingly a noted problem in Swedish school (Wikström, 2005), with private schools being more implicated in this issue than state schools.

The Swedish teachers and students who took part in this study collectively illustrated a system that of opaque access to differentiation that, for some students, leads to an increase of confidence and drive to access elite environments, and to identify themselves as strong and capable in mathematics and science. Again, in the Swedish system, the Natural Science track holds the highest prestige academically, and it is particularly in mathematics where differentiation occurs, and is seen by some as inevitable and inescapable (Ruthven, 1987). The winners of this game joked about skipping classes, of the boredom of having worked ahead in the ‘faster but not deeper’ strategy and the wonderful surprise of finally being challenged.

For others though, the lack of these opportunities and the signals the educational structures send to them about themselves are brutally discouraging. For the Swedish system, in comparison with Finland and the United States, acceleration is a prominent way of differentiating students, but a system of acceleration varies from school to school. Between school differences interact with students’ personal and family resources, particularly at the point of transition to upper-secondary where the increased competition causes some students to reassess their ambitions and self-assessments downwards, while other students with more support increase their investment and commitment to learning mathematics and science.

## 6.2 Stratification in Finland

The premise of the Finland study was similar to that of Sweden; that is, to look primarily at the stratification implied by the choice of mathematics and science course progressions at the upper secondary level, for example, the choice of long versus short mathematics. It quickly became apparent that compulsory schooling in Finland is trending towards increased differentiation as is Sweden. Also similar to Sweden is that the increase in school choice is increasing differentiation.

In Finland, this shift is also due to the proliferation of specialist programs at the lower secondary school, an option that is used predominantly by educated parents (Seppänen and Sairanen, 2011). As discussed in the previous chapter, many of these structures, while labelled differently, are used by educated families in ways that are analogous with gifted and talented programmes in United States schools. Perhaps more surprising, and so emphasised in this chapter, is that ability grouping is occurring in Finnish compulsory schools, and that despite the relative equality of Finnish schools, there is a clear recognition of the status and rigour of different compulsory schools.

### Ability grouping

Similarly to the Swedish case, some students in Finland had experienced ability grouping, despite a legislative ban on ability grouping dating to the 1980s. Sami, for example, was taking Long Mathematics at the Large Suburban Lukio:

Sami: You know in the 9th grade [the last year of compulsory school] we actually did that kind of thing that all the people who studied math so all the people actually were separated into three classes A, B and C so that those who were weaker were in A and those who were strong in C and B was that middle, midway.

I was in C, I was put there, I wasn't asked, nobody was asked actually they were just put. Probably according to grades and when I was there at C group there were people who were even better than me and... well I to be honest I don't know what kind of studies there where in A and B groups but I suppose in C group it was more advanced.

Similar to the Swedish case, an euphemism is used to denote the different hierarchical groups rather than clear labelling. The grouping happened automatically for Sami. How-

ever, coming from a less-prestigious compulsory school, like the French students from less advantaged schools described by Broccolichi (1999), he loses his status of top of the class when moving to upper-secondary, where Sami says that ‘One thing I have come to see in comparison with the other students: I am pretty slow’. He’s increasingly unsure of university, and looking equally at the possibility of vocational school. Again, here is contrast without compensatory changes in ways of working or self-assessment.

While Sami starts off being positively distinguished by ability grouping, other students had to cope with the signal that ability grouping gave them of their lack of potential and possibilities in mathematics. Vera, for example, is taking Short Mathematics, doing extremely well at it, and planning to take well over the required number of courses. She transferred to her current large, highly regarded lukio from a school with an environment that she describes as being focused on drinking and partying. Interestingly, despite her growing interest in mathematics, teachers from her compulsory school had specifically recommended that school to her because it had a Finnish language focus, although she did not have a special interest in the subject. She had been placed in a group for students who struggled with mathematics, however, an experience that she described as negative and in contrast with her current, enthusiastic attitude towards the Large Magnet School:

JS: It sounds like you already knew you were interested in school, interested in studying . . .

Vera: In [lower secondary] I wasn’t ‘cause I have some studying problems in there. I was like slow to learn some things and teachers, they put the bad students in front of the class and it was like. . . soo insulting. A little bit but not so much, and just I was like quiet in the back of the class and studying a little bit. But I didn’t like it so much. But every year when I got older I just got more interested about studying and now I like it quite really much, I want to learn things I want to study more and more and more.

Here Vera, like Maj in Sweden, report the negative impact of ability grouping on the students who are labelled as low performing. The impact seems to reverberate throughout years of schooling. However Vera, also discussed in the last chapter, seems to some extent galvanised by her anger about the labelling. Also discussed in the previous chapter is the way she develops into an independent and strong student. By her own volition she transfers to a more selective upper-secondary school, one that is combined with the Large Magnet Lukio, discussed further in Chapter 8. There she flourishes. It is curious that both her compulsory school teachers and parents assumed that a less-academic, more

humanities- oriented environment would suite her better. This reflects the difficulties that particularly (and possibly especially young women) might face at points of transition. This is similar to the case of Monika in Sweden, discussed in Chapter 9; no one is suggesting more ambitious STEM oriented trajectories for these young women. Perhaps it is assumed that fashionable, social young women in particular are incongruous with rigorous academic or STEM oriented environments. Her example also shows how ability grouping in this case does not take into consideration non-cognitive factors like passion, interest and diligence or ‘grit’ (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011) that are key factors in the learning trajectories of students like Vera.

The narratives of students’ experiences of ability grouping in Finland are strikingly similar to student narratives in countries where the practice is more common. Again, what is of particular note is that, as in Sweden, the practice is not as transparent as it might be in the United States, England, or Australia, where the practice has been a greater focus of research. Ability grouping, and the use of acceleration, was less prominent in students’ narratives in Finland than in Sweden or the United States.

### **Awareness of between school Stratification: ‘Their 10 is not the same as somebody else’s. . .’**

For many of the Finnish student participants, however, there was a keen awareness of the status of different schools. The greatest difference came from specialist lower secondary schools, which particularly had an impact, according to students, due to their environments. Like in Sweden, however, students were aware that grades and teaching varied from school to school. Joona, a student at the Small Magnet Lukio, for example, went to a lower-secondary school that concentrated in math and science. Now attending a private magnet school he was discussing the social divisions in his school. For him there was a connection between students who were coming from lower-performing lower-secondary schools as being those most likely to experience discouragement and corresponding disaffection or dis identification with the magnet school:

Joona: . . . Because there is not exact standard to get mathematics teaching in the ylä-aste [lower secondary] and some get straight 10s [the highest possible grade] in ylä-aste but when they enter high school they realise their teaching is not that good and they realise their 10 is not the same 10 as somebody else’s. And then they fall back, and then when they start to struggle in mathematics, they start not to like it—like me with biology. And they struggle and then they

don't like it and that's when they most likely fall towards the regular students.

Joonas's recognition that scores may be equivalent, while real differences between schools is masked, perhaps particularly for advanced students, echoes similar issues within the Swedish schools system. From his point of view it is, again, particularly such students who are most likely to 'fall', dis-identify or develop a maladaptive habit towards advanced mathematics and science learning. Interestingly, for Joonas, this is tied also with students' social choices; the academic dis-identification is linked to increased socialising with students from the non-selective lukio that shares the same campus.

There was also the suggestion that more savvy students and families paid a great deal of attention to the status of schools in Finland. For example, Soila had attended one of the most elite schools in the area for compulsory school. However she decided, like Vera by her own volition and despite the disapproval of her mother and grandmother, to enrol in the Large Magnet Lukio. I asked:

JS: Can you tell me a little bit about the atmosphere there [the former, elite school] compared to here?

Soila: There—because it's a school that starts from the third grade and you have like a test to get in there—pretty much there are only the best students in there and the teachers always told us how we were better—better people than others and I didn't like that.

The status of the school was important for Soila's family as well, but she did not enjoy the atmosphere this created. The concern with status and awareness of the average points needed to get into each school also seemed to be characteristic of more privileged students and schools. Other students were less concerned with their placement. This coincides with recent research suggesting that more educated families are making use of the opportunities for specialist classes and school choice at significantly higher rates than others (Seppänen and Sairanen, 2011). This suggests that there is a majority in Finland that, perhaps bolstered by the PISA findings, seems unconcerned with between school differences and hierarchies, but also a segment of the society that is perhaps increasingly preoccupied with ensuring that their children are in superior schools and programmes not only at the lukio level, but increasingly during comprehensive school. Although open publication of average points and scores (league tables) is forbidden, nonetheless savvy students and families were keenly aware of the hierarchies between schools and the points needed to attend. As discussed in the last chapter, this perhaps contributes to a lack of transparency in the system.

### 6.3 Policy implications

While there is a common conception that ability grouping is rare in Sweden and Finland, this chapter supports the notion that it is an active practice in both, especially in Sweden. Forms of stratification like ability grouping and between-school sorting are prevalent, and their effects in the Swedish and Finnish contexts are similar to their well-documented effects in other countries, suggesting a general universality to the outcomes of those structures.

Particularly notable in both of these contexts is the way in which inequalities might also be exacerbated because those structures are not widespread or standardised. Opportunities for acceleration or enriched learning environments were not visible or available to all students. Furthermore, even within the relatively equitable environments of Sweden and Finland, the negative impacts of structures like ability grouping are highlighted by the experiences of students like Maj in Sweden and Vera in Finland. The negative impact on students' adaptive habitus in non-trivial, though ability grouping might likewise bolster the confidence of some students. Nevertheless, it is clear that it hurt both the confidence, and the future opportunities to study mathematics and science for Maj and Vera, who both have a desire to study further mathematics. This perhaps hidden practice of differentiation in Sweden and Finland should be as much of a concern of educational policy in those systems as it is elsewhere, particularly as it may be increasing. The lack of transparency presents an additional danger to the fairness of these educational systems.

#### **The interaction of transition and stratification**

Again, the interaction of stratification and transition arises as a key point in students' trajectories in mathematics and science. In the excerpts discussed here from both Sweden and Finland, there is the suggestion that high-performing students from low-performing schools may be at particular risk at the transition to upper-secondary. There is a theme throughout the interviews of confident students experiencing a shock at transition, despite having sailed through lower-secondary mathematics and science. Students from higher performing schools, and with strong school and family resources, like Josefina, discussed in this chapter, are able to adjust their course. Other students, however, are at high risk for setting their course away from mathematics and science.

Furthermore, particularly for those students who had been high achievers, the sort of

automatic high-performance without effort that characterised their compulsory school mathematics and science careers faltered at the transition to upper-secondary school as they encountered more competitive environments as well as increasingly difficult material. Perhaps this was due in part to the relation of structures like ability grouping to a non-adaptive fixed-mindset (Dweck, 2006) in contrast with the adaptive, effort oriented growth-mindset that students like Josefina (or Sakari, discussed in Chapter 9) develop with the support of their family and school communities. Structures like ability grouping as policy are more congruous with a fixed-mindset.

However, what deflects these students from possible trajectories towards mathematics and science is likely not a lack of ability, or even interest, but a lack of adaptive, non-cognitive skills like self-concept and the belief that they can succeed with effort, rather than that they do not have the essential ability to succeed in advanced mathematics and science. Students' experiences with this intersection of stratification and transition highlight the importance of the adaptive habitus in student persistence.

In the next chapter, student the effect of other structures, structures of extra-curricular learning and enrichment will be discussed in relation to the development of other aspects of an adaptive habitus towards, and persistence in, STEM fields.



# Chapter 7

## Enrichment and extracurricular learning

The models in Chapter 4 demonstrate the strong connections between extracurricular involvement and persistence, as well as between extracurricular involvement and adaptive habitus. The models also show how extracurricular involvement is closely linked with family background, gifted identification, and educational track, and in some cases, dependent upon the school. These connections are suggestive as to how enrichment functions: it may be a valuable tool in both encouraging persistence, and in developing adaptive non-cognitive skills, and accessing such activities is dependent on family background, and a student's allocation of track and school (Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2012). Enrichment can also be another way of stratifying or differentiating students.

Drawing primarily on the student interviews in all three countries, this chapter explores the effects of different extracurricular experiences— or the lack of them— have on students and on their intentions to persist in STEM fields. The discussion in this chapter is organised by key types of enrichment, participating students experienced across the three different settings. These are:

1. Competitions as enrichment and indicators of talent
2. Camps versus real research experiences
3. Enrichment through induction into the family profession
4. Student driven computer technology extracurricular activities

5. An example of a non-selective highly effective enrichment programme.

An analysis of what *participants* described as effective experiences (in terms of increasing their interest in and commitment to persisting in STEM fields) across these different types of enrichment, as well as the three different national settings, suggests a characterisation of effective STEM enrichment. I find that the most powerful enrichment experiences are ones that expose students to real science and mentorship. Such experiences helped students imagine themselves as future STEM professionals. This supports the findings of Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012, pp. 19, 21) in England that students must be able to conceive of what it is to be scientist, and be able to imagine themselves as one, in order to persist in science.

In the course of the interviews, students were specific about what type of activities they found transformative to their interest and desire to persist in STEM fields:

- Activities involving authentic, real-life experiences of science and engineering
- Exposure to STEM professionals and authentic working environments
- Activities that involved a sense of inclusion into a community of practice
- Activities that were challenging and open ended, with no pre-determined correct solution.

The characteristics of enrichment programmes presented in the list above are effective in two ways. First, programmes of these types show students what real mathematics and science are, and exposes them to the wonder of STEM learning. Too, such programmes have the capacity to acculturate or inculcate students into STEM disciplines. That is, they also provide the opportunity for students to develop a sense of identity and habitus within a STEM discipline.

## 7.1 Competitions

While science enrichment might involve laboratory experiments and research, mathematics enrichment usually involves competitions. Many of the students interviewed had taken a mathematics test as a competition at one point or another during school. For some, the tests provided encouraging information, but for others, the tests were a signal to invest time and energy in other subjects. Charles, for example, was taking Higher Level Mathematics in the IB programme at the Historical Lukio. While he longed to continue

his studies in mathematics, he noted that he had never done well in competitions, or been able to train for them. In contrast, he had been able to be involved in many enrichment activities related to medicine (his case is discussed in more detail later in this chapter), and was aware that this gave him an advantage in pursuing that subject. Because of the competitions, he abandoned his ideas of studying mathematics further in favour of medicine. Efram, in the small IB Gymnasium in Sweden, had a similar negative experience of his mathematical skills in competitions. His performance in these were for him a signal to focus on other subjects: ‘It confirmed my belief that I didn’t have a natural gift for it.’ Notably, he confessed to never training for the competitions.

One aspect of mathematics competitions that might lead to mixed effects overall is that while there is widespread access in theory to such competitions, the training for them is limited to elite schools. That means that while many students might be taking part, and forming self-concepts in part due to their performance, only a few students are actively training for them. Thus, students coming from more ordinary, or simply less STEM-focused schools, face competition with students who are more interested, and certainly better trained—students who, by having been selected into and choosing to attend elite mathematics programs, have had more opportunities to develop true expert performance (Butterworth, 2006; Ericsson, Roring, and Nandagopal, 2007). However, when other students face this competition, there seems to be an opportunity for them to decide they do not have the ability to compete. Mathematics competitions are a key area, perhaps, when the belief to change one’s ability, or mindset, included as part of an adaptive habitus, becomes active.

Both Charles and Efram are otherwise high performing students, but neither has had the opportunity to engage in serious training for mathematics competitions. In the next two sections, I will look at examples of students who are attending a specialist school and do have the opportunity to train for mathematics competitions—the prestigious Mathematics Olympiad in particular. I will demonstrate how this training affects their intentions to persist.

## **Competitions as catalysts for growth**

Sakari is a student at the Small Magnet Lukio. When I interviewed him in his last year of lukio, he was already taking university level mathematics at the local university, and was on the Finnish national Mathematics Olympiad team. However, he described himself as not having been an outstanding student before upper secondary. Even during testing

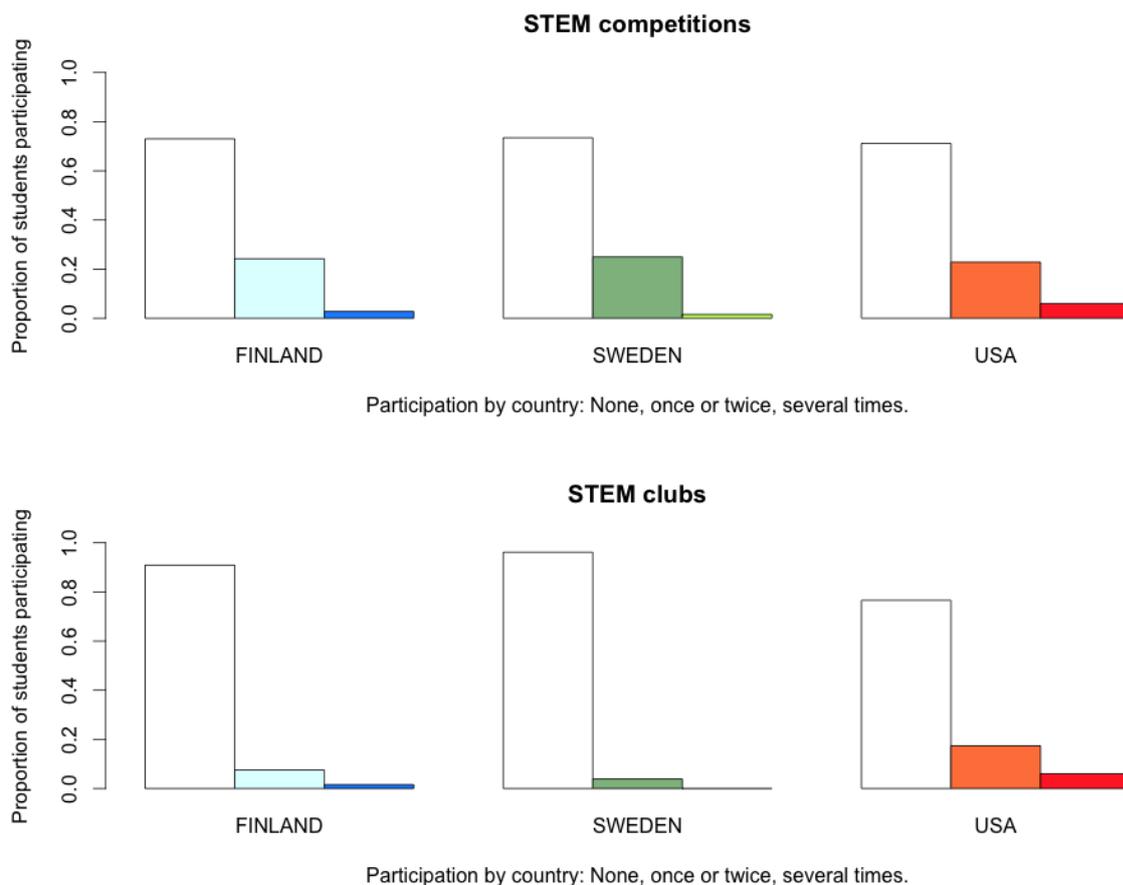


Figure 7.1: **Clubs and competitions:** students surveyed in all three sites participated in STEM competitions at similar levels. The analysis of the interviews suggests that competitions on their own may have little or even negative impact on persistence; the training and community that can develop within programmes preparing students for competition matters. However, particularly in Finland and Sweden, fewer students in the survey had accessed STEM clubs, such as robotics or mathematics clubs where training often takes place (see Section 7.5, as well as the discussion of Sakari’s progression towards STEM both here in Section 7.1 and in Chapter 9), and which can provide an opportunity for the development of community and non-cognitive skills, or adaptive habitus towards STEM.

to get into the Lukio, he did not perform as well as many of his classmates:

Sakari: In [lower secondary] there was some competitions but I didn’t do that well in that actually and the other student from our [lower secondary] who came here, he always beat me in those competitions, so. . .

JS: And what about now, may I ask?

Sakari: Now I beat him like every day. [laughing] Well, it's—it's more about being interested. . .

What is particularly remarkable about Sakari is that in addition to a demonstrated high level of performance, he held some of the most adaptive beliefs of any of the students I interviewed. He started out curious but unsure of his own ability, and ties his tremendous success to effort: 'I think if you're really interested in mathematics then that's the equivalent of being good at mathematics. I mean, I don't consider myself exceptionally talented but I just consider myself exceptionally interested in mathematics, so, you just have to do hard work.' Sakari demonstrates passion and perseverance (Duckworth, Peterson, Matthews, and Kelly, 2007), the willingness to dig into the discomfort of deliberate practice (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011) and, perhaps most importantly, a growth mindset (Dweck, 1999, 2006). These attributes emerge as part of his participation in intensive training for mathematics competitions:

Sakari: Well, obviously I just noticed that when I trained more then I could do better. For example after I got chosen to the team then before the competition we had like, um, two months of training and I learned really much—a lot about competition mathematics during that time and I really noticed that it does make a difference how much you train.

It is notable that Sakari's engagement is sustained even though Finland performs poorly in these international competitions. His interest is not about the glory of winning. On a local level, though, by his engagement and drive, he surpasses classmates who entered with higher scores. His transition to university mathematics had been seamless; he knows some of his classmates already from the competitions and he definitely plans to continue to study mathematics.

## **Competitions encouraging a fixed mindset**

Schoolmates Sakari and Joona have opposite mindsets. Sakari, who evinces a growth mindset, relishes the challenge of competition and becomes more engaged in mathematics through participating. In contrast, Joona, who ascribes to a more fixed mindset, and who has always been an outstanding student is turned off by taking part in the competitions, and in particular in competing with students from schools where the training for such competitions is more intensive. Joona is an example of how even an extremely talented, interested student can get turned-off by competitions as enrichment.

Before lukio, Joonas was a high-performing student for whom learning was easy. In his eighth grade year, he was in the top ten students in Finland on a mathematics competition. His performance meant he was accepted directly into the Small Magnet Lukio: ‘I already had full points [to get accepted] here. So I didn’t even take the exam to come in here like the others. And there were only two of us who got straight in.’ Like Sakari, Joonas tried out the training for Mathematics Olympiad but he did not enjoy the experience:

Joonas: So I’ve been there and those problems are—that’s part of maths that are not easy for me. But it is also that they are not teachers who teach there. They are just some old olympiad guys who just liked it and they don’t know actually how to teach and they don’t- they start so high that if you don’t know the basics then you’re really—its no use. That’s something I...its too hard.

Joonas seemed to have a pattern of rejecting challenge. About competition mathematics he said: ‘... those are the things that I don’t even learn that well. I think they are—I don’t need them at all.’ So while Joonas used earlier competitions to bolster his self-concept, he rejected the Mathematic Olympiad competition, perhaps because it was in contrast with his view of learning, invested in the idea of natural talent.

He was encouraged in mathematics by a teacher: I think he saw through me that I’m a special one for this. As its I think its not too common that people get the information straight in and then just can use it like its always been there. That’s, yeah—and I think I think because he’s been teaching a lot mathematics I think he saw that.

Joonas has a strong self-concept and is an excellent student. He is focusing upon industrial engineering, which is the most selective programme in Finland and often the most lucrative upon graduation. However, his self-concept is maintained at the same time he avoided challenging experiences (not only mathematics competition, but biology studies as well).

Joonas mentioned that attitude was important to learning:

JS: ... Like your attitude is affecting how well you are doing?

Joonas: Yeah because I am positive, I’m positively... I have a positive attitude for this. I like to study and there’s a difference if you must study or if you like to study. (...) If you think you must study then its not that free and then you might feel ‘I have to—I have to—’ and then you learn nothing.

JS: Did you feel differently when you were at the [Mathematics Olympiad] sessions

Joona: Yeah because...because...I don't...yeah that's the— ah I get the feeling like I would be one of the not so good ones...

Joona described learning as easy for him, and that the ease was something that distinguished him. His quickness and ability, however, had also perhaps meant that he had a disadvantage in non-cognitive skills that would help him in persisting through difficult tasks and failures, important skills for long-term success. However, at the same time, he shies away from the challenge of the competitions because of a feeling that he would not be one of the 'good ones'. Maintaining that identity is important to him, echoing research on disaffected gifted-identified students in the United States. A student in a study by Fredricks, Alfeld, and Eccles (2010, p. 24) describes this phenomenon: 'So if I wasn't smart anymore then I wasn't anything, so I had to make sure I maintained that.'. The preoccupation with maintaining an identity as gifted, or as a 'good one' seems to inhibit these students from taking risks.

The competitive aspect of Mathematics Olympiad as an enrichment activity was perhaps detrimental here, because competitions are invariably also rankings. Failure is made visible. If someone believes they would 'not be one of the good ones', and they are not provided with an alternative narrative of the purpose of such competition (for example with a Growth Mindset conceptualisation of ability (Dweck, 2006)), participation might seem too risky. On the other hand, Sakari's experience shows the potential of mathematics competitions to develop an adaptive, challenge oriented habitus. Much seems to depend on the ethos of the extracurricular involvement in these competitions.

Joona's experience is also reflected in the other contexts, for example in students who participated in mathematics competitions in the United States, similarly without training. There, students described being selected by teachers from gifted classes to take part in competitions; they were not drawn to the competitions through choice. Sandra, a student at a high performing suburban high school, for example, had been taking part in the competitions for several years, yet never engaged in the sort of practice and study that Sakari accessed. As the competition became more serious, their performance relative to their peers decreased, resulting in discouragement:

Sandra: Yeah, when we were younger we would get first in both [mathematics competitions], but now there's like all these really smart schools from [a larger metropolitan area in the region-schools with dedicated training]... And it's

very depressing.

While many of the students who regularly took part in the competitions in the United States found them fun, neither Sandra nor her peers who were interviewed reported their interest to increase through participation. Again, students were selected for participation not because of interest, but by teacher recommendation, and they did not have access to the intensive training and the community or support or mentorship which were salient factors in Sakari's development in contrast.

## Competitions as indicators of talent

The directionality of the relationship between extracurricular involvement in STEM activities and eventual success in those fields is complex.. First of all, engagement and certainly success in extracurricular activities such as mathematics competitions is dependent on a host of personal and social factors, which would also predict a successful career as a mathematician. Yet the use of extracurricular performance (e.g., in mathematics competitions) as an indicator of potential is problematic. For example, writing for an audience of mathematicians, Andreescu, Gallian, Kane, and Mertz (2008) provide an analysis that conflates performance on a prestigious mathematics exam for undergraduates in the United States with the potential or desire to become a mathematician.

These authors likewise suggest that it is problematic that many women who have become professors of mathematics in the United States should have been encouraged to take such exams. They ignore a population of mathematicians who might not perform well on such contests, but be excellent researchers, or who would be discouraged by a profession that would but even more emphasis than it already does on such tests, which while useful, should certainly not be seen as the only, or most important indicator of future expertise.

This is clearly seen in the contrast between Sakari and Joona. Joona begins with higher scores and better performance on mathematics competitions. However, over time, Sakari, deeply interested in the subject and believing in the importance of hard work rather than his own ability, outperforms Sakari. The 'grittier competitor' (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011) wins here, too, although it is Joona who is headed for the more financially rewarding career.

## Summary and policy implications

Mathematics competitions are a common vehicle for mathematics enrichment, but they really only function as enrichment if involvement includes training and active participation over time. Too often, mathematic competitions serve as opaque measurements of ability, and probably are used just as reasons that students choose not to persist in mathematics and science as they do support students in pursuing these fields. Furthermore the contrast between Joona and Sakari suggest that the framing the purpose of the competition, and the challenges that the competitions provide is important. Is it an opportunity to develop non-cognitive skills or simply a test of talent? Again, whether such a structure is approached with a fixed-mindset or growth mindset is important.

There are a number of policy implications that arose from my interviews with students who participated in competitions as well as relevant literature. The importance of training to competitions might be emphasised, thus value in the hard work behind the seems, not only the performance. Also, how the competitions are used and considered are important. Are the competitions a way of signifying belonging in the mathematics community? Do we allow mathematicians to be brilliant who might be bad at such competitions? Using such contests as signifiers has serious drawbacks. For example, Timo, a brilliant mathematics and computer science student never did well on the competitions, he considered himself slow. Yet (having just one a prize for original research in computer science) he was clearly productive and creative in real life. A system would not want to exclude or stigmatise such a capable student from pursuing STEM fields. Mathematics competitions have implications both for and against persistence, but the opportunity for engagement and enrichment experienced by Sakari, for example, was a clear and important factor for him in choosing to persist in mathematics.

## 7.2 Fun camps versus real research

Some students had the opportunity to attend research camps or engage in serious laboratory work. While brief, these experiences were important for the students engaged in them. They contrast with summer camps aimed at encouraging students towards science, which across settings were uniformly described as fun, but shallow and having little impact of future plans.

## Camps to foster engagement

Sofia, at the Historical Gymnasium in Sweden, was planning to study law at the time I spoke with her, but was taking the rigorous Natural Science programme.<sup>1</sup> She twice attended a summer camp for girls at a prestigious technological university, but her experiences did not convince her to enter into science fields:

Sofia: It was inspiring, it was really fun, um, however, it hasn't really inspired me to continue because it was really simple and it was—you could see through that, okay, they let us play with liquid nitrogen because they know that we think its fun [laughing].

JS: Now its not—you don't feel there was any effect...

Sofia: No not really, but it was fun.

Sofia describes a camp that was meant to entice girls, but provided no challenge, and did not spark her interest. She was involved because of her parent's encouragement, and while it was positive experience, it did not affect persistence. When I interviewed Emelia, from the IB programme, at the Historical Lukio, she was headed the next summer to the Millennium Youth Camp. This camp is extremely selective and draws students from around the world, its aim being '... to find young people interested in mathematics, science and technology, and help them start up a career in these fields' (Technology Academy Finland, 2012). Emelia was an exceptional student, and she did not have the intention of pursuing a science career. However, for her, it was another way of pursuing self-development:

JS: What do you think about going to something that is focusing on science and technology...

Emelia: I find it a little bit, I wouldn't say disturbing but [laughs] I find it interesting in the sense that I feel that there might be a lot of people who don't think like me but I also think of it as an opportunity to also be able to appreciate sciences more...

Here, this hyper-selective programme is used in part as a mark of distinction, something interesting for an outstanding student to do. She describes the selection process of having begun with 1000 applicants to 100 in the next round to the finalist camp attendees. Both Sofia and Emelia were describing camps that aimed to build enthusiasm and excitement.

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<sup>1</sup>Sofia ended up in one of the most selective law programs in Sweden, also an example of how the natural science programme serves as the track for elite university admittance, rather than for retention in STEM fields

They centred around fun activities and provided exposure to science problems. However, when contrasted with the rigorous research experiences described in the next section, these enjoyable camps had no impact on student persistence. Whereas students in both Finland and Sweden who had access to actual research practice highlight such experiences as turning point in their interest and determination to pursue STEM careers, none of the participants who had attended light camps aimed at fostering excitement about STEM (many of which targeted girls in particular) described their participation as having an impact on their dispositions towards, or decisions regarding pursuing STEM fields.

## **Real research experiences**

In Sweden, Inga attended the Historical Gymnasium and heard about an opportunity to be involved in a summer research program the summer before her final year. A university scientist who came and spoke with her class introduced the program. For Inga, the ‘hands-on’ involvement with research problems and the professions was crucial in persistence. In fact, it proved to be pivotal to her decision to pursue science after gymnasium:

Inga: We had these glasses and the lab coats and it felt very real and I was like out in the world doing experiments and it felt very exciting so I enjoyed it.

For Inga, it was not only the science, but the authentic setting that was important. Being in a real laboratory with ‘glasses and lab coats’ was a pivotal experience for her deciding to pursue further studies.

Tanvi, also in Sweden, had a similar brief but formative laboratory experience. Tanvi attended the Private Gymnasium, which shared among its chain of schools a special science centre. Tanvi attended an intensive biotech enrichment course there, and described it as pivotal in her desire to continue on with biology: ‘This is something I want to continue with (...) It really helped me to choose what I wanted to do in the future.’ To Tanvi, the experience working in a professional-grade laboratory setting with research scientists was a ‘whole new level’, importantly one that was distinct from what she could experience at school. Tanvi regarded the laboratory work as formative to her aspirations, although the experience was short in duration. For Minna in Finland, attending the Large Magnet Lukio, participating in a dissection lab affirmed her desire to study medicine:

Minna: It was one class where we were cutting all the heart and the like eye and stuff and it was really interesting.

JS: Wow an eye would be...

Minna: [laughs] It was pretty gross.

JS: And so is that something that you think is typical for lukios or is it special here that you get to do that...

Minna: No, yeah it's only here.

JS: Because it sounds like quite a bit—So what did you think about that experience

Minna: I think it's really cool and it was really good for, like, for those who consider to take like medical science or something like that it's like good to see what it's like

In this case, Minna had access to this special laboratory because she attended the Large Magnet School. The interesting thing though, is that she was not enrolled in the special natural science concentration. Rather, she was in the ordinary line, and furthermore, taking Short Mathematics. Even so, she was able to access real laboratory work through her school that affirmed her desire to study medicine.

At the same school, a fieldwork expedition helped Soila decide that she did not want to be a biologist: looking at through the microscope at a water sample 'I realised that biology isn't my thing [laughs]'. She was enrolled in Long Mathematics and the natural science concentration, and the experience helped her to narrow her interests towards mathematics and computer science.

For Inga, Tanvi, Minna and Soila, real research experience helped them imagine their future careers in science. For Soila, it was also helpful in discovering what she didn't want to do, and narrowing her focus to mathematics and computer related fields.

## **Laboratory work as apprenticeship**

Lily was a student at the Private Gymnasium. When I interviewed her, her extensive research project, involving green tea and cancer cells was a finalist in a national competition. She had conducted laboratory work for the project at a prestigious research institute where her mother works:

Lily: So I have to learn the basic how do you do the cell culture and everything. I don't know how to do that because the school doesn't programme—they do

not have it. So I asked my mom, can you ask your colleagues, I can come to your lab for two weeks and learn the basics?

She described it as a ‘memory for a lifetime’. This was one of the many laboratory experiences Lily had had through her parents, she noted that she had been in labs since she was six years old. Her father identified herself as a natural scientist after she took one of his goldfish and cut it open to see what it was like inside (‘Well I was just curious’). Despite her father being a ‘fish lover’, he was not angry. Lily recalled him saying, ‘You’ve got talent!’ Her father’s reaction was to identify her as a scientist.

Lily was passionate about the idea of science, that there was always a question to be answered, and the possibility of working towards a cure for cancer. Beyond interest though, she was becoming comfortable in the laboratory environment with other scientists who she noted had ‘funny humours’. Beyond the content there is the opportunity to absorb the ways the laboratory environment functions, and how science is done in practice. In Lily’s case, family connections were critical to accessing the valuable laboratory research experience she enjoyed.

## **Summary and policy implications**

For participating students, crucial experiences of participating in camps and laboratory work were not necessarily long in duration. Rather, the salient experiences shared key themes. They were:

- Challenging environments seemed to be important to true engagement
- Authentic research experiences trumped fun and amusing ones for being linked (by students) to persistence
- Students appreciated being involved in real research outside of typical classroom settings, in settings that modelled professional environments

This is in contrast with many enrichment programmes, which in the name of access, focus on fun or light STEM activities. Students in this study were attracted instead by more authentic experiences. That programmes of short duration seemed to be effective in promoting persistence is worthy of further investigation. Perhaps with enrichment the focus should be on quality over quantity.

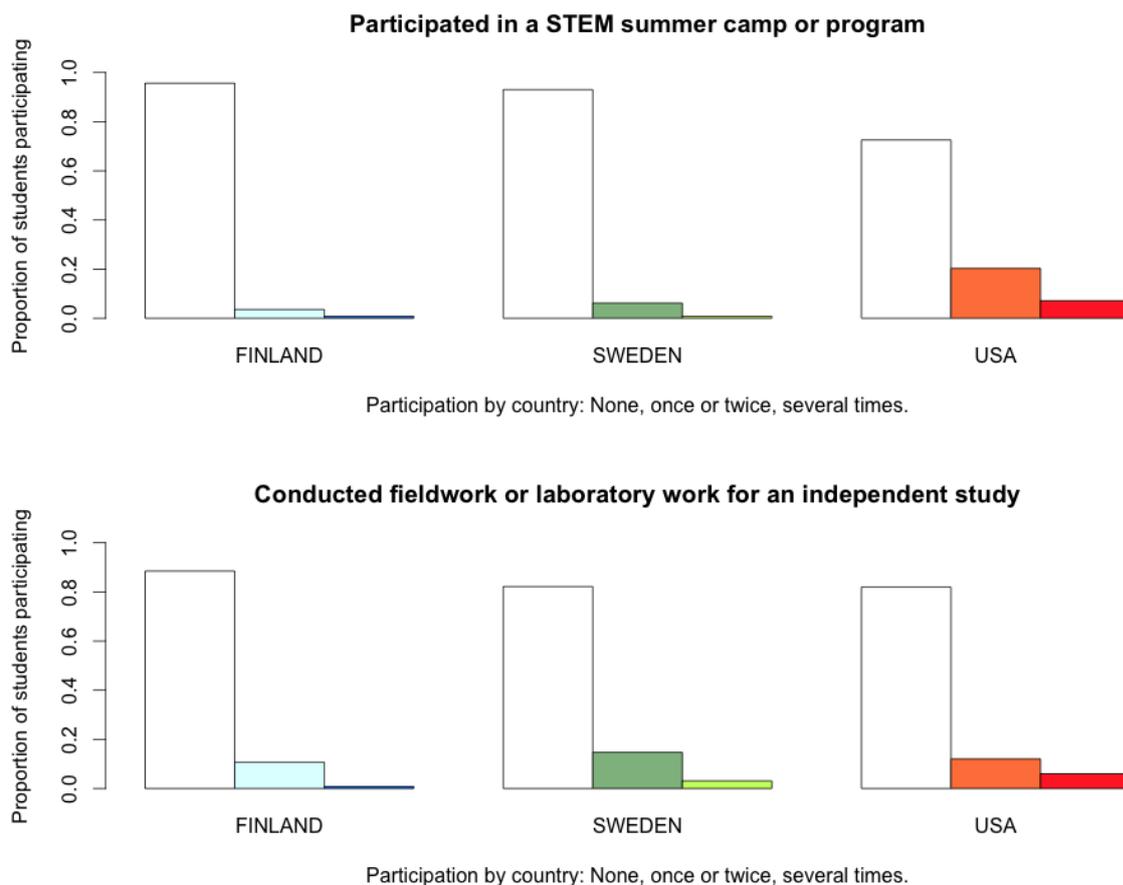


Figure 7.2: **Camps and Research:** the interview analysis suggests that real research experiences facilitated persistence more than light summer camps that aimed at engagement in STEM fields. While students had similar levels of participation in research across the three sites, United States students surveyed had attended more camps, which this study suggests are less efficient in their impact on STEM persistence, see Section 7.2.

## Gender

In the course of the interviews, young women in particular noted how real-world laboratory experience was formative. This suggests that getting the hands-on experience may be particularly helpful to young women, and young women should be targeted with challenging, real research experiences rather than experiences that merely promote fun in order to develop enthusiasm. Real, challenging experiences in the laboratory had the benefit of helping these young women imagine themselves in a science career, and developed their adaptive dispositions, their habitus, towards work in these fields.

## Access

The students I spoke with were accessing the research experiences through their schools. Inga, for example, attended a local university programme that was advertised in person to her elite class at the Historical Gymnasium. Inga's experience is typical; extracurricular activities are often most heavily advertised to the most privileged students. Tanvi, Minna and Soila accessed special programmes particular to their school.

Given how well received research experience programmes are by the students who attend, it is worth asking how such programmes can be scaled up. Tanvi's private school offers one possibility. A chain of schools share a single science centre with high-tech laboratories, where research scientists come to give some of the tuition to students. The students rotate through for intensive courses.

According to the young women I spoke with, such intensive short courses, even a week or so at a time, had a big impact on their desire to persist in STEM fields. One can imagine a municipality, or group of municipalities sharing such a science centre, saving lab costs, and allowing students to engage in real research and laboratory work. Further school-based ideas for engaging students in real research are given in the next chapter.

## 7.3 It's all in the family: accessing powerful enrichment experiences through family members

Some of the most powerful examples of intensive enrichment came from students who were following the career paths of their parents. As demonstrated by Lily, mentioned earlier, enrichment activities can be a direct extension of family capital and habitus. The families were invested in providing opportunities for their children, while at the sometime not directly demanding they follow a particular path. Instead, the enrichment activities engaged and interested the students, providing valuable experience,, but also lead the students towards the 'family career.'

### Inevitability

Charles is an example of how the family, through the use of extracurricular and enrichment activities, can shape a students' trajectory towards STEM fields. He was an IB

student at the Historical School was interested in many different subjects, but particularly mathematics and physics. He spoke with a bit of longing about it:

Charles: Well, I was thinking I love the Cambridge program that you have and there you could have taken the theoretical physics slash maths path and then you could have gone to quantum physics from a maths oriented perspective, and that's what I would have wanted to do but then it was too late because I didn't have the physics so that's why I had to abandon that one.

His parents had not been pleased about his ambitions:

Charles: Mathematics was as a subject—as a subject it was so interesting and then, as I had lots of discussions with my mom and my dad, and my dad, he said that it's not a good choice because you're, most likely you get a job that's—it's a fun subject but then the career prospects may not always be— or you don't know where you will end up and maybe, well for example becoming a math teacher is not something I like but then there's not many things that you could do with a maths degree, other than a limited amount of things. But I think maths because it's so I like maths and it's interesting so that's what got me into thinking about it.

Despite his desire, Charles could not see himself as a mathematician, particularly in contrast with the path he ultimately chose: medicine. Charles's father was a doctor, and over the years Charles had engaged in many enrichment activities and volunteer work related to medicine, including doing job shadowing at a hospital and volunteering with disabled and sick children, and the Red Cross. He became aware that such experiences would give him an admissions advantage when applying to British schools, The extracurricular involvement is '...one of the reasons I decided to go with medicine because I thought that's the one subject where I have a realistic chance of getting in, if I apply.'

His activities put him 'in a better position to compete'. While his choice of medicine seems genuine, the degree to which he has been guided in that direction isn't apparent to him. He reasoned that his extracurricular activity '...perhaps shows that I'm more into medicine [than mathematics] because that's what I've chosen over doing math problems.' His choices, however, were clearly formed within a particular family habitus and by accessing the professional resources and guidance of his father. For him medicine, a goal out of reach for most, is described as a sort of inevitable fall-back plan, but one which, nevertheless, enrichment has been important in achieving. Enrichment helped Charles realise the goal as well as to develop a sense of comfort with the profession. His is

activities allowed him to easily imagine himself as a future doctor.

## **Summary and policy implications**

Both Lily and Charles were among the most committed future doctors and scientists interviewed. The enrichment that sends them on this path is entwined with their families. Their families provide the opportunities and the direction towards STEM activities, but it is the enrichment that they access through their families that provides authentic, real experiences and exposure to the workplace that the students cite as decisive in their continued interest. The extracurricular activities seem to be a key channel through which the transfer of STEM capital (or science habitus, in the terminology of Archer, DeWitt, Osborne, Dillon, Willis, and Wong (2012), is transferred.

Designing enrichment activities, it would be wise to consider what families rich in STEM capital do for their children, particularly when they seem to be encouraging their children to persist in STEM fields. Here, Lily and Charles are given opportunities to test their interest in real settings. They are exposed to challenging, authentic activities such as first aid and laboratory research, as well as exposure to other professionals in addition to their parents.

## **7.4 Informal enrichment: ‘developing on the outside’**

In the previous sections, I described how students accessed STEM enrichment programmes and activities through more or less structured and formal activities. However, I also encountered other students who pursued extracurricular STEM interests in informal settings that were not necessarily recognised by the schools they attended. Strikingly, all of the students interviewed in this study who aspired to computer related careers developed this interest in computers and technology primarily ‘on the outside’ as Cory from Sahale High School in the United States described it in the pilot research. Their activities represent part of a wider trend of students developing technology related skills outside of formal classrooms, often through gaming and leisure involvement (See, e.g., Kafai and Peppler, 2011).

Particularly in the absence of school curricula focusing on computers and technology, such

informal learning settings become increasingly important to the development of saleable technology skills. They are also the avenues through which students develop identities and assurance to aspire to future careers and education in related fields. Accordingly, ‘Educators should be especially interested in DIY [do it yourself] communities given the amount of time youth voluntarily spend in intense learning as they tackle highly technical practices. . . across various DIY networks’ (Kafai and Peppler, 2011, p. 89). Yet, across the countries included in this study, this development, as Cory forcefully stated, is happening *outside of class*. For the students who are so engaged, progression to further studies becomes a natural extension of their own interests and the confidence they have developed in skills that are significantly, not taught in most schools, again complicating issues of access. Here, the extracurricular involvement is truly extracurricular and student driven.

## **A natural progression**

Rauli, a student in Finland, has been at times an indifferent student. It is his independent, extracurricular engagement with computers that acts as the thread that propels him towards university. He was a student at the Suburban Lukio that is often ranked (in terms of test scores) as among the lowest in the municipality. The lukio is near his home, and he did not consider going to another school. His enrolment in lukio was not a foregone conclusion. He states that his preference would have been for vocational education: ‘I came to lukio because I didn’t know what I wanted to do so there was the fact that I basically want to do something for a living as soon as possible. So I wanted to go other ways than lukio, but I just didn’t know what to do. So I came here.’ In lukio he has been studying Long Mathematics and physics. He is planning to continue to university in computer science, but his back up plan is English. His career path and choice of interests have developed almost entirely through his engagement with informal learning using computers.

Like many of the Finnish respondents, Rauli describes his decision to focus on computer science as one that is independent from his parents. In fact, he described his parents as people who don’t have too much advice to give regarding his educational future: ‘I don’t really talk about school with my mother, and well, my father thinks it’s my business and not his. He doesn’t even understand the whole lukio system so he just trusts that I am doing what I think is best.’ His father, though, does work with computers, and Rauli began his interest with computers by playing games with him as a young child.

Neither has school been a decisive factor in Rauli's interests; no computer programming courses have been available to him during his school career. Rauli is not particularly concerned with grades or access to elite university programs. The environment at his school does not press him to intensify his formal studies: 'Well it's easy here, because, well, there basically is no competitions so it's—you can just sit back and enjoy. And you won't be different from others because you don't do anything.' This is a comfortable fit for him, also providing an interesting contrast with students in previous chapters who were adamant in their appreciation of more competitive, elite environments.

It is *outside of school* where Rauli finds his inspiration for further studies. His primary aspiration is to study computer science or information technology, but his back up plan in English. These two possibilities are linked through his long-term, self-driven involvement in computer-based activities:

JS: How have you gotten good at [English]?

Rauli: Well at first, basically the computer games. It all started when I was seven years old and I got a PlayStation. And my cousin bought me a game because he wanted to play it and he came over to our place to play it and he had to translate everything to me and that's where I learned for starters and well, after that I've just somehow been good at it in school and when I got a bit better at it I started to actually understand the dialogue in the computer games and I learned more from that and...

JS: Wow. That's really interesting. So in terms of your programming, when you're learning, trying to learn to do something like PHP how do you learn that?

Rauli: Well, I've mostly just gone on to the internet and searched for the guides and stuff like that and well read them and done the exercises and

JS: Are there particular places that you're getting that information or is it just like

Rauli: Well there's a lot of guides so I think there was a site that had links and ratings to different guides and I just picked those which the people thought were best.

JS: Is that in English or in Finnish, or...?

Rauli: In English mostly.

Rauli's leisure activities have also been a site of powerful learning for him. Furthermore, his access to technology learning is dependent on his language skills. For Rauli, his journey towards computer science seems almost inevitable. While many of his schoolmates struggle to imagine themselves in university programmes, or fix on a particular career, he has clear goals that fit with his disposition and experience:

Rauli: . . . And well because the fact that I've been living with computers my whole life at some point I started actually understanding some of it and that led to me helping my friends and family fixing some problems with them. And well that led to of course the fact that I'm starting to think to get a career in the business.

He describes his learning with computers in school as negligible. Although Rauli's family does not seem to be involved in helping him navigate educational structures (he describes his father as not understanding what happens in lukio), his family environment has helped to make him familiar and confident with technology. Again, family STEM capital, in this case access to computers through his father and introduction to the online world through a cousin, are key to his trajectory. Formal schooling, in contrast, did not add to his growing expertise and interest. Learning on his own, online, and from friends, Rauli has also been involved in website design, teaching himself PHP and even making some money from designing sites for friends.

In Rauli's case, the fact that his learning was completely self-directed and informal seems crucial to his involvement. When asked if he would have wanted a more structured space to learn these extra skills at his school, he was adamant that he would not have used them:

JS: Would you wish that there were, I mean like how, if there were extra programs after school or something like that. . .

Rauli: Well, I would probably wouldn't participate because well its after school I try to do and like to do things other than school and I would probably feel like wasting my time doing something serious.

JS: Oh okay, so when you were doing it on your own it didn't seem. . .

Rauli: Yah, it mostly seemed like a hobby.

The majority of Finnish students interviewed noted how formal extracurricular activities did not necessarily foster their expertise or interest in computer science. In Rauli's case, there is almost a sense that the disconnection between his 'hobby' and formal schooling

may have been positive. It gave him a sense of ownership over his activities, and kept them separate from the slight disaffection he experiences towards schooling. For Rauli, his adaptive habitus towards technology and computers outside of school is not completely aligned with an adaptive habitus towards schooling.

## **Imagining a future STEM career**

Coming from a neighbourhood with some of the lowest socio-economic indicators in the municipality, Rauli describes himself as ‘not thinking too much about the future’ during his first two years of Lukio. By his final year, when I interviewed him, though, he had made up his mind: ‘I’ve kind of set my mind on going to study information technology.’ How did this happen? A key moment for Rauli was attending an open day for university faculties, which he participated in with encouragement from his guidance counsellor. In that open day, Rauli had a key moment of recognition for all of his informal involvement with computers:

Rauli: Well I went there and checked out the booths and the information technology part of them and talked with some guys from there.

JS: And how was that?

Rauli: Well it was rather nice when they gave me basically all the information I needed on how to apply and things like that. And what they studying, and how to get in, and what is the studying in the university like. And well, they were pretty excited actually, the guys I saw, when I told them I had done some programming things and it was my hobby. They just said ‘Okay! You are coming Here!’

For Rauli, this was a key moment. First, he gained valuable information about how the process of applying to university actually works. Many of Rauli’s peers from more privileged backgrounds already have a clear idea of the process, but for Rauli, this contact was an important step in understanding admissions and what studying at University would be like. Second, the university students distinguished him as belonging because of the skills he had developed outside of school. His extracurricular activities were recognised and valued in that context. At a time when computer programming and information technology are not yet a standard part of school curricula, Rauli’s long term hobby provides him with an important distinction that aids him in forming a connection to and aspirations to university studies. Rauli’s informal learning through his computer-based

hobbies will likely be transferred to formal educational capital through certification at the university.

## **Authentic challenge**

Another aspect of Rauli's engagement was the possibility of engaging in 'real' activities. For example, he made money by designing websites for friends and acquaintances. For the students involved in DIY extracurricular engagement with computers, there was a sense that they were, through computers accessing and solving real problems. Furthermore, it seemed important to the students that the activities they were engaging in due to choice were authentic, driven by their own necessity and interest.

Göran, a student at the Magnet Gymnasium in Sweden, explained why he wanted to continue with computer science. For him, it was tied with a feeling of accomplishment despite other challenges:

Göran: Doing this problem solving is one of the most rewarding things I've done. I mean when you actually feel you've done something and your rewarded because now it works and you did it yourself—you made it work I mean that's satisfaction in a way you don't get from anything else.

JS: I was going to ask is it different than successfully completing a course in school is a different feeling. . .

Göran: Yeah, it is. Because completing a course is something you have to do and this is something you do on your own, of your own interest. You kind of get the feeling you are doing something unique for yourself nobody else is doing this I'm doing this and I'm actually solving the problems and its actually going well and I mean that kind of feeling you don't get that kind of feeling from anything else and I mean, it might have been some computer game crashing, I don't know why so I sit up, I got to figure out what's wrong and I think is it gonna be that one perhaps I need to reinstall some routines for my graphical card and I mean there are so many possibilities to solve a problem especially when it comes to computers. You've got to pinpoint those that actually work and doing that and actually getting the results that you've been expecting its just its great. I don't get that feeling else—that's sure.

Like for Rauli, Göran's extracurricular engagement with technology came through video games and was absolutely key to his intentions to persist in a computer science field

at university level. He demonstrated the development of assurance and self-confidence, and problem solving, key non-cognitive skills—but he developed these outside of school. Again, for both Göran and Rauli, the real-life, authentic nature of their activities with computers and technology is key to their interest.

## **Summary and policy implications of ‘do it yourself’ enrichment**

A number of key theme arose in the interviews with students engaged in DIY enrichment activities, First, the challenge and reward of real problem solving was important for engagement. Second, students were accessing valuable learning experiences not scaffolded by formal schooling. These informal experiences served as a point of distinction that created a sense of belonging in further education. Finally, their engagement in these activities was key to their decisions to pursue further studies in STEM fields.

For students like Rauli and Göran, engagement with technology and engineering happens outside of school. However, engagement in these activities is dependent primarily on informal experiences and networks, and access to technological resources. In this way, students like Rauli and Göran are accessing opportunities that would not be available to all of their peers. Why is this important for STEM policy, particularly regarding enrichment?

In order to progress in his extracurricular projects, Rauli took advantage of free resources, online forums and openly available to all students who have internet access. However, other students may lack the technological tools, familiarity and awareness, or self-efficacy (a sense of agency or assurance that one can find an answer online, or ask a question and get help, for example) that accessing these free resources requires. These are all things that school structures can facilitate. Today, a large quantity of learning in fields such as computer programming and web design happens online through free forums (such as those where Rauli began to learn his programming skills), and in the engagement in leisure activities or open source projects, all of which are based on creating and sharing.

Can forums really be sites of learning? The amount of free, high quality technological educational material on the internet is astounding, particularly for open-source programmes and used extensively in this research project, to for example, learn R programming. Students can access material and tips and from high-profile academics as well as fellow students. Furthermore, online communities can introduce students into ways of being and habits of conduct. For example Jared (2010) has shown that on the NRich website, which aims to provide mathematics enrichment, and used moderation in the form of scaf-

folding by University of Cambridge mathematics students, forum participants encourage each other towards high-level problem solving, encouraging persistence rather than giving each other answers. This website is an example of DIY embedded in an intentional, directed effort to engage students. Jenkins, Clinton, Purushotma, Robison, and Weigel (2006) argue that, ‘Schools as institutions have been slow to react to the emergence of this new participatory culture; the greatest opportunity for change is currently found in after school programs and informal learning communities.’ This participatory culture—and free access to it—were necessary structures to Rauli’s trajectory towards computer science. Furthermore, the creative, self-driven problem solving aspects of these activities mean that students like Rauli are developing assurance (self-efficacy) and problem solving skills, in addition to familiarity with technology.

Should the goal be to increase participation for students like Rauli, educational structures need to acknowledge what Jenkins et al. term the participation gap: ‘The unequal access to the opportunities, experiences, skills, and knowledge that will prepare youth for full participation in the world of tomorrow’ (Jenkins, Clinton, Purushotma, Robison, and Weigel, 2006, p. 3) This gap seems to be widening, as schools in affluent areas in Finland are actively teaching programming, engaging students through gaming, and allowing technology use on campus through smartphones and other devices. In schools like Rauli’s however, these resources are simply not available.

In the United States, Goode and Margolis’s (2011) work on the National Science Foundation Broadening Participation in Computing project underscores the importance of such participation, and the difficulty of implementing a rigorous, inquiry based computer science curriculum that reaches all students. Rauli’s experience shows the possible power of extra-curricular, student driven learning in real world settings, but his case also reveals how access to this learning is mediated by a student’s social as well as technological resources, rather than publicly available through school, even though his learning environment, is ultimately free and open to all.

## **7.5 Robotics: competition, community and non-cognitive skills**

Competitive robotics competitions have been rapidly expanding throughout the United States since the inception of this research project. One of the most prominent programs is called FIRST Robotics. FIRST (For Inspiration and Recognition of Science and Tech-

nology) is a rapidly expanding program with the aim to ‘...inspire young people to be science and technology leaders, by engaging them the in exciting mentor-based programs that build science, engineering and technology skills...’ (FIRST, 2012). FIRST competitions incorporate many of the policy ideas sprinkled throughout this chapter. The process of designing the robot for competition is challenging, it involves authentic, real challenges, and it exposes students working with mentors who usually include practicing STEM professionals. In particular, most teams have adult mentors that include professional engineers who are volunteers drawn from local industry. Furthermore, the organization focuses on building non-cognitive skills, such as teamwork, good sportsmanship, and perseverance, a rarity for STEM enrichment programmes.

The Robotics Team I interviewed, however, was an atypical example. Thus said, it is a, a case that provides critical contrast (Robson, 2002) with other participants included in the study. They had recently attracted media attention for being more or less kicked out of a local public high school. This was in part because of the refusal of the directors to become selective. As the oldest team in the area, the ethos of their structure was challenged as competition in increased and their hosting high school desired to have a team equivalent to what other high schools were creating. As a mentor said: ‘We are an exception from most FIRST teams. Anybody who walks in off the street is welcome here. The only thing required is that they do their best, whatever their best is, you know. If your best is sitting and sorting screws that’s okay, that’s your best.’ This is also the attitude they asked participating students to adopt.

## **Inclusive enrichment**

Their programme was not simply inclusive because of an open-door policy. The mentors went to great lengths to make it inclusive in practice. They mobilised community resources to provide food for students on the team, and provided informal tutoring to members who were struggling. Interestingly, discussions with the adults mentors from this team emphasised the barriers to participation in enrichment at many local schools. They were the only interviews with adults that raised the difficulty in accessing extracurricular learning for less advantaged students.

However, they were still competitors with the challenging task of building and programming a robot for competition. As a parent with a participating student described it, ‘They’re give a larger problem than they can solve in a shorter time than they need to solve it and they work at doing as well as they can do. And most of them do a really

good job of getting close to what they've been asked to do.' The size of the challenge means that all participants reach a point of struggle, and that struggle is an opportunity to develop resilience.

## **Fostering engagement**

The members of the Robotics Team were distinct from the other students engaged in intense enrichment activities. They were not from advantaged family background and they were not elite students. Nevertheless, they accomplished an incredible amount, and were passionately engaged with their project. Involvement had academic implications for them.

For Alex, the team captain, involvement changed his view of mathematics in the classroom:

Alex: I think its my understanding of how things work. . . Its not as frustrating any more its not. . . It has a purpose now.

JS: Do you think you have a different perspective than the other students in your class now?

Alex: Mhmm like most people are just—its just numbers and they are cranking it out to get a grade. They don't really understand why they are doing it.

JS: And how is it for you?

Alex: Well now I know it serves a purpose and it has real world applications to it. I might not always know what it is, but at least there's a reason for it.

This was echoed by his team mates. In regular, rather than elite classes, Alison contrasted her point of view with that of her peers:

Alison: 'Most of the kids in my class they don't really pay attention enough to understand the material. They don't, what I get—they don't understand why you need it. Whereas me, I understand clearly on why you need it.' As the value of mathematics increased for them, so did their diligence in the classroom.

JS: Would you describe yourself as being interested in science or interested in mathematics at this point?

Alison: Beforehand, not very much. After, like now? A lot more than I was. This program has really been- helped a lot in opening my eyes to on why we really need to take the classes and why it is important. So now I am actually trying harder on my subjects instead of just saying—instead of just slacking off.

In addition, participation gave them access to authentic engineering experiences which were in contrast with the cookie cutter labs they were exposed to at school:

Alex: I typically hate the labs. I've always had problems writing up the paper the follow up paper for it

JS: But you don't have the kind of problem...

Alex: Here

JS: Yeah

Alex: Well I mean, they don't want exact definite results as long as it works then it works.

JS: Right. Whereas in school—

Alex: Its like this is something that has been demonstrated before we want you to just repeat it.

## **Non-cognitive skills**

What was perhaps most striking about their involvement in this challenging, team oriented project was that members of the team expressed the development of adaptive habitus. They described it as emerging from the pressure of competition and the bonding of the team through intense work. For example, Alex, the team captain, described evolution of metacognitive skills:

JS: What do you think you get out of going to the competitions?

Alex: I think, how to deal with myself. You know, when you're under pressure you're a totally different person. So, you know, coming to terms with how to deal with my own emotions and how to react to things.

For Allison, the team 'helped me become more outgoing', and the mentors gave examples of students whom they believed the programme had kept in school. Through a combina-

tion of inclusion and support, as well as rigorous challenge, the Robotics Team reached and supported students who might otherwise not have had access to these powerful learning experiences.

## Summary and policy implications

Struggling and at risk students can benefit from serious STEM enrichment, too. However, supporting access might mean thinking holistically about what students require in order to participate. For example, food, extra tutoring and transportation might be precursors to active participation. However, what is clear is that it is not just elite students that benefit from high-quality, authentic enrichment programmes. All too often underrepresented groups, such as women, are offered light versions of STEM enrichment, perhaps with the thought that such programmes make STEM less threatening. Students' experiences with the immensely challenging and demanding Robotics Team discussed here, however, show how the same environments that are valued by elite students can be transformative to other students as well. This emphasises the need to expand access to such high-quality learning opportunities to a greater spectrum of students, without making assumptions about who can and cannot benefit from participation.

## 7.6 Policy implications

The examples in this section show how family background (particularly family STEM capital), school and track mediate student access to extracurricular activities. Some students are invited to participate because of their school or track placement. Others have access through parents who are researchers or doctors, as with the cases of Lily and Charles. Across the different forms of enrichment, family background was important in accessing these opportunities, as it is important in students' placements in more formal educational structures, which also mediated student access. While some enrichment programmes are aimed only at elite students, and used in part to provide distinction (for example in university entrance), the case of the Robotics Team and that of Sakari at the Small Magnet Lukio, show that average or struggling students can gain tremendously from extracurricular activities.

## Mechanisms of access to STEM enrichment

If only elite students are invited to participate in enrichment, huge amounts of passionate talent will be excluded. Indeed, as with the case of Sakari in comparison with his classmate, resilience in the face of challenge might be more important than quickness (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011). Considering the provision of STEM enrichment, particularly if its goal truly is promote retention and produce innovative scientists, investment should be made in dedicated, interested students regardless of their academic standing. For computer science, if there is no structure in place to give access to students, then the mechanism of selection will be based completely on individual dispositions and resources.

For all of the students with real computer science engagement, gaming was the gateway into developing an adaptive habitus for computer science. A recent study of university undergraduates suggested that the lack of retention in computer science is linked to women's perceptions of the environment and characterisation of the field, and small changes in the physical environment impact women's willingness to persist in the discipline (Cheryan, Plaut, Davies, and Steele, 2009). In an era of declining participation by women in this field, which is of such economic importance, access should not be left up to chance. If there is no countervailing mechanism in place to encourage young women, or provide welcoming environments for them, this interaction of gender and retention in computer science is likely to continue.

## Characterising effective STEM enrichment

Across the different forms of extracurricular activities, students were clear about what aspects of the programmes and activities ignited their enthusiasm the most. These were, drawing on the examples discussed in this chapter:

- Activities involving authentic, real-life experiences of science and engineering: For example, getting to work in a real laboratory with genuine research materials in contrast with typical school laboratories, collecting water samples during a fieldwork expedition or building a website or robot for actual use.
- Exposure to STEM professionals and authentic working environments: For example, working with volunteer engineers while building a robot, working along side research scientists in the laboratory.

- Activities that involved a sense of inclusion into a community of practice: Feeling included in the laboratory environment, contributing to the robotics team, or being recognised by others for computer know-how.
- Activities that were challenging and open ended, with no pre-determined correct solution: This was a key theme, and included laboratory and fieldwork experiences, creative problem solving for the robotics builds and independent research projects. Perhaps school leaders and policy makers might consider investing in such experiences over shallow enrichment aimed at making STEM friendlier. The authentic challenge, if supported, is what turned these students on to STEM. Again, short-term exposure seemed effective for many students, and the model of the Private Swedish Gymnasium gives one possible structural answer: a professional grade laboratory that is shared by many schools. Furthermore, fostering local collaboration with industry can provide students with opportunities to see STEM in action, something to which mathematics and science teachers at typical schools simply do not have access. Such programmes require more time, effort and determination than financial resources.

This characterisation points toward the need for such in-depth and quality experiences. However, many of the students' activities were not long in duration. The laboratory work might have been a week or two in duration. Yet, these experiences loomed large in students' narratives, providing a window through which they encountered the messy, open-ended and exciting world of STEM. Furthermore, when encountered through interactions with professionals, this world was humanised and domesticated; it became a world in which they could imagine themselves as future professionals.

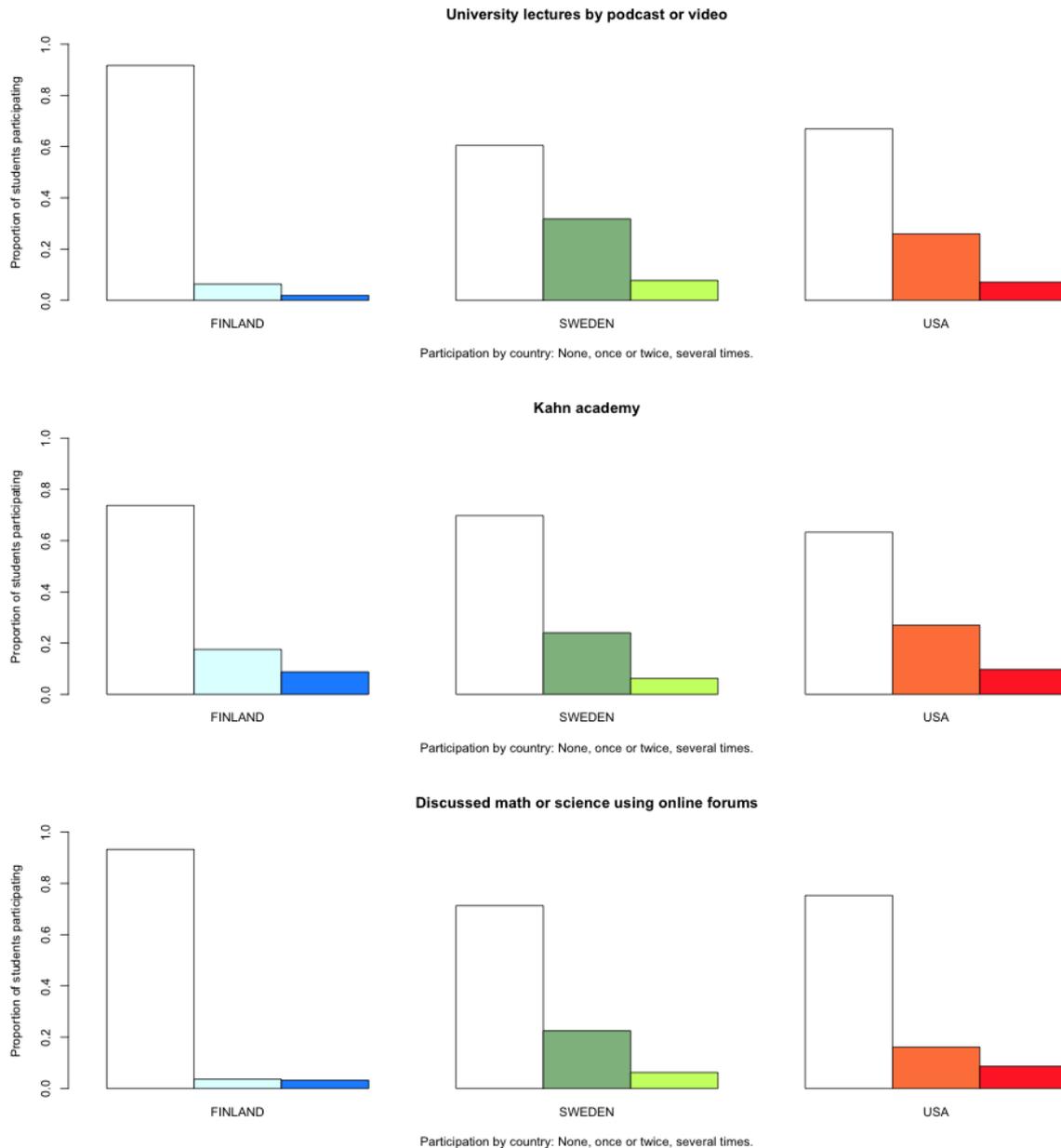


Figure 7.3: **‘Do it yourself’ enrichment**: while Section 7.4 discusses the case of Rauli in Finland who accessed powerful STEM learning online, the survey suggested that his experience is not widespread in Finland; a smaller proportion of students were taking advantage of such resources. Very few students across any of the settings had taught themselves a computer programming language outside of school. The results also suggest that the reach of online courses from university and sources such as the Kahn Academy are having an impact, particularly interesting since in preliminary feedback on the survey instrument, teachers in Sweden were skeptical that any students would be using those resources, suggesting a disconnect between the students and teachers.



## Chapter 8

# Effective specialist schools: two contrasting structures

This chapter is about structure at the school level. Previously, the effects of structures such as school transitions and forms of differentiation (Chapters 5 and 6) as well as access to enrichment (Chapter 7) have been discussed in terms of patterns and generalities at the country level. The survey analysis in Chapter 4 suggests the importance of an additional structure: specialist schools. This chapter focuses on two contrasting STEM magnet schools that have been formed within larger generalist schools, examining not only the special environments such schools, but how transition, differentiation and access to enrichment are realised within them. I examine these two case studies to understand how school-level structures impact students' engagement and identification with STEM fields, both within and without the specialist tracks or schools.

The focus in this chapter is upon two remarkable Finnish schools. In each, school leadership has intentionally crafted environments to foster enthusiasm for and high achievement in science and mathematics. In particular, leadership at both schools take into account the development of habitus (although they would not use that term) and encourage students to access authentic mathematics and science enrichment as discussed in the last chapter. Notably, school leadership at each site has implemented very different policies in order to meet their goals of fostering a community that promotes engagement and performance in STEM fields. Both schools exist within larger schools; that is, they are a selective magnet school that sits in the same building as a less selective generalist school. In each case, the school leadership has gone about structuring the differentiation between the ordinary lines and the general lines in completely different ways.

## Context

For context, it is important to remember that Finnish students have been in largely non-differentiated learning until age 17. The examples in the chapter demonstrate how there are students who scale up their interest and performance in science and mathematics after beginning upper secondary school. For some of these students, that means that they are entering elite science and mathematics courses only at age 16, and there is a great deal of choice involved, as discussed in the next chapter. This context should be kept in mind as these schools are not as selective as the Magnet schools given recent media attention in the United States. Finn and Hockett (2012), have stated that increased provision for talented students before high school (age 14) is needed to complement such selective schools. Neither of the schools that serve as my examples are the most selective school in the local educational market.

Considering late differentiation, the example of the Small Magnet Lukio is particularly interesting. It demonstrates that it is possible to achieve nationally elite outcomes in mathematics for students who have not been accelerated until age 16 or 17. This may seem remarkable when compared with the United States structures of allocating students to differentiated mathematics courses at an early age, and contrary to the general policy recommendations suggested by Finn and Hockett (2012).

## Introducing the two schools

Both schools are successful in meeting their aims as STEM focused specialist schools, but structurally the implementation of the schools provides for striking contrasts. In the first school I consider, the Small Magnet Lukio, there is a stark difference between students in and outside of the specialist line. The Small Magnet Lukio is also in a less affluent area of the city. In the Small Magnet Lukio, community is carefully crafted. Building an adaptive habitus (encouraging aspirations, belonging, a disposition towards effort and a growth mindset) is a goal of school leadership.

In the Large Magnet Lukio, the specialist line is invisible, due to a recent policy change enacted by the school leadership. In the Large Magnet Lukio, inciting interest in science among all students (in and outside the magnet school) is seen as a key goal of school leadership, and reducing the ‘moral boundary drawing’ (Sayer, 2005a, pp. 952–953) between students an object of school policy.

The analysis of each school begins with an overview of the school structure and envi-

ronment, followed by a discussion of the notable characteristics of each school, and how these structures influence students' determinations to pursue STEM fields.

## 8.1 Small Magnet Lukio: elite talent, grit and deliberate practice

The Small Magnet Lukio (SML) focuses on mathematics. It is actually a school within a school, sharing the same building as a larger, fairly diverse general upper-secondary located in a poorer area of the municipality.<sup>1</sup>

### Structural overview

#### Admissions

The students are admitted to the school via two possible pathways. The first is through grades from lower secondary as well as a mathematics test specifically for the school. Even with good grades, if the student cannot get any points on the school's entrance exam they are not admitted. In practice, very few students are rejected, maybe one or two a year according to school leadership. Students may also be admitted through high performance in a national mathematics competition that is given in lower secondary schools throughout Finland. The school draws students from throughout the metropolitan area, and the region.

#### Differentiation

Students in the mathematics track have special activities and orientation. Their mathematics courses are accelerated, and they have extra courses. These extra courses are officially open to all students at the school, but in practice, very few of the students in the regular line take advantage of these courses.

Mathematics line students tend to all take their non-mathematics courses together as a group, but these classes are not exclusively for them, so they are mixed with students from the general line. This practice is in contrast with the majority of Swedish schools,

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<sup>1</sup>One day when I was there, I overheard two girls talking about an American boy being beaten up earlier that day, which thereafter influenced my feeling of the school, overall, as being fairly rough.

where natural science lines have a separate curriculum across all subjects, or schools in the United States, where it would be typical for advanced students to be taking elite courses across most academic subjects. Within the mathematics line, students could scale their participation up or down; the extra tuition is entirely optional after the first year.

### **Cultivation of community and habitus**

School leadership purposefully developed activities to bolster a sense of identity and community among students. Particularly of interest from the point of view of encouraging STEM persistence, the students were purposefully introduced to the idea that they should identify with high performing former students, alumni who were had become mathematicians, scientists and engineers. Students habitus (or character) was also formed through social programmes, as well as through the scaffolding of self-concepts, growth mindset, assurance, and diligence, described further below.

### **Results**

The school was regularly producing members of the Finnish national Mathematics Olympiad team, and students were winning national prizes for their research work (one of the students I interviewed had created an algorithm to improve image compression). Students were aiming for further studies in mathematics (to become professors and researchers), and selective programmes at the prestigious technology university such as industrial engineering.

While not all students engaged fully with all that was offered by the school, students from the school were prominently represented in national contests. While the students interviewed had chosen the school out of an interest in mathematics, the school was decidedly a site of growth for them, not only mathematically, but socially as well.

#### **8.1.1 Community building**

School leadership offered activities that gave the students many opportunities to work with older students and alumni. This gave a practical advantage to the students. For example, Sakari and Timo were aided as they moved to university studies in their final year:

Sakari: (...) There have been a lot of old students from this school who have taught me mathematics and stuff and then I can meet them again at the university now and it's kind of like... um... it wasn't really such a big thing because I already now have the people there.

The sense of community and connection to alumni the students experienced was due to careful effort on the part of the SML Dean, who was himself an alumnus of the school and also the lead mathematics teacher there. For him, building the community had pedagogical importance:

SML Dean: Of course a community is a valuable thing of its own; it's more fun to go to a place where you have friends. But it also greatly enhances the results. For the good students, if they have tight connections in the group, they discuss mathematical matters and they can learn from their peers, and for the weaker students, it is very beneficial for them to have friends who are better at mathematics. And if they spend time with them so— Well it is not maybe so that knowledge would diffuse from one student to another but it seems to happen a bit like that. Of course they are able to help each other and in mathematics group work is efficient.

Notably, for the SML Dean, building the community is in part about creating a network of peer-learning that would benefit weaker students, too. The community building has a practical place in learning, an idea that is supported by education research (Boaler, 2008).

Building community was encouraged through a variety of structured activities, including an induction for the mathematics line students at the beginning of each school year, called the Night of Mathematics. Organised by former students, it involved a competition whose purpose was to mix older and younger students on teams and have them tackle a problem set that included both easy and difficult problems in such a way that everyone *could* contribute, combined with a timeline that ensured everyone *must* contribute in order for a team to win: 'They have to delegate between themselves how to— who solves which [problem] and they have to communicate and work together and that is one way to integrate them into the school.' In other words, a sort of constructed 'contributive justice' (Sayer, 2011) such that everyone's work was of value.

However, for the SML Dean, the mathematics is a minor part of what happens at the Nights of Mathematics.

SML Dean: The really efficient part is after midnight? we have started at

5 pm and after midnight when the lectures and competitions are over so its sort of tradition that we encourage that they would stay awake until morning. Because its a good way for them to play card games and social games and just hang out in the school building and get to know each other. And also when they are more tired its easier to maybe lower their defenses a bit and get to know people (. . .) Of course they maybe learn some math in the process– the previous students are teaching– but that’s not very important. (. . .) Because if you want to be able to build connections, it helps if you eat together. Okay, that happens in school quite normally. A common uniform would be good, but that’s not very practical in schools I think and not very necessary either [laughs]. But just physical closeness is one thing as well. If we make them either hang out tired in the school or just lie on mattresses in some dark class and discuss some random things at 5 in the morning, it is good for the spirit.

Here there is a deliberate cultivation of students’ closeness and sense of belonging, the opposite of anxiety and sense of misfit, and an important aspect of the adaptive habitus as defined in the quantitative model. Students’ ‘spirits’ are acknowledged here.<sup>1</sup> The school also had trips to nature, involving a science course, where the students lived in small cabins together and prepared food together: ‘Those are just simple tricks.’ Nonetheless, such ‘tricks’ are not considered as standard in (public) schools in Finland, Sweden, or the United States.

The Night of Mathematics, which happened twice a year at the demand of students, served as an opportunity to get new students to identify with, and feel comfortable around, accomplished alumni: It was quite nice to on their first week of lukio to say to the first graders ‘this guy and this and this and this, they have done all these heroic deeds and here they sit playing cards with you!’ and they are fun guys and girls as well. The students immediately had the opportunity to mix with successful, older peers in an informal setting, and thus to be included among a group that might otherwise seem intimidating and elite (Reay, Crozier, and Clayton, 2009). The alumni help to ‘transfer traditions’ and keep school spirit up, normalising the idea of mathematics and related fields as exciting and fun, but also part of future successful adult careers. This concerted effort to include students in a community of practice has been regarded as key in retaining students in STEM fields (e.g., Aschbacher, Li, and Roth, 2010).

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<sup>1</sup>The head of school repudiated the idea he was ‘producing’ [my word choice] future mathematicians or engineers; mathematics is something that should be taught on par with (and not instead of) art and music, something to be understood and enjoyed, even if one could not or would not become an artist or musician—part of liberal education

### 8.1.2 Habitus building

In the last section, the idea that school leadership was actively building community was introduced. In addition to community, the school leadership encouraged students to develop an adaptive habitus towards studying, and towards mathematics in particular. The key areas where this was done were: 1. Aspirations, 2. Effort and perseverance, 3. Growth mindset, and lastly, 4. Passion. Bandura (2011, p. 13), reflecting on a career of research into self-efficacy, states:

Resilient self-efficacy requires experience in overcoming obstacles through perseverant effort. Resilience is also built by learning how to manage failure so that it is informative rather than demoralising. The second way of developing self-efficacy is by social modelling. Seeing people similar to oneself succeed by perseverant effort raises observers' aspirations and beliefs in their own capabilities resolve increases the chance of success.

The SML leadership worked to do both these things. Using alumni to help form aspirations and adaptive mindsets

The encouragement of networking between current students and alumni is one way in which the school leadership encouraged the formation of adaptive aspiration on the part of students.

The success of former students was highlighted, however in a less formal way than Demerath, Lynch, and Davidson (2008, pp. 276–277) document in their ethnography of an academically oriented United States high school. They authors call this phenomenon 'technologies of recognition'. This technology of recognition served to craft the school environment, and also to purposefully shape students' ambitions.

The SML Dean was explicit about this use of these alumni for supporting students' aspirations, as well as the development of adaptive traits like grit (Duckworth, Peterson, Matthews, and Kelly, 2007):

SML Dean: It's a way to motivate— they can see that success comes to those who study hard. So it's a great help for a teacher to have such a sort of pool of ex-students who can be used as examples.

For some students, these specific examples were key in their choices. Sakari and Timo, for example, learned from older students that they had taken university courses during the last year of lukio, and figured out how to position themselves to do the same. The

achievements of former students became metrics against which the judged own performance, setting a higher bar for their own aspirations. This process, of purposefully using alumni as a way of increasing students aspirations, but also making them seem more attainable, since the achievements were now embodied within members of their network (in the form of alumni with whom they were now acquainted) coincides with Bandura's (2011, p. 13) conclusion that: 'The second way of developing self-efficacy is by social modelling. Seeing people similar to oneself succeed by perseverant effort raises observers' aspirations and beliefs in their own capabilities resolve increases the chance of success.'

In the SML, the social modelling happened through interactions with older students and alumni, and, perhaps more importantly, signalling from the teacher that these former students were just like them, and had struggled just as they were struggling. This positioned struggle and hard work as normative and necessary to success, which seemed to encourage a growth mindset (Dweck, 2006) in some students.

### **Creating challenges to foster grit, effort, and perseverance**

The SML Dean made a point of challenging students, but also guiding them towards the idea that these challenges could be overcome with hard work, perseverance, and self-efficacy, particularly in the form of recognising that it is normal to get help, and figuring out how to do it:

SML Dean: When they first start, I try to make them sweat with the mathematics. The right feeling would be that they feel that 'Oops this is difficult and I don't think I am going to manage'. And then I try to make them do the first exam quite early on. And usually the result is not very good. . . And then I'll explain, that this is completely normal and every other year's class has done the same thing that they don't do very well in the first exam. It's just (...) normal. So one week later, same exam, let's study. And that sort of forces them to work hard and also cling to each other to survive. I'm using quite strong words of course it's not that bad as it sounds. But that's the sort of idea, that making them work at the very beginning it directs their focus towards getting results. And also, I encourage as much as I can for them to take support from each other. So the idea is that the class would have a common purpose of doing well and helping each other to achieve it.

The SML Dean works to create an environment that emphasised hard work and collaborative effort. He purposefully encourages all the students to develop both perseverance,

highlighted by Duckworth et al. as being key to performance and a growth mindset, have shown to be associated with better learning outcomes and engagement, particularly at points of transition (i.e., Blackwell, Trzesniewski, and Dweck, 2007). These ideas seem to have been successfully absorbed by the students. Duckworth, Peterson, Matthews, and Kelly (2007), for example, have defined *grit* as a blend of passion and perseverance.

Sakari, a student at SML and member of the Mathematics Olympiad team embodies this disposition: ‘I think if you’re really interested in mathematics then that’s the equivalent of being good at mathematics. I mean I don’t consider myself exceptionally talented but I just consider myself exceptionally interested in mathematics, so, you just have to do hard work.’

According to the SML Dean, this message is not just important for motivating struggling students. They also aim to get this message across to the strongest students.

SML Dean: For the better students the basic courses are not a problem. They get good marks without much sweat, though we do prefer the sweat because that build the skills needed for studying the hard things. But they get along fine. For them what we offer is this wide range of special courses that introduce new ideas, new ways of thinking that are completely different from the basic material. And also they can go further in the basic material. The things they would need in the first year of university studies and such.<sup>1</sup>

This emphasis on pushing students towards challenge, and looking for ways to stretch quick students to ‘build the skills they [need] for studying the hard things’ directly relates to Bandura’s description of the development of self-efficacy: ‘Resilient self-efficacy requires experience in overcoming obstacles through perseverant effort.’ Looking for ways of exposing quicker students to this is one thing that led the school leadership to encourage involvement in competition mathematics:

SML Dean: Its something that they can’t sort of perfectly master (. . .) And its good to sort of have to work against one’s limits, to meet one’s limits and surpass them and the competitions they are quite difficult and its a good thing they are muddling difficult problems. There is a concerted effort to build the non-cognitive resources, or the adaptive habitus of students in this way.

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<sup>1</sup>This care to expose students to the material they would otherwise encounter during their first year of university is an effective way of smoothing the transition. This is what Sakari, whose trajectory is described in more detail in Chapter 9 experiences.

## Focusing on a growth mindset

In mathematics courses at SML, students were pushed not only to pass, but to exceed their own performance. The SML Dean asked students to retake exams, even if they had already achieved a passing grade:

SML Dean: You got a seven out of ten– that’s not your level, retake it in two weeks time and I expect you to have 9 or 10’. Okay so it works. And if they really want to study for the next exam, they might do really much better than in the first one. And also that’s important for the [average] students that they don’t get the feeling ‘okay, I got six out of ten from the first course, of that’s horrible!’ (...) It could come out as a shock: ‘I had nine in ninth grade in mathematics, how could I be this bad’. So the right idea for them is that: ‘well, I’m not very good at it now, I could be very good at it one year later’. So I try to move the focus to the future. You’re taking the final exams in two years time from now and we have lots of time to train in that time, and if necessary you can do the first course five times or take the exams five times.

Through these patterns, as well as through repeated referencing of alumni who had also struggled, the SML Dean supports the development of a ‘growth mindset.’ Dweck (2006) defines the *growth mindset* as one that is conducive to student perseverance in particular, as the ontology behind the growth mindset implies that there is a reward for increasing effort and attempting to overcome weaknesses. Teachers and school leadership recalled the experiences of alumni as a way of motivating students. For struggling students, the alumni served as proof that low scores in the first year were not markers of limited talent, and need not exclude exceptional performance due to hard work later on:

Sakari: Well, not all the ones who excelled in the end did as good in the beginning’. That there is a bright future waiting for everyone who wants to put effort into this and we have those role models and I can compare their scores with the previous years and see mmm they didn’t do that great in the first year, but then in the *third* year, then they were really good.

This sort of work in imagining possible futures is powerful. Having high expectations influences student outcomes (Wigfield and Eccles, 2000). In addition the Dean is explicitly offering a model of high expectations and perseverance, components of grit and deliberate practice (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011). Such characteristics have been shown to be powerful indicators of resilience and long-term

success.

Perhaps as a consequence students like Sakari attributed their phenomenal success to their own passion and hard work:

Sakari: In [lower secondary] there was some competitions but I didn't do that well in that actually and... the other student from our [lower secondary] who came here [J: okay]he—he always beat me in those competitions so um...

J: And what about now, may I ask?

Sakari: Now I beat him like every day. Well it's, it's more about being interested. He doesn't come to [the voluntary trainings at a specialist school] so I think I've got a big advantage from there.

Sakari attributes his performance to hard work, to diligence, motivation and interest. This is in particular contrast with some of the assumptions underlying the conclusion regarding the loss of passion by Fredricks, Alfeld, and Eccles (2010), because his case clearly shows the importance of interest and passion as well as access (his growth comes primarily through non-compulsory learning activities, but activities that would have been difficult to access at another school).

While the school leadership does not use the terminology of Duckworth or Dweck, the sorts of skills the leadership aims to foster are in accordance with those frameworks. In addition to these adaptive dispositions towards ways of working and approaching challenge, there was also structures within the school that seemed fundamental to engaging students in advanced STEM learning, which will be the topic of the next section.

### **8.1.3 A flexible choice-based structure creates the potential for passionate engagement**

Duckworth's idea of grit, as mentioned above, is an adaptive disposition towards hard work and overcoming difficulty and is combined with passion. Grit is arguably related to self-efficacy and growth mindset. How to increase the engagement and passion of elite students is particularly of interest, given that students in gifted programmes report a lack of interest and challenge (Fredricks, Alfeld, and Eccles, 2010).

One of the distinguishing features of the Small Magnet Lukio was the availability of special, advanced classes, often un-graded. These short courses on complex topics were

sometimes taught by former students.<sup>1</sup> During the first year, students were required to try out these courses, but after that it was voluntary. First, these activities provided a space for the development of expertise (Butterworth, 2006; Ericsson, Roring, and Nandagopal, 2007) unavailable at other schools. However, it is also important to note that they were largely voluntary, allowing students to self-select their level of engagement. Students could choose their level of engagement, and furthermore, their level of engagement had little to do with general college admittance, unlike performance in standard courses. This structure encouraged some students in the growth of a self-directed participation that fostered the development of true passion and expertise.

Regarding the development of expertise, these extra courses increased opportunities for students to learn in a structured environment, and to scale-up their engagement above and beyond standard advanced mathematics and science courses. I asked Sakari how many hours he was spending doing mathematics a week:

Sakari: Well, mmm, in school courses about seven hours a week. Then of course Mondays we had the mathematics extra lessons and that was like three hours, so ten hours a week. Then every sixth week we had like, I don't know, twenty hours at [the training at a specialist school in competitions mathematics]...

Based on substantial research regarding the development of high-level performance, Ericsson, Roring, and Nandagopal (2007) argue the assumptions of much of the research on producing outstanding talent, instead pointing to what they call 'deliberate practice,' concerted effortful work towards mastery. This demanding practice, requiring assurance, diligence, and a degree of passion, related directly to Sakari's approach to learning. The school provided a structure in which he was able to enact this practice.

It was also notable that students were selecting themselves into these activities through choice and commitment. Fredricks, Alfeld, and Eccles (2010) compared students in gifted programmes in the United States to students engaged in advanced music and sports, and found the students in academic programmes much less engaged. However, those students had not chosen to practice and engage in their academic courses in the same way as the musicians and athletes, who are required to engage in that way to gain admittance to sports teams, orchestras or bands. In contrast, the most passionate students at the Small Magnet Lukio were more similar to students studying art and sport; they chose their level of engagement and competition (academic competitions were also a feature of the

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<sup>1</sup>This was sometimes on a volunteer basis, by alumni who might be university students or early career researchers, and thus a very affordable model.

school). Engaged, passionate students at the Small Magnet Lukio, exemplified by Sakari here, show that a school environment that is aligned more with the ideas of producing expert performance (rather than giftedness, i.e., Ericsson, Roring, and Nandagopal, 2007) can provide a structure for the growth of passion and talent.

Teachers and school leadership made of point of this flexibility, using it to respond to and encourage students' passion:

SML Dean: if some of my current students ask for hyper-real numbers, and I haven't got the foggiest idea about that but I do know that this one ex-student of mine knows something about it, he mentioned it at one point so I called him and he emailed me an article about it, and I read it and okay this is good stuff and then I explained to the student what those hyper real numbers are.

For Timo, these extra courses were critical to his interest in mathematics: 'I think these are the courses that really showed how mathematics can be interesting'. His passion was also sparked through training for the competitions, although he describes himself as slow, he enjoyed the problems 'really original ideas' and said 'I think that my life would have been really boring [laughs]' without these extra courses. The flexibility of the school allowed it to scale up to students interests, fostering students' passions, but also providing for a true development of expertise.

#### **8.1.4 Contrast with other specialist schools**

The approach taken at this school is in contrast with students' experiences at the Magnet Gymnasium in Sweden, which also specialised in mathematics, and was also selective. Like Sakari at the Finnish SML, Bengt in Sweden was taking courses at the university in mathematics. Unlike Sakari, he was not part of a community there, and had yet to encounter anything he found particularly interesting. 'Too easy' is a prominent phrase in Bengt's interview as is 'boredom'. Rather than things being interesting, they are the 'least boring'. He says 'I don't really like to do stuff, I'm pretty lazy'. The schools he has been in have let him go fast (Bengt describes himself as quick in mathematics: 'At least I'm quick when it comes to maths. I don't know if its easy in that way always, but its always been really pretty fast.'). He was a year ahead in mathematics even at the specialist gymnasium from which he was about to graduate. However, Bengt's academic results are not particularly great, he notes that it is characteristic of himself that he almost gets good marks and test scores, but doesn't quite manage it. His experience recalls the

tension in mathematics differentiation between going faster or going deeper (Horn, 2007) in a subject that is often seen as linear and hierarchical (Ruthven, 1987).

Getting by with being satisfied with passing marks from, for example, reading a biology book on the way to the exam, Bengt was never encouraged to reach his full potential. He was allowed to go fast without challenging himself to do well and had what might be characterised as fixed mindset (Dweck, 2006); his performance was do to ability, and diligence had little to do with his outcomes. His case contrasts with his classmate Göran who struggled in mathematics during compulsory school, but with help from his grandmother, a teacher, improves his performance through hard work, does well at the gymnasium, and is headed towards a university programme in computer engineering. Göran already had non-cognitive resources when he came to the school that helped him take advantage of it. However, unlike at the Finnish magnet schools discussed here there was no structure in place for the development of those skills; Bengt is not exhorted to change his ways or perform to a higher standard.

Another of Bengt's classmates, Stefan is also struggling. Before high school 'I was always one of the top in every class.' He moves cities just to attend the Magnet Gymnaisum, but it doesn't go well.. When I spoke with him, he was still struggling to get himself to attend school regularly: 'I've never had to change my ways', he insisted, while he also said 'I feel like a retard sometimes.'<sup>1</sup> Both Bengt and Stefan were missing support in developing skills to overcome their problems. They were not asked to retake tests until they got the best grade they could get, that experiencing failure was normal and could be overcome, or drilled with the idea that effort and self-management skills were necessary no matter how quick they were. There was not modelling of how to build resilience by overcoming failure (Bandura, 2011, p. 13).

### 8.1.5 Social aspects of differentiation

For Timo, the community created by the SML was important. He noted that he had met people involved in mathematics competitions who weren't at a special lukio so it while was possible to do mathematics in another environment ' they don't have people who are also interested in mathematics around them, so its possible but its not so fun [laughs]'

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<sup>1</sup>The school itself was privately run, without a nurse or psychologist (common in Finnish schools), poorly managed (according to one of the teachers I interviewed). Stefan, perhaps, was particularly vulnerable to this lack of resources, having in addition struggles with his personal life and at one point feeling so low that he described all his routines being lost to the point that he couldn't brush his teeth.

However, the strength of the in-group community, and the difference between the students in the general line and the mathematics line created tensions similar to those found in United States high schools with Advanced Placement, International Baccalaureate and honours tracks (Saari, 2009, 2013). The academic separation becomes a social one:

Joona: Well its a natural separation because like we were having this Swedish lesson yesterday (...) We three from the mathematical sit in the front row and there was one row empty and then the three others sit in the back [laughs]. So it's really like this?there are these holes between, there are– it's really– and in the one corridor there, there is the mathematical side and there is the regular side. It's really you don't– you don't– if you are an outsider you don't see it.<sup>1</sup> But it really is there and it's tough to walk around in the wrong– you might end up in the wrong place. You can't sit anywhere you want. Its not that strict but its still there and its– and I don't want to go there because I think they are not. Well they are not so nice people the regular ones. Because they have an average when they come in its like seven and a half.<sup>2</sup>

Joona further notes that the mathematics students were teased with the epithet 'matekisti,' a play on the word 'masokisti' ( masochist).<sup>3</sup>

Here Joona ties the students' scores to their worth 'they are not so nice people', engaging in a sort of moral boundary drawing (Sayer, 2005a, p. 952) similar to that done by elite mathematics students in the United States (Saari, 2009), who described students in lower tracks as 'trouble makers' and 'future drop-outs'. This is important to educational policy because it suggests a way that school structures might be implicated in the development of belief systems. This phenomenon is well documented in the United States (Kim, 1998), where even young children (Weinger, 2000) have been noted to link poverty to negative character. Such biases are not unusual, particularly among elite groups (Jost, Pelham, and Carvallo, 2002), though they were not evident in Joonas's schoolmates' interviews in this study.

However, it should be noted that Joona's characterisation, as well as similar opinions of differences discussed in Chapters 5 and 6 for example, might reflect real distinctions

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<sup>1</sup> I didn't see it, but it was fairly easy to identify the mathematics lukio students, some of whom were playing chess, and were mostly young men, from other groups socialising in the open hallway.

<sup>2</sup>Joona was very aware of averages for admission in different schools in the municipality. He chose the SML although his marks from lower secondary would likely have earned him a spot in one of the elite schools in the city centre. However, he did not want to be one of the lowest at the school, where he had heard the teachers did not provide help for students.

<sup>3</sup>An English equivalent might be 'mathechist'.

between tracks that go beyond academic performance and engagement. Track placement and the environments thus created by stratification are not simply about academic scores; they are also linked to behaviour (for an example from the Netherlands, see Van Houtte and Stevens. It is possible that the students in the general line were indeed engaged in more risky and dangerous behaviours.

In any case, it seems that in the creation of the distinctive community in the SML coincided with a stark division between students in the general line, and a recognition of difference that is common with stratification, and indeed, one of its most desired outcomes (Hertberg-Davis and Callahan, 2008). A viewpoint of a participating student from the general lukio reflects this. Johanna, for example, was studying Long Mathematics in the general school. She had recently moved to the city and lived nearby:

Johanna: I'm the only girl in my high school that reads physics. There are some in the mathematics high school but not in ours, so its we have to be in their class, the same groups with the mathematics high school in physics so. . . But sometimes I think when I'm with them that they're so much smarter than me and its kind of like, they're kind of looking at us normal high schoolers that we are just a little bit dumber or more stupid than they are or something. But I think they are really they don't think that but we think they do. Johanna's participation in the advanced science courses meant that she experienced the boundaries between the two schools. She and her family were not particularly familiar with the school market in the city, and did not agonise over school choice as some of the Small Magnet Lukio students had. They had recently moved there and this lukio happened to be close to Johanna's home. Contrasting herself with both the ambitions mathematics, she stated that liked 'to have good grades but I don't take too much stress about it'.

She saw a clear distinction between the mathematics line students and the rest of the school:

Johanna: I think they are more competitive, they really want to get good grades and they want to learn and they want to take everything out of high school that they can get. I don't know if its just in our high school, but the normal high schoolers, they don't really. It's just we're hanging out here and it doesn't really matter what grades—well some students are like that, they don't care if it s a 9 or 8 or 7 as long as there is some number.

Despite the possibility of discouragement through being exposed to competition with elite students (i.e., as predicted by the Big Fish Little Pond Effect Seaton, Marsh, and Craven, 2010). Johanna was still applying to difficult programmes at a prestigious technical university, including the same programme as Joonas. Johanna shared Joonas's negative view about the ambitions of the general line students as a group, but it should be noted that he also thought their presence was beneficial, contrasting with another magnet school in Finland: '...they balance each other so there is—the mathematical guys know what reality is like'.

### 8.1.6 Summary

The Small Magnet School has selective admissions, but in practice, students with a wide variety of levels of academic and mathematical achievement are admitted. The school leadership makes a concerted effort to foster an adaptive habitus towards mathematics and academic ambitions, and the school produces an inordinate number of high-level competitors, as well as academics in STEM fields.

This was done through encouraging their aspirations towards performance and persistence in mathematics and related fields, and, of particular note, urging students to cultivate a growth mindset (Dweck, 1999, 2006) that places prominence on the importance of effort and hard work to change one's ability (Blackwell, Trzesniewski, and Dweck, 2007), as well as perseverance, passion or grit (Duckworth, Peterson, Matthews, and Kelly, 2007), dispositions that are strongly related to positive outcomes, both in terms of learning, and over the life-course.

Students are encouraged to develop aspirations, perseverance, a growth mindset, and passion for mathematics. Instruction is scaled up to meet student's interest and enrichment activities are widely promoted, although students are free to ignore these aspects of the school as well, seemingly without stigma. The tight community, however, coincided with a certain amount of tension between groups at the school. The tension was similar to schools with Advanced Placement or International Baccalaureate programmes, where the classes are not strictly separated, but where students tend to be isolated within the stratified structures of the schools. At one school, this pack of students was called an 'AP Squad' (Saari, 2008), which ultimately created an exclusive bubble within a larger, inclusive school. The contrast between the friction and divisions created by such differentiation within schools as opposed to between schools deserves further consideration. Many of the students interviewed at the elite historical schools in Sweden and Finland

enjoyed the exclusivity of their school environments, contrasting it with previous, inclusive, schools. In those elite schools, ‘reality’ in Joona’s terms, is invisible, however. It would be interesting to pull apart the different effects that elite environments might have on students whether they are free-standing or embedded within a more inclusive environment.

The next section focuses on the Large Magnet Lukio, which was also a school within a school, but as shall be discussed, was integrated into the general lukio with which it shared its campus.

## **8.2 Large Magnet Lukio: science for everyone**

The Large Magnet Lukio (LML) focuses on sciences. It offers more courses than a typical lukio, and has more advanced laboratories. Students also have the opportunity for science courses involving fieldwork outside the school. The school is large and students have many choices for classes in every subject. The neighbourhood is average to slightly below average on economic indicators (Vuori, Tikkanen, and Selander, 2008, p. 14), but a slightly more affluent neighbourhood when compared to that of the SML. The school is particularly interesting because of a structural rarity: although the school was designed around an elite science line, similar to SML, the school leadership had chosen to make this line invisible. This addresses head-on the uncomfortable issue of social as well as academic stratification. There was a high level of enthusiasm among the students interviewed, both for science and for their school. One student noted that classmates had moved from other cities to attend the school. There was a busy, congenial feeling to the hallways. What was particularly radical about the school is that its selective, specialist line in science was almost invisible

### **8.2.1 Overview of school structure**

#### **Admissions**

Students were admitted to both the science line and the general line according to their scores from lower secondary. About a third of the students were in the science line, and that line had on average higher scores. Many students entered the general line without having any intention of studying science.

## **Differentiation**

In the recent past, the head of school made the decision to make the natural science line students invisible both to teachers as well as to other students. All of their classes were mixed with other students, and all students had the right to take the special courses that were offered to the natural science students.

## **Enrichment**

The distinction of the natural science students lay in their opportunity to take more, higher-level science courses in lieu of other subjects, including advanced laboratory work. These laboratory classes, as well as out-of-school trips were open to students from both lines. There was a concerted effort in the school organisation to encourage students to think of future careers, and to engage in science.

## **Outcomes**

Students from the school regularly participated in science competitions. One had just placed highly in a biology olympiad, although these competitions were not a focus of the school. Students regularly proceeded to medical school and further study in other STEM fields, particularly from the Natural Science line according to the school administration.

### **8.2.2 Offering opportunities to imagine futures in STEM careers**

One of the strengths of the school was in providing the opportunity for more advanced laboratory work than other schools. Eero, a student considering continuing to medicine or biology, or becoming a fireman, took courses out of interest ‘...even if the course hasn’t had much use for later study I’ve just taken it out of interest, like the courses of laboratory work like cutting open pigs stomachs and so on’. These courses gave students hands on experience that helped them confirm their interest, as was the case with Eero and Minna, or realise that such work was not for them, as happened with Soila, helping her narrow her focus to mathematics and computer science.

Outside of school, students had the opportunity to go on a sailing trip, for example, that included field work and research. For Eero, the experience was partly about being with friends and enjoying the trip, however it also affected his thinking about biology:

Eero: I did a lot of microscoping of the samples we got and I really got interested in looking at what we found. And when I was telling one of the teachers of what I thought was wrong with one of the fishes I was looking at or something like that, she said something like she could imagine me in a research lab doing the same thing. Well that was nice, its something encouraging to hear that, that I'm actually making some good points about what I'm looking at.

For Eero, the experience provided fun and interesting exposure to biology, but also a moment of recognition, when a teacher signalled that this could be a future career path for him.

The biology teacher I interviewed considered the teaching at the school to be quite ordinary, 'learning by doing', what everyone was taught to do at Finnish university teacher training. At the same time, it seemed a principal the teacher believed in:

Teacher 1: To wake up curiosity, to see something, to feel something concrete, to do it by himself, herself, to get the plankton out of the sea by yourself with net and to put it under the microscope lens and watch it... So I think its much more interesting than just look[ing] at the picture somewhere...

### **8.2.3 Attracting high quality, specialist teachers capable of exposing students to realistic STEM work**

These important opportunities to explore real research and STEM work were likely enhanced by the quality of teachers that the school was able to attract. Despite the teachers' insistence that what they were doing was ordinary for Finnish schools, the students were enthusiastic about the teaching at the Large Magnet Lukio in a way that did not arise in any of the other schools in the study. In contrast, at some of the elite schools, students made a point of saying it was their *classmates* that drove the environment. Vera, for example, taking Short Mathematics, had transferred from another school where she had been very unhappy. Teachers from her lower secondary school had recommended the school because it focused on Finnish language. Her brother had attended the regular line at LML and recommended it to her because of the teachers. Vera was not particularly

interested in science when she came to the school, but her feelings changed:

Vera: Those courses [in science] where I have been. They have been really really interesting courses. And I think that in this school, when I am going to some course and I think I am not interested at all about biology but the teachers are so good that they take me into the subject and I start to like it[laughs] and now I think that I want to study every subject but I can't we don't have enough time to take all the courses...

The students note that it is the interest and enthusiasm of the teachers that is infectious. From Juha, in the science line and taking Short Mathematics: 'The atmosphere is really encouraging so its mainly perhaps that, and teachers are also really into biology and geography of course and well they, those are the two main things.' Soila reported the same from her mathematics teachers:

Soila: When the mathematics teachers are so interested and excited about math it kind, you know you kind of feel it in the classroom that they are interested in it (...) I think its because of the teachers, that's why I got interested in mathematics because you know it would be fun to feel, you know, like they do about math and when they see like a calculation they are like oh my god this is so cool! You know it's fun to be in the class because they're so excited.

For Vera in particular, the teaching seemed to play a big part in her developing intention to pursue a mathematically oriented career. She had thought about mathematics, although her parents discouraged the idea. She was interested in economics because it was described on university admissions materials as being math intensive. Vera's performance was increasing, even though she had moved from a less to a more selective environment.<sup>1</sup> Like her schoolmates, she pointed to the enthusiasm of the teachers as a key motivation:

Vera: The teachers are more they really seem to like their job and they are interested about what they are teaching to us so its like, it motivates us more. And I learn much better here then I learned in the other school lessons so its a huge difference between and my numbers in here they are getting higher all the time.

In the LML, the students interviewed portrayed teachers as a powerful force for inspiring and maintaining their interest in science. In particular, it was teachers genuinely inter-

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<sup>1</sup>An interesting counter example to the Big Fish Little Pod Effect (e.g., Marsh and Hau, 2003).

ested in the subject, but also a sense that the teachers were happy to be there, in the classroom that was recognised by the students. The biology teacher interviewed denied there was anything special about her teaching. However, she noted the importance of being able to teach more advanced course. She talked about, how teaching advantaged students, their engagement, and the flexibility given to her planning:

LML Teacher 1: The groups are smaller so the atmosphere is quite free of course and of course its not so formal. I think the atmosphere means a lot and they express themselves in a more open way. They dare to ask and they dare to comment and they are more communicative. The students interviewed from both the Large Magnet Lukio and the general lukio were enthusiastic about the specialist courses as well, and the interested community of students the school fostered. This was a key draw of the school for the students. Likewise, the ability to teach advanced level courses to interested students was a key benefit for teachers. It seemed as if because of this environment, the school was able to attract teachers with a genuine passion for STEM subjects.

This, in addition to the structure of teacher education in Finland, which demands a master's degree from lukio level teachers, meant that students were exposed to a high level of real science. This exposure at school also includes out-of-school experience such as advanced laboratory work and field trips, which as discussed in Chapter 7 are experiences associated with increased engagement and persistence. These experiences provided the opportunity for teachers to model realistic STEM work, and for students to imagine themselves in such roles, increasing the opportunity to develop an identity as a future STEM professional.

It is particularly notable that all students had access to these elite opportunities. The community of interested students included students from the less-selective general line. This exceptional inclusion is discussed further in the next section, and creates a contrast with the Small Magnet Lukio, where the creation of group identity was intertwined with the development of an adaptive habitus toward STEM.

#### **8.2.4 Creating high expectations for all students through radical integration of advanced STEM courses**

Unlike other schools involved in this study with specialist lines (the Historical Lukio and Small Magnet Lukio, all the Swedish gymnasiums and United States high schools),

the divisions between the science line students and the general line students at LML were invisible— even to teachers. This was a relatively new policy choice of the school leadership.

Furthermore, all classes were available to all students, including courses with advanced laboratory work, and students from the general line took advantage of this opportunity, unlike at SML. This meant that even the teachers did not know, within an advanced course, which were the LML students and thus this distinction could not bias their expectations for students. The original structure of the school had been quite different:

JS: Sometimes this sort of program would be a school within a school and they would have their own classes?

LML Teacher 2: When this school was founded about 10 years ago we had this system where we had own classes for the national science line, yes. It started that way, and when they started to learn mathematics, there were groups, which were only the national science lines and only the general lines. But now we have a mixed class all over and I think its better that way. They are going to be mixed anyway (...) and I don't see any difference in the system when we started, when there was a national science line mathematics and then the general mathematics and now from the first course they are mixed and I really don't know which line.

Like a doctor who doesn't know she or he is giving a placebo to a patient in a drug trial, the teacher's at the LML were forced to treat students as if they were all in the same line, and this difference matters, since prior to the policy change, teachers did have different expectations for different students. These sorts of differences are exactly why drugs are required to go through double-blind studies, and so it is particularly interesting to see this approach in a school context.

First the school leadership removed the special classes for science line students. More recently, the head of school had decided to make is so teachers did not know which students belonged to which line. Previously, the teachers had known which students were in the science line, and had used this to try to motivate certain students to do better:

LML Teacher 1: I would say that: 'I expect more from you because you are on this line'. That I would kind of point out that why haven't you done you're homework, that you have chosen this line and you don't even know this thing or just like you know- just in a conversation. But now I don't know if they

are or not. As mentioned above, expectations are powerful factors in students choices and development (e.g., Wigfield and Eccles, 2000), and demanding better performance from some students implies that it is not demanded of others. While the teachers said that it might be possible to guess over time who was in the natural science line it wasn't clear in the classroom, despite the difference in selectivity of the two lines. This is a further suggestion about the arbitrary nature of stratification in schools, and the effect that using interest, enthusiasm, and drive in allocating students to courses can have, despite previous academic achievement. The structural change due to the school leadership was subtle, but seemed to have a powerful effect, making it impossible for teachers to differentiate their expectations of students based on their track placement, and encouraging high expectations and engagement of general students at the school.

A flexible, choice-based structure and invisible differentiation fosters engagement throughout the school. Above it has been stated that stratification often is associated with the creation of social distance, and the creation of group biases, and indeed this seemed to be the case at the Small Magnet Lukio. It was partially in acknowledgement of this problem that the Large Magnet Lukio leadership decided to remove the distinction of the science line:

LML Teacher 2: First when there was only the natural science students in the first class they they knew that all the pupils who were in the class were in the natural science line. So they thought that they were some kind of better [people]– or whatever, and they looked the general line students, 'they are just a little bit lower than us' and that's not so... So when they first come now in classes they don't even know who is in the general line or in the natural science line. They are in the same level they don't think that 'because I am in the natural science line I must be very different from the others'. They don't think that.

Again, this seemed supported by the students' interviews. Even though they said it was evident who was on the science line, there was no real separation. As Eero (science line) put it the students on the science line were '... definitely a bit weirder but in a nice way. I mean I do like the atmosphere in this school everybody gets along with others but you can really tell by things like someone looking a bit hippy or something like that you can probably guess that the said person is in the natural science line...'. While students could tell the difference, groups in the school were mostly 'mixed up' according to Soila,

also in the natural science line. Eero said: ‘...people don’t really put titles on people like ah nerd good guy nerd good guy and so on ah you can be much more freely what you want to be and you can just be yourself and also there’s nothing like, well I haven’t really I don’t think there’s bullying or anything like that.’

Even though there was not a special community formed for students in the science line, or perhaps *because* such a community was not cultivated, the school in general had a pro-science atmosphere. Juha, taking the science line and short mathematics, felt it was a safe place for expressing enthusiasm and interest in science:

Juha: You can be more open about your interest in biology and geography since other students also are into science no matter is it physics or chemistry or mathematics since we are all like, geeks.

This wasn’t something particular to the science line but rather the interest was throughout whole school, as Juha continued: ‘the interest in science is more than average (...) it is spread in all, for all students in this school.’ The lack of distinction and the ability to choose advanced courses seemed fundamental to the creation of a school environment that encouraged STEM participation and interest in wide variety of students. Unlike examples of students in lower strata discussed in Chapters 5 and 6, the students in the regular line were not told that they were not able or not allowed to pursue advanced mathematics or science studies. Rather, all students were invited to have high aspirations in STEM courses, and to develop an positive, adaptive habitus towards science.

Furthermore, coinciding with the effect of choice in the Small Magnet Lukio, the ability for both specialist and general lukio students to choose advanced courses seemed important in the cultivation of persistence and passion. Regardless of prior performance or current enrolment, students were able to choose their path in advanced mathematics and science learning, with seeming positive effects especially for those students who might have been discovering their interest for the first time.

## 8.2.5 Summary

The Large Magnet Lukio provided student with meaningful enrichment activities and access to real laboratory work, which, as discussed in the last chapter, seems to be a key factor in students’ interests and aspirations, and ultimately in their desire to persist in STEM fields. The school attracted some elite students, but did not separate them at all, and all students had access to the high-level curriculum. Vera said in a slightly

exasperated tone: ‘...our principal he’s just—he wants that we *all* should study the natural sciences cause he’s so interested about them’. Students were notably positive about the environment of the school, the freedom they felt amongst their classmates, and also the enthusiasm of the mathematics and science teachers.

It may have been coincidence, but the young women interviewed were particularly positive about their experiences with mathematics and science, and three out of four of them were interested in pursuing further studies in STEM related fields: Vera was interested in pursuing mathematics further, Soila (the only young woman interviewed from the science line) was keen on mathematics or computer science, and Minna was planning to study for medicine.

For Vera, LML had been a place of academic transformation, just as SML had been for Sakari. Like Sakari, Vera had found a passion for learning: ‘I want to learn things I want to study more and more and more’ and was taking all the mathematics courses possible for Short Mathematics.

The school had a steady production of graduates into STEM programmes at the tertiary level, and every other year (estimated by the teachers) there was a student winning a prestigious prize or national competition in science. However, the strength of the school was also in the general engagement and persistence it seemed to foster, as well as a positive environment, although it was constructed through the absence of group identity, rather than its careful formation.

### 8.3 Policy Implications

In this chapter, two very different specialist schools are described. Both are seemed to be effective in reaching the goals they set out to accomplish, but these goals were not identical. The contrasts between these two school structures bare further study. However, the two sites I studied are successful in their mission of supporting a STEM curriculum and students, and thus a number of policy suggestions may be drawn in regards to the structuring of specialist schools:

**Fostering high level talent:** It is possible to foster extremely high level talent without early differentiation, and indeed, SML was more successful in doing so than the Swedish example, where Bengt had been accelerated early, but ended up lost in terms of interest and ambition.

**Adaptive habitus development:** A possible reason for the student success at SML was the concerted cultivation of habitus and school environment within the context of mathematics education. Furthermore, at both the SML and LML, students had access to high-level practitioners and the opportunity to engage in STEM activities that gave a broader perspective on these fields. As discussed in the last chapter, such opportunities provide students a chance to begin to imagine themselves as STEM professionals, coinciding with research that suggests the importance of development of identity in the retention of engagement in STEM (Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2010).

**Flexibility:** At both SML and LML, students had the opportunity to scale-up their interest and studies in mathematics and science. Notably, at LML this was available to all students, and students across the school were encouraged to be enthusiastic about science. Again, the advanced offerings at each school were selected primarily through interest. In the LML, this was encouraged and more available for students in the general school as well as students in the magnet school.

**Radical integration:** While having a strong in-group identity seemed to have some benefits in terms of retention and engagement at SML, the lack of group definition was a strength at LML, where students enjoyed the atmosphere and mixing between students in the school, and where there was less of a moral boundary drawing (Sayer, 2005a, p. 952–953) between different lines.

**The crafting of character:** In a sense, both schools were engaged in crafting students' characters, with many positive outcomes for students, but perhaps costs as well. Furthermore, exactly what habitus should a school be crafting and who should decide? To set forth a goal is a dangerous task. At the same time, it is clear that a habitus is formed regardless of the intentionality (e.g., Zevenbergen, 2005).

The costs and benefits of the various methods depend on what the ultimate goals of educational policy might be. Both of these schools seemed effective in encouraging retention in STEM fields. SML offered an opportunity for some students to experience a seamless transfer to tertiary education. LML seemed to produce strong willingness to persist and self-efficacy, particularly among the young women interviewed. LML further contrasts with almost all other forms of stratified access to STEM education; in most cases, the social stratification is a desired outcome, if not of policy makers, perhaps to educational consumers (as it is in, e.g., Hertberg-Davis and Callahan, 2008), whether such preference

is fully conscious or not.<sup>1</sup> The leadership in both magnet schools crafted structures that acknowledged the importance of identity and habitus in student engagement with science and mathematics.

Further cautions should be acknowledged. While these were two very interesting schools with interesting ideas about how to structure advanced science and mathematics learning, it should be noted that some research finds negative effects in self-concept for students attending selective schools. These effects were both durable over time (Marsh, Trautwein, Lüdtke, Baumert, and Köller, 2007), and apparent across countries (Marsh and Hau, 2003). However, such effects, and indeed, even a lack of value-added for academic performance on average (Marsh, 1991; Finn and Hockett, 2012), might obscure the unique potential of such schools to foster the growth of engagement and other adaptive, non-cognitive skills (an adaptive habitus towards STEM in particular) among a wide range of students.

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<sup>1</sup>Such uses of stratification are discussed further in Chapters 5 and 6.

## Chapter 9

# Mechanism, Transparency, Permeability: illustrations

The problem of engaging and inspiring students in STEM education is a common focus of research, policy rhetoric, and enrichment programmes (e.g., Archer, DeWitt, Osborne, Dillon, Willis, and Wong, 2010; Aschbacher, Li, and Roth, 2010; Dickson, 2010; Bracey, 2011; National Science Board, 2010). Indeed, this problem was a focus of Chapters 7 and 8. This chapter offers a variation on the theme of engagement by examining the experience of students who are trying to ‘scale up’ their STEM engagement themselves as they aspire to further their studies in STEM fields. The students included in this chapter have already evidenced grit and passion for pursuing STEM fields; their experiences make visible how local educational structures impact students’ choices and opportunities to persist in STEM. The question of how their respective schools systems respond to their engagement is of interest both from the standpoint of equity, and also from the standpoint of efficiency.

The four young people whose educational trajectories are related here – Sakari from Finland, Monika from Sweden, and Alex and Cory from the United States – are seeking upward mobility within each stratified educational structure. Their choices, as well as their opportunities, help to highlight not only the structural possibility for persistence in each case, but how the generation of secondary effects of social background within each structure can inhibit persistence.

Previous chapters attempted to establish how stratification occurs in each of the settings included in this study, and that aspects of the different systems function in homologous ways across settings. However, the structures of stratification, particularly with regards to

mathematics and science education, are different in important ways that impact student persistence. In this chapter, the framework of Mechanism, Transparency, and Permeability will be used to draw contrasts between the students' experiences, and their capability to persist in STEM fields, within these different structures. These illustrations are meant both to be characterisations of each of the educational systems, and also to show the value of this framework in pinpointing the key differences between each of the stratified structures that generate inefficiency and inequality through the promulgation of secondary effects— effects in particular that inhibit student persistence in STEM fields.

The terminology of this framework has been used throughout the dissertation, and a more detailed outline is presented in Chapter 1. The aim of this framework is to change the focus of policies from binary disagreements about tracking or school choice to a focus on the elements of stratified educational structures that might be most generative of inequities and inefficiencies, and in turn, to corresponding remedies. Such a focus may help to inspire reforms that are of value to both those whose primary concern is equity, and those whose primary goal is efficiency (with regards to the maximisation of talent, for example), thus opening the possibility for practical policy changes to move forward. Briefly, the framework consists of the following factors:

*MECHANISM: What physical, tangible criteria (including geography, financial resources, age) determine how and when a student's assignment within an education system will take place?*

*TRANSPARENCY: How clear and understandable are the allocations of education, and the consequences of these allocations for educational access and future opportunities?*

*PERMEABILITY: Is it possible to move from one educational stratum to another over time? Does this possibility exist for adults as well as young people?*

Again, the illustrations here are outliers, students who come into tension with their respective educational system and who increase their interest in persisting in STEM fields over time. There is one key illustration from each country, beginning in Finland, then Sweden and finally the United States. There is a second illustration from the United States where two very similar cases with contrasting outcomes help reveal the impediments less privileged students face when seeking upward mobility in the educational system there.

## 9.1 Sakari: ‘It’s more about being interested’

Sakari is a student at the Small Magnet Lukio that is located in one of the poorer areas of a Finnish city, as described in Chapter 8. Students can enter the school by doing well on a national mathematics exam, or by their grades from middle school. If a student is really keen on entering, it is likely he or she will get in. Sakari is a young man who had difficulties during elementary school, started to become interested in mathematics in lower secondary school (the only subject he says he did okay in at that level), gets accepted to a specialist school and becomes a nationally competitive mathematician by the end of his upper secondary career, surpassing many students who started with stronger academic histories and higher tests scores. Prior to lukio, he describes himself as being an indifferent student, rather unhappy at school. At age 13, he found out through classmates that higher performing students had been tracked into a more advanced mathematics course at the *ylä-aste* [lower secondary] level:

Sakari: We had in our *ylä-aste* [lower secondary] different classes for different levels in mathematics so that students who were better at mathematics would have more teaching and lessons.

JS: Okay, and how did you get into that class was it, was there a test to take or?

Sakari: No... well from *ala-aste* [primary school] we just compared notes [grades/marks] and then the ones with the note got the best class and so actually I didn’t start in there because I was kind of um... wild in *ala-aste* and well then I was like ‘What?! Why am I not in this class?’ Then I was like very nice and got good grades and then I got there. This change was when Sakari was ages 13-15.

While Sakari began to be more engaged in *ylä-aste* [lower secondary], he does not describe his performance as exceptional. It is lukio that his performance and interest accelerate:

Sakari: In *ylä-aste* [lower secondary] there was some competitions but I didn’t do that well in that actually and... the other student from our *ylä-aste* [lower secondary] who came here, he always beat me in those competitions, so...

JS: And what about now, may I ask?

Sakari: Now I beat him like every day. [laughing] Well, it’s-it’s more about

being interested. . .

For Sakari, the transition from lower secondary to upper secondary at age 16 was easy: ‘My grades got *a lot* better somehow. I mean, a *REALLY* lot better, like one and half grade out of 10. And I don’t know how it happened. Maybe I was just not listening in ylä-aste [lower secondary]’.

Enrolling in the specialist lukio coincided with an academic blossoming, as well as a social one. Sakari describes himself as not having many friends in primary and lower secondary school—very different from the confident, social presence he had during our interview. Along with confidence, Sakari exhibits an adaptive habitus, and all of the non-cognitive skills that are promoted as predicting eventual perseverance and success. He believes in the importance of effort, he has preference for challenge and so on.

In Sakari’s case, the educational structure allows him to accelerate rapidly from age 16. It is important to note that though he was in a class that had a bit more mathematics than other classes from age 13 to 15, he did not experience any significant enrichment until 16. Yet, his performance is outstanding, better than his classmates who originally scored higher than him. He attributes his performance less to giftedness than to something approaching deliberate practice (Ericsson, Roring, and Nandagopal, 2007; Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011), that is, to concentrated, passionate, effortful involvement. At his specialist school, he can further ‘scale up’ his interests. There are voluntary, advanced courses and participation opportunities for intensive training. What is important to consider here is that these do not offer any general distinction in Finland, where extracurricular involvement is not needed for university entrance and mathematics is less of a distinguishing subject than in other countries (see Chapter 5). For Sakari, these extra courses were not required, and are accessed by student choice.

He describes his interest as ‘something that came up when I went to this lukio’. He started out curious but unsure of his own ability, and ties his success to effort: ‘I think if you’re really interested in mathematics then that’s the equivalent of being good at mathematics. I mean, I don’t consider myself exceptionally talented but I just consider myself exceptionally interested in mathematics, so, you just have to do hard work.’ This is a belief structure strongly related to positive outcomes (Duckworth, Peterson, Matthews, and Kelly, 2007; Dweck, 1999). Furthermore, he was exhibiting exactly the sort of passion that Fredricks, Alfeld, and Eccles (2010) fail to discover in elite American students (discussed, for example in Chapters 1 and 8). I argue that the mechanism of selection is key to this difference in outcomes: Sakari has chosen to engage, and the system has been permeable enough to allow him to do so.

Sakari's case reveals important characteristics about how stratification functions in Finland. First, he experiences ability tracking at the lower-secondary level, something that is supposed to not exist in Finland. That he began lower-secondary unaware of this stratification hints at a growing lack of transparency in the Finnish educational system as these specialist classes become more common. Second, the structure of the allocation at the transition to upper-secondary allows Sakari, who had not been an exceptional student, to take advantage of a programme that capitalises on his growing interest in mathematics, leading to a truly remarkable academic career. This transition happened at age 16 for Sakari. By the end of upper-secondary, he was taking courses at the local university, and had far surpassed the minimum number of credits needed to graduate from upper-secondary.

He is an example of how an educational structure can allow for exceptional acceleration even when the allocation happens comparatively later in a student's career. This was made possible by having the mechanism of allocation be one of choice; the specialist school may have the most challenging opportunities available, but it is not the most prestigious upper-secondary in the region studied. As discussed in Chapter 8, within the school, his involvement is also due to choice, and the flexible nature of the school curriculum allows it to respond to his increasing interest, hard work, and performance.

Sakari's choices, as he describes them, have been very independent. Because the mechanism of allocation is in part due to interest and passion, the educational structure in effect selects for these traits, arguably with a more efficient outcome than will be illustrated in the Swedish and United States narratives in this chapter. Sakari is well-positioned to succeed at the tertiary level and beyond. As described in the last chapter, Sakari's school has facilitated opportunities for networking with alumni, and this has resulted in Sakari starting university courses during upper-secondary. Furthermore, he felt the transition to university work was easy. Not only was some of the curriculum familiar, but through his network, he already knew several people in the local department.

It is important to reiterate that despite the elite curriculum Sakari has accessed during upper-secondary, his school was not particularly selective. He was able to enter into this elite environment despite lack-lustre early academic results, and despite not having been accelerated at an early age. Furthermore, he did not need parental intervention to get into the programme. How to get to the Small Magnet School and take advantage of the further optional opportunities for enrichment the school provides were transparent. It should be noted that while the school leadership works hard to create a sense of community, his position as a Finnish male likely contributed to his sense of comfort and

ultimate success at the school, which is actually a long distance from his home. In this way, his experience contrasts with that of Monika, from Sweden, who will be discussed next.

Sakari's story illustrates the drastic impact of permeability on an individual's outcomes. The school structure allows him to find an interest at age 15, and allows him to accelerate rapidly at that point, despite uneven academic performance earlier. His school's focus on not only acceleration, but the development of an adaptive habitus, as discussed in Chapter 8 are also key. Bengt, a Swedish student discussed in Chapter 5 and 6, was simply accelerated, without the benefit of an environment that fostered the development of an adaptive habitus, with much more tenuous results and a rough transition to tertiary level STEM studies. In contrast, Sakari is exactly the sort of student that potential future STEM vanguard that policy makers such as Bearing and colleagues (National Science Board, 2010) urge schools to produce. Yet, it is very possible that his trajectory would be impossible in the United States, as the case of Alex will later demonstrate. Monika's experience within the Swedish schools system, described next, will be discussed, a trajectory that might be considered almost the inverse of Sakari's.

## 9.2 Monika: 'I was afraid...'

Monika was a high performing student during compulsory school, particularly in mathematics. She had a self-described passion for mathematics and problem solving during primary school. She chose to go to her local gymnasium, which was close to home in a district where 95 percent of the students are of foreign origin. She loves mathematics and wants to be an engineer, a career she fixed on during her upper-secondary education. However, her path is made challenging because she chose to take the Social Science track over the Natural Science track during her upper-secondary studies. As a consequence, in order to get her place in an engineering programme, she must pass an intensive year of Natural Science courses at the local university. The impact of Swedish school structures on Monika's opportunities and choices to study advanced mathematics are explored in this section. The possible intersection Reay (2008) of Monika's background and gender with these structures is also noted.

Based on average scores, Monika's gymnasium was one of the lowest performing schools in the city. She and other high-performing students chose the school, which was overwhelmingly attended by students of foreign background, because it was nearby and more

comfortable for them. Her opinion of the school differed from popular opinion.

Monika: ‘Some people said the school was crappy because of the...students who were going here... I found this school very good because the things I have heard from my friends and the others I hang out with–They weren’t right.’

Monika’s story resonates with work by Bunar (2010) on the tension between schools for children of immigrants and schools where ‘Swedish’ students go, and the disparities of status between them. For Monika and schoolmates who made similar decisions, attending a more prestigious school would have meant traveling to the city centre and navigating an environment where they would have been a minority. This one the first place where the structure of choice breaks down when it encounters students’ social position; the cost and risk of making a choice to attend a better school is higher for some students.

Monika’s favourite subject before upper-secondary school was mathematics. She had been the top mathematics student in her class and regularly asked the teacher for extra mathematics tasks to do at home. Despite this, and in contrast with some of her male classmates, Monika did not receive any encouragement to choose the Natural Science line at gymnasium:

JS: Did your teacher ever try to get you to go into the natural science programme?

Monika: Mmm... [5 seconds silence] Actually... No. I hadn’t that contact with my teacher. So she didn’t talk to me in that way– like a friend. She only talked to me as a teacher. So I didn’t get any tips.

JS: About?

Monika: About what I was going to study.

For Monika, although she was a high performing student in mathematics, there seemed to be no official encouragement for her to continue to Natural Sciences in gymnasium. This perhaps fed her concern about the difficulty of the Natural Science line and demonstrates the power of teacher expectations on student choices. As I discuss later, such factors such as self-doubt and low teacher expectations may perhaps be stronger for underrepresented groups such as girls and minorities (Jussim, Eccles, and Madon, 1996; McKown and Weinstein, 2002).

As discussed in Chapters 5 and 6, the Natural Science line serves as a more elite line in the Swedish Gymnasium, and has a reputation for being more difficult. Despite Monika’s

high level of confidence and interest in Mathematics, she was less sure about laboratory sciences, and her friends' experiences helped dissuade her from taking the risk of trying the Natural Science line:

Monika: . . . My friends that studied the [...] natural science and they told me it was hard and that scared me a little bit because I didn't want to study the natural science and then after a year quite it and begin another programme because I was afraid that I would maybe restart my year. And I didn't want to do that.

Due to the lack of permeability in the Swedish system, it was not possible for Monika to take advanced mathematics only. By bundling courses together in programmes, rather than allowing for a la carte selection (as is possible in both Finland and the United States to some extent), the system becomes less permeable. The lack of flexibility makes Monika's choice all or nothing: she cannot take advanced math without taking advanced science. Furthermore, switching from the Natural Science to Social Science track would involve adding an entire year to her gymnasium studies. Permeability from the Social Science track to Natural Sciences is more difficult. For Monika, the risk seemed too high, particularly when she was given no formal encouragement within the school system to try.

Monika's trajectory towards a future STEM career is also made difficult by the lack of transparency in the Swedish system. She reveals that she thought the Social Science would give her a good grounding for further university studies:

Monika: I thought if I could get good grades on those courses then it would give me a high grade for the schools after gymnasium. And I thought it would be an easy programme for me to choose between many schools and programmes.

Yet, as discussed in Chapter 5, it is the Natural Science line that gives the best access to tertiary education. There is additional lack of transparency, as will be discussed below, due to habit of teaching different mathematics curricula to Social Science and Natural Science students, even for the same course.

The result is that Monika is placed in a course that is too easy for her:

Monika: The first year here, yes, and ah, I didn't study so much because I already know what the teacher was going through at the board. So . . . I got the top grade, too, at the course. So . . .

For the first two years of gymnasium, Monika was never challenged in her mathematics courses. During her second year, she attends an information session at a local university and becomes certain that she wants to become an engineer. As a consequence, she enrolls in an extra mathematics course, Mathematics C. However, despite her top marks in her first mathematics courses, which were aimed at Social Science students, she feels unprepared for this course: ‘... when I started the C course it was instead of going up one level it felt like the Mathematics C course was five levels up.’ She is still determined to learn but her sense of self-efficacy seems brittle: I—I don’t feel like the top student anymore’. She is now afraid of her ability to be successful in her chosen path towards engineering:

Monika: ... The way I act now—I don’t think its going to work in [the natural science base programme] because... you have—you get a lot of work. It is, it is a lot of work I have to do and I am afraid to not finish the work...

For Monika, being placed in a mathematics track below her level has compounded the challenge of pursuing STEM after upper secondary. Not only has the curriculum she has been offered been lacking in rigour (despite being named identically with courses taught to the natural science students, an issue of transparency discussed in Chapters 5 and 6), but she is out of practice in studying. Monika is uncertain of her ability to complete the course well, she experiences a loss of self-assurance and sense of self-efficacy. Sayer (2011, p. 10) writes that ‘[v]irtues are embodied dispositions acquired through repeatedly active well...’. If this is the case, the Monika is truly disadvantaged by having had mathematics course work that was too easy for her, thus removing her need to study.

The lack of opportunities to ‘scale up’ and general lack of permeability means that she has had few options for ways of developing expertise. This is in contrast to Sakari’s experience as discussed in the section above. Yet, these are skills that Monika needs not only to complete the Mathematics C course at gymnasium, but to make it through the rigorous Natural Science preparatory year at the local university, which she needs to do in order to qualify for admittance to the engineering programme. So, after choosing the Social Science line due to a worry about needing an extra year, Monika will need an extra year of schooling in any case. Furthermore, while coding the survey, it became clear that some Swedish students who have already taken the Natural Science programme, and taken mathematics past Mathematics C were also planning to take the preparatory year of natural sciences at the university before heading to challenging STEM programmes. For these students, the preparatory year is a way to strengthen three years of gymnasium studies. In contrast, Monika will have to learn in one year, in a new, more competitive

environment, material that she could have studied over the course of three years had she chosen the natural science programme when she entered gymnasium.

In her story, there are various aspects at play. It is possible that both her gender and immigrant background played a part in the absence of official recommendations for her to pursue a more rigorous course of study at gymnasium. Certainly, while Monika had high self-efficacy in mathematics, the same cannot be said for science, which bundled together at the secondary level made the social-science track more appealing.

Allocation in Monika's case was by choice, but this choice was delineated by a lack of transparency at the point of transition and lack of permeability (within her programme, there was no apparent way to move to more accelerated mathematics at the beginning of gymnasium without science). Her choice resulted in two years of mathematics courses covering material she had learned prior to gymnasium, arguably a waste of resources both for Monika and for the state-funded education system. However, the availability of a free natural science programme allows for the possibility of permeability at the transition to tertiary education, compensating somewhat for the earlier mis-allocation. Monika is both aware she needs to change the way she is working, and exhibiting lower self-efficacy about her ability to overcome the challenges she now faces in taking advantage of the permeability the year of basic natural science studies at university provides. Her development of a less-well adapted habitus is non-trivial. In addition to the findings here that suggest the importance of non-cognitive skills in students' intentions to persist, a diminished sense of self-efficacy towards mathematics and science, in addition to challenges to her self-concept put Monika's future attainment (Chen and Pajares, 2009) and persistence at risk.

On the other hand, if Monika is successful in the year-long preparatory programme, she has a prestigious spot in an engineering programme awaiting her. In this case, the potential permeability offered by the programme, particularly as the course is free in Sweden, presents Monika with a clear, transparent, way of changing her allocation within the educational system.

### **9.3 Alex: 'They wouldn't let me'**

Not all students who would like to move between strata are able to do so. Alex is the team captain of a Robotics Team in his penultimate year of high school in the United States. His robotics team is unique because the team meetings take place outside of school and are open to everyone. The mentors of the team contrast their policies with

surrounding schools where students are required to have taken certain courses in order to join robotics clubs. Like Sakari and Monika, Alex's interest in STEM fields grows during upper-secondary, in his case due in large part to his extracurricular work. Also like Sakari, Alex describes himself as an indifferent student during primary school. However, unlike Sakari, when this changes, and his interest and passion grow, the school structure does not respond.

During the interview Alex presents as a mature, calm and confident young man who is interested in becoming a computer engineer. He has grown as a leader as well as academically through his involvement with FIRST robotics having '... used trigonometry and physics to kind of figure out the momentum of this or the friction of that or figure out the firing angle for something'. Using mathematics in the robotics club 'you have to think about it and it's more of a connection.'

Alex was not interested in math and science before high school, and describes himself as hating mathematics in elementary school:

Alex: It confused me a lot. I didn't know how to do something, and you know, the class would just go on without me regardless if I knew what we were doing or not. And it caused a lot of frustration.

His interest has grown over the course of his high school years, which he attributes in part to his teachers and to changes within himself: 'In Freshman Year<sup>1</sup> I learned how to finally take notes, that it really matters, rather than [being] a bunch of miscellaneous stuff. So that helped me learn the material better.' In contrast with students who struggle from the transition from lower to upper secondary level mathematics, mathematics in high school has been easier for Alex:

Alex: I didn't really understand low-level mathematics in middle school. And then, as soon as I got to high school, it was suddenly I understood everything and the class was too easy for me. But at that point they wouldn't let me [change into a higher level course]. The school doesn't have organic learning. Everybody's forced to fit into this mould. 'You have to learn at our pace'—even though people learn at different rates. So it gets really aggravating. It [his experience with robotics] allowed me to look at something and feel more relaxed about solving it. I mean, there's no rush—take it at my own pace regardless of what the teacher is saying.

When Alex was struggling before upper-secondary school, mathematics was source of

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<sup>1</sup>The first year of high school in the United States, at roughly age 14.

stress. Now he is performing strongly in it, there is not chance to change his position in the system. It wasn't possible for him to adjust the courses he was taking during high school. Like the elite students in American high schools discussed by Hertberg-Davis and Callahan (2008), his academic disposition sets him apart from his peers. The robotics team serves as a refuge for Alex, in contrast to his math courses where he sometimes 'gets a little overexcited' and 'people hate when people are smarter...so they get upset over that'.

The mechanism of allocation for the robotic programme here is choice. This is an exception rather than the rule; at most of the schools in the area pre-requisites exist, and team leaders here reported application processes for school-based programmes. However, this programme was open to all students, and in turn provided a powerful learning environment for Alex that he may not have had in school. In contrast, allocation to advanced mathematics and science tracks happened early in the United States educational system, and Alex, who comes from a less advantaged background than Cory, also from the United States and discussed next, is not able to change his placement in the stratified structures. Alex's case illustrates a lack of permeability he faces within the formal school structure.

His interest and performance in school have increased because of his extracurricular involvement, but there is no way to change his track placement. This leaves him vulnerable; unlike some of the other upwardly mobile students discussed here, he will not have the official distinction on his academic record of being moved to more advanced mathematics courses, despite his likely ability to cope well with them. The strikingly similar case of Cory, drawn from the preliminary interviews in a different school district, in a different state suggests that Alex's case is not unique.

## **9.4 Cory: 'My parents forced me into the enrichment class'**

Cory took part in a group interview at a suburban International Baccalaureate high school (Saari, 2008). His story is brought up here because it both mirrors and contrasts remarkably well with that of Alex. Cory was also actively involved in robotics competitions and other academic extra-curricular activities, considering these as the core of his academic development: 'I feel like I'm almost entirely developed on the outside'. There were two classmates in the interview with Cory, and they had both participated in gifted or enrich-

ment courses throughout middle school (junior high) and before. Cory's situation was different:

Cory: In my case actually I was late [in accessing the advanced or gifted track]. I actually only got into enrichment in like eighth grade, and then only like half of it so I don't know...there were some problems with 6th grade stuff, like tests and I wasn't very good at them so they put me in normal classes and once you're in there you're pretty much stuck in there. So pretty much I had to like between me and my parents forced me into the enrichment class I guess.

Like Alex and Sakari, Cory describes himself as not being an exceptional student during compulsory school. The following year, at the end of ninth grade (age 14), his interest in computers takes off. Now known as a computer whiz, his classmates are incredulous that he began working with the so recently:

Cory: Up till– all the way through ninth grade I hated computers more than anything in the world. Like, I hated the guts out of computers.

George (a classmate): Are you serious?

Cory: Oh yeah, I hated them so much.

George: You've got to be kidding me.

Cory: I'd get like a physical pain every time I saw a computer. I couldn't type at all I didn't even know how to like– it was bad– but then–

George: So you've learned all this stuff in three years!?

For Cory, his computer activities, including robotics building with his team outside of class, were the biggest factor to his engagement and learning, just like with Alex. His parents support his involvement and furthermore, respond to his increased interest in STEM by encouraging him to access advanced mathematics and science, which in his school is offered through the International Baccalaureate programme. However, this programme is considered an extension of gifted and talented provision within his district. At first the school is reluctant to let him change his allocation, just as Alex experienced. The difference is that Cory has strong involvement and resources on the part of his parents.

Despite the school structures initial refusal to respond to Cory's growth of interest and performance, Cory does well in the International Baccalaureate programme. Again, an-

other example of a student who was accelerated rather late (after age 14) and after having mediocre performance during compulsory school. In this case, family resources were necessary to enact this change. Without determined action on the part of parents ‘forcing’ the change in allocation, Cory would not have been moved upward within the educational strata of his school system. Alex is an example of a student with a similar trajectory, but without the social capital to change his allocation with the (formal) educational system. While both Alex and Cory have notably participation and leadership experience in their extracurricular activities, experiences that are valuable to persistence in STEM fields, only Cory benefits from having the formal credentials that signal an advantage position within a stratified educational system.

## 9.5 Discussion

Three of the four case studies presented in this chapter are examples of how students can make dramatic improvement over time, both in their performance and their engagement with STEM learning. Alex achieves this through accessing a powerful extracurricular programme, one that exceptionally is open to all according to interest. Sakari has perhaps the most dramatic upward mobility in his respective system, by accessing a semi-selective specialist school that accelerates his interest and performance. Cory is also shaped by accessing extracurricular activities in technology and robotics. His trajectory leads him from being a mediocre student to participating in an elite programme at the upper-secondary level. It is notable that all of these examples are males, who reported developing academically after age 13. Alex’s story is of particular interest, because, despite academic development, he is not able to achieve upward mobility in the rigidly stratified formal school system. In terms of allocation, the school structure that Alex encounters in the United States seems in accordance with a fixed mindset (Dweck, 2006) that is based on an ontology of ability that does not allow for the possibility of the transformations that these three young men embody. The lack of response within the system is not only a source of inequity, however, it is also inefficient as it makes the persistence of talented, passionate students more difficult.

Unlike the cases of Alex, Sakari, and Cory, Monika begins her academic career as an outstanding student in mathematics. Despite this, she isn’t advised or encouraged to take the more prestigious, mathematics intensive, natural science track in upper-secondary at the Swedish gymnasium. The lack of permeability and transparency in the Swedish system further hinder her progress. However, within the educational structure as a whole,

there is a path, albeit a challenging one, to allow for permeability in cases like hers: through an intensive one-year study programme in natural sciences. In Sweden, the tuition at such a programme is currently free, increasing the potential of permeability at that point in the structure. The efficacy of such a programme is worthy of future investigation, as it is a promising compensatory policy that might be implemented in other systems.

### **9.5.1 Characterising the educational systems**

The framework used in these illustrations also lends itself to a characterisation of each country, which will be given here. Using these characterisations, the importance of permeability is raised in importance as a distinguisher between the structures, and a key feature for both equity and efficiency. As such, it presents an alternative to future policy reform considerations, both with regards to structuring increased differentiation for the production of high-level talent, and increased equity through outright attempts to remove distinction and stratification.

#### **United States**

It is particularly through the mechanism of allocation and the lack of permeability that the school structures in the United States are most prohibitive for persistence in STEM fields in comparison. A system that discourages interested, capable students from pursuing advanced science and mathematics, when those students were allocated to a lower academic strata early in their career (when such decisions are more closely linked with family background), might be considered to promote both inequity and to be highly inefficient in terms of retention in STEM fields.

#### **Sweden**

In summary, in Sweden, the lack of transparency and lack of permeability at the upper secondary level may hinder student persistence in STEM fields, particularly for less self-efficacious students. However, the system has compensatory measures (the year of remedial science and mathematics) to prepare students for tertiary study, thus increasing permeability, and students' possibilities to pursue further STEM studies.

## Finland

Compared with Sweden and the United States, the Finnish system is significantly more permeable. Students are able to choose mathematics and science classes independently and recover from earlier choices more easily when considering post-secondary schooling. However, access to enrichment is lacking in transparency and inconsistently distributed throughout schools, creating concerns both for equity, and in terms of effective use of such programmes to reach ordinary students. Overall, the comparatively high levels of permeability and transparency, combined with student choice as a main mechanism of allocation are what make the Finnish educational structure of interest in terms of considering policies that might increase students opportunities to persist in STEM fields. Sakari's case exemplifies, furthermore, how a lack of early stratification might not preclude the development of elite talent. Rather, in contrast with the story of Alex's progress, it suggests that permeability might enhance the the discovery of the passion and perseverance that drive elite performance (Duckworth, Kirby, Tsukayama, Berstein, and Ericsson, 2011). His case also suggests how differentiation (though a magnet school in this case), can create opportunity for upward mobility.

A historical review of policy documents contemporaneous to the structural reforms of the Finnish education during the last century suggest that this permeability is no accident, but direct result of policy: '...the present system leading to educational blind alleys should be replaced by another, which permits to combine and utilise previous studies to a larger extent. An endeavour to open passages is indeed one of the basic motives underlying the entire school reform in Finland.' (Nyberg, 1970). This is not a natural evolution of the Finnish system, but rather a feature of the system that was purposefully implemented with concerted effort. It seems to have been successful, when juxtaposed with they structures in the United States and Sweden. Rather than ridding the system of stratification and the upper-secondary level (the system is highly stratified) the Finnish system might be better characterised by its transparency and permeability.

### 9.5.2 Summary

The trajectories of Alex and Monika in particular illustrate how mechanism, transparency and permeability can contribute to the secondary effects of class, gender, and racy that diffract students from educational pathways. This diffraction occurs through both structural possibilities and impossibilities, but also through student choices occurring within those contexts. In these examples, stratification works both to prohibit retention and to

promote it. By focusing on a single element of stratification, for example tracking within schools, or school choice, the complex and intersecting ways that students are stratified in Finland, Sweden and the United States would be obscured. Instead, by focusing on elements of Mechanism, Transparency, and Permeability, key ways in which school structures bound student choice and agency are brought to the fore. The framework serves to bring explanation to the lack of meritocracy with STEM disciplines, and educational structures in general (Brown and Tannock, 2009; Souto-Otero, 2010; Goldthorpe and Jackson, 2008) that not only perpetuate existing inequalities, but generate secondary effects of these inequalities, increasing the inefficiency of the production of STEM talent. In particular, permeability emerges as a key, and under-considered aspect of educational policy.

## 9.6 Policy implications: focusing on Permeability

Research into equity often focuses on the mechanisms that allocate students into stratified educational systems. However, these cases also illustrate the importance of permeability for both mobility and efficiency. If a school structure seeks to maximise the amount of talent it ‘finds’, then it is important to establish policies of permeability. A transparent and permeable system allows students such as Sakari, access powerful learning despite former academic weakness. In Sakari’s experience, the school structures were responsive for his needs, allowing him to scale up not just in speed, but depth and challenge as well.

In contrast, the lack of permeability in the Swedish gymnasium mean that Monika had an ‘all or nothing’ choice to make– mathematics and all the sciences together, or none at an advanced level. This was clearly an important factor in her decisions. Combined with this, she was experiences a loss in assurance, and her belief in her ability to regulate her own studies, and this belief in one’s ability to self-regulate is important to academic outcomes (Chen and Pajares, 2009). This is especially worrisome because for her to achieve the upward permeability she aspires to. In order to claim her spot in the engineering programme, she first needs to succeed in an intensive year of science and mathematics courses, where she will be competing with classmates who are better prepared.

However, Alex’s position is even more tenuous. He is exactly the sort of passionate, hard working leader that policy makers claim they are looking for, furthermore well-rounded by his extra-curricular leadership experience. Despite this, no matter how much he improves

in skill, he will not have the credentials his schoolmates do who are in elite courses. This disparity will follow him as he competes for entry into university and for scholarship money. To take the courses that he could have taken in high school, in order to catch up with his more fortunate peers, he will have to pay a great deal of money, placing an additional burden on his chance of permeability.

While Monika's narrative suggests how personal and social constraints can prohibit the potential of choice within an educational structure in part through the development of a maladaptive habitus (or a weakening of non-cognitive skills), Alex's case shows forcefully how an adaptive disposition is not enough. Without family resources and permeable school structures, this talented young man is at risk of being diffracted from his aspirations of becoming an engineer. His case highlights the danger of assuming that the development of individual traits can compensate for unequal structure, a viewpoint that Heckman, whose research has highlighted the importance of non-cognitive skills, and inspired the development of this dissertation (e.g., Borghans, Duckworth, Heckman, and ter Weel, 2008; Heckman, 2008; Cunha and Heckman, 2009; Almlund, Duckworth, Heckman, and Kautz, 2011) seems to hold according to a recent interview:

I think what we've learned is that these human capabilities can be shaped. And as an economist, what I like about it is that it has this possibility of reducing inequality, but not doing it through the standard mechanism of just handing out money and transfers from the rich to the poor. That's ancient. The idea is you make the poor highly capable. That there really is a possibility of giving people more possibilities. That there really is the chance of improving their capabilities.

(As interviewed by Glass, 2012)

It does not matter how passionate or diligent Alex may be, however, if the educational structure will not allow him to scale up his studies, and attain recognition for his work. That is, despite the evidence for the importance of non-cognitive skills (adaptive habitus) in student persistence, structural possibility ultimately trumps adaptive habitus and individual traits.

Going further, I argue that permeability should be a key consideration in the development of both formal and informal learning environments that aim to foster STEM talent. If stratification is unavoidable, then one way to assuage the inequities of differentiation is to ensure that it is permeable across the life course. Increasing permeability may also increase efficiency. The examples of Alex and Sakari show how talented individuals might emerge far later than students are allocated to durable track placements in the United

States. Their progression supports the idea that passion, effort, and interest are key to outstanding achievement; but that is becoming increasingly supported Duckworth, Kirby, Tsukayama, Berstein, and Ericsson (2011); Ericsson, Roring, and Nandagopal (2007).

By considering the permeability as a key factor of educational systems, policy makers can learn from research, considering how educational structures might both foster and reflect in their own policies a growth mindset, to use Dweck's (2006) terminology, rather than a fixed one. By acknowledging the potential of students to grow and learn, equity might be enhanced not through the 'ironing out of distinctions' (Nagel, 1991, p. 135), but through the opening of passages (Nyberg, 1970) through which students might enter advanced STEM learning, selected in part by their own grit and passion. Permeability extends the age at which allocation to elite learning can occur, but it can also be considered that it extends the possibility of uncovering and fostering a wider range of elite talent. Increasing permeability, then, is attractive for the standpoint of both equity and efficiency. As such, increasing opportunities for permeability might be the sort of reform effort many different, and sometimes opposing, groups can get behind.



# Chapter 10

## Conclusions

In this final chapter, I present an overview of my study's key findings in four parts. Part One revisits the Mechanism, Transparency and Permeability framework, and briefly characterises each of the educational systems using this framework. In Part Two, I summarise the most notable themes arising from the survey analysis, beginning with a recap of the six structural equation models discussed in Chapter 4, which relate school structures to habitus and persistence. These themes are discussed in light of the analysis of the interviews and education policies in each setting. Directions for further research are also suggested. Part Three focuses on two sometimes contentious structures: magnet schools and extracurricular programmes. In Part Four, I return to the concepts of Transparency and Permeability, which arise from the conclusions of this research as important aspects of educational policies from both the standpoint of efficiency and equity. Transparency and permeability are offered not only as an important frame for understanding contrasts in equity and efficiency in this comparison, but as promising signposts for considering policy reforms in the future.

### **Part I: Mechanism, Transparency and Permeability: comparing Finland, Sweden and the United States.**

In Chapter 9, the Mechanism, Transparency and Permeability framework was developed further and illustrated with examples from the interviews. My motivation for emphasising this framework is, first, that it has been useful in moving past superficial characterisations of the educational systems in Finland, Sweden and the United States, particularly concerning issues of equity and access. Rather than focusing on a particular incarnation

of stratification this framework pinpoints other aspects of school structures that might be altered to promote or hinder equity and efficiency.

The roots of the framework arise from a need to deepen the comparative understanding of the three contrasting systems of differentiation in Finland, Sweden and the United States. At first glance, Finland and Sweden seem to have considerably less stratified educational systems, particularly with regard to mathematics tracks (e.g. Oakes, 2008). However, the results of this study suggest that if a holistic view of the educational system is considered, both Finland and Sweden are highly stratified. They are, however, stratified differently.

While Sweden, and especially Finland, do have comparatively less differentiated schooling at the compulsory level, this is followed by a high level of (very competitive) differentiation at the upper-secondary school stage. Rather surprisingly, the analysis of the interviews here suggests that in Finland and Sweden, competitive sorting for entry into upper-secondary schools functions socially in much the same way as tracking in the United States, with the use and experience of elite schools mirroring the use and experience of elite tracks.<sup>1</sup> In all three settings, one of the main benefits of this stratification, as reported by the elite students in particular, is the creation of learning environments with like-minded, school-oriented peers, in a strikingly similar fashion to elite students in the United States and elsewhere (i.e., Zevenbergen, 2005).

In the Finnish and Swedish systems of competitive school choice, it is between schools where the important social separation occurs. This happens particularly at the upper-secondary level, and increasingly at the lower secondary level. There, the elite students' descriptions of themselves in contrast with peers at less well-ranked schools were very similar to the differences drawn by students in the United States when comparing different tracks within schools (Saari, 2013). There seems to be a homology in the ways that people (and more advantaged families in particular) make use of the different structures of sorting students. Structurally distinct forms of differentiation led to similar results regarding social use and segregation. These are some of the unintended (for the most part) consequences of stratification policies that nonetheless seem strikingly durable, despite distinct cultural settings and differentiation structures.

However, this does not mean that there are not important differences in equity and efficiency of opportunity that are engendered by how these different systems stratify. This is where the Mechanism, Transparency and Permeability framework is useful. It

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<sup>1</sup>Often tracks targeted at students identified as gifted and talented, including honours, Advanced Placement, and International Baccalaureate courses at the upper-secondary level.

was developed over the course of this study, and reiterated here because of its utility in pinpointing the signature aspects of enacted educational policies. Briefly, the framework is constructed as follows:

1. **Mechanism:** how, why, where and when students are selected or given access to learning;
2. **Transparency:** how understandable are the ‘rules of the game’, how well do the actual uses of educational structures align with their official purposes;
3. **Permeability:** how much possibility is there for upward mobility within an educational structure over time.

These three facets of policy are also useful in understanding how features of stratified educational structures contribute to, or exaggerate, inequalities and inefficiencies in a system, as Chapter 9 attempted to illustrate. Below, mathematics and science educational structures in Finland, Sweden and the United States are summarised according to this framework.

## **Mechanism, Transparency and Permeability in Finland, Sweden and the United States**

In this section, the framework of Mechanism, Transparency and Permeability is used to focus the comparison between Finland, Sweden and the United States. Characterisations of the systems according to their predominant structures using this framework can be found in the diagram below, followed by brief explanations. See Chapters 5, 6 and particularly Chapter 9 Section 9.5.1 for further details and discussion.

**Table 10.1: Comparative characterisations of the three systems using the Mechanism, Transparency and Permeability framework.**

	MECHANISM	TRANSPARENCY	PERMEABILITY
	<i>when</i> Late* <i>how</i> Choice <i>what</i> Performance	HIGH	HIGH
	<i>when</i> Late* <i>how</i> Choice/competitive <i>what</i> Performance**	LOW	MIXED
	<i>when</i> Early <i>how</i> Parents/testing <i>what</i> Capital/performance	LOW	LOW
<p>* Increasingly early due to special programmes and school choice, particularly in Sweden</p> <p>** However, performance is measured more subjectively, on the school-level, see Chapters 5 and 6</p>			

## **Finland**

For mathematics and science, the mechanism of allocation is predominately one of student choice and interest. Little parental intervention occurs, and allocation to advanced mathematics happens late, at age 16. The system is transparent; the choice between long and short mathematics is well delineated, and the mathematics and science required for university admittance is clear to students. Advanced mathematics and science are not used as ‘weeder’ courses for further study.

Compared with Sweden and the United States, the Finnish system is significantly more permeable. Again, the mechanism of allocation to advanced mathematics and science is primarily by choice, allowing students to recover from earlier lacklustre academic performance, as Sakari, whose story is given in Chapter 9, illustrates.

Access to enrichment, however, is inconsistently distributed between schools, creating concerns both for equity, and the efficacy of such programmes to reach ordinary students. It might be considered that there is also a lack of transparency here; valuable enrichment activities are unevenly distributed and advertised, and therefore not all students and families are aware of such opportunities, or the educational value they might potentially offer.

Overall, comparatively high permeability and transparency, combined with student choice as a main mechanism of allocation, distinguish the Finnish system.

## **Sweden**

In Sweden, the mechanism of selection into advanced mathematics and science is also largely by choice, but is also mediated by test scores, since students apply to a particular study track, as well as the school. Transparency is lessened in Sweden due to chaotic stratification practices before upper secondary, opaque ways of structuring national courses, and the use of the natural science line as the true academic track, although that is not its stated purpose, as discussed in Chapter 5. In comparison with Finland, the Swedish system is also less permeable. Unlike in Finland, someone who tries the natural science track and then decides to scale back to the social science track would have to take an extra year to complete upper secondary school, increasing the risks attendant to trying advanced mathematics and science. Furthermore, mathematics and science are bundled together, which this study suggests further decreases permeability. On the other hand, well-promoted post-secondary programmes are offered with the explicit purpose of

preparing students for STEM studies at the university level, compensating for the impermeable upper secondary school structure. This is an interesting model that might be given further consideration in other educational systems.

As in Finland, access to mathematics and science enrichment is inconsistent, and the mechanism of allocation seemed often to be through parents or according to school. Again, enrichment is an aspect that might benefit from further expansion.

In summary, in Sweden, the lack of transparency and lack of permeability at the upper secondary level may hinder student persistence in STEM fields, particularly for less self-efficacious students. However, the system has compensatory measures (the year of remedial science and mathematics) to prepare students for tertiary study, thus increasing permeability, and students' possibilities to pursue further STEM studies.

## **United States**

In the school systems represented in this study, the mechanism of allocation occurred early (at eight years of age, through gifted and talented tracking). Regardless of timing, track placement was linked with parental intervention, and sometimes with testing, although opportunities were also determined by residential area. The mechanisms of selection thus rely more heavily on students' family background and less on student choice or performance than in Finland and Sweden.

The system in the United States was comparatively less transparent in two key ways. First, advanced mathematics and science are often accessed through prior enrolment in honours or gifted and talented courses. This means that students and parents need to understand, years in advance, how allocation occurs in practice to be correctly positioned for advanced STEM coursework at the secondary school level. Second, a lack of standard courses meant that in science in particular, the naming and content of courses was difficult to parse. The result is that the only clearly distinguished courses become the Advanced Placement or International Baccalaureate courses, which are independently certified by third parties, and provide some standard for evaluation by families and universities.

For students in standard level courses, this means that understanding their placement and track within the school in mathematics and science is challenging. Particularly for science courses, there were diverse options, like a restaurant menu of appealing and exotic dishes, but no accompanying description to help the diner predict what he or she would actually be eating. Such a system may leave room for innovation, but it is also markedly

less transparent, further privileging students in advanced courses whose work can be more easily understood and evaluated by universities.

In terms of permeability, the United States' system is the least permeable of the three. Not only is it difficult for students to alter their placement within the system if their ability in and interest towards advanced mathematics and science increases during upper secondary school, but opportunities to compensate for earlier missteps or lack of interest are difficult if not insurmountable. The high cost and lack of formal compensatory route (in comparison with the intense remedial mathematics and science year offered by Swedish universities) results in a further hurdle for those who wish to pursue STEM studies after secondary school, particularly for poor students.

On the other hand, enrichment activities are more widely recognised, valued, and available, in contrast with Finland and Sweden. The importance of these programmes and their existence is most transparent in the United States. However, the mechanism of allocation to these programmes suggests that not all students in a given school are truly able to access the programmes that are offered.

The potential of school structures to hinder persistence in the United States due to the mechanisms of allocation and the lack of permeability is particularly distinguished by this comparison. The combination of a system that discourages interested, capable students from pursuing advanced science and mathematics, when those students were allocated to a lower academic strata early in their career (when such decisions are more closely linked with family background), might be considered to promote both inequity and to be highly inefficient in promoting talent in STEM fields.

In the next section, I give an overview of the analysis of the six structural equation models from Chapter 4, discussing the results of these models in the context of interviews, and some of the policy implications of considering adaptive habitus as an important factor in the relationship between school structures and student persistence.

## **Part II: Habitus, non-cognitive skills and student persistence**

The second piece of theoretical and methodological development necessary to this project was the use of habitus and its relation to non-cognitive attributes like self-concept, self-efficacy, and the value of the subject. In this study, Bourdieu's *habitus* (e.g., Bourdieu and Wacquant, 1992; Bourdieu, 1977), as well as the continued development of the concept

by other scholars (e.g Sayer, 2005b), provides a language and a metaphorical tool for understanding the disparate choices, opportunities, and successes of different sorts of people in these different systems, one that highlights the ways that students' choices to persist, or not, are based on more than conscious, rational evaluations, but embedded in more complex social and psychological realities. In psychology, students' choices are related to constructs such as self-efficacy and task-value. Here, these psychology-based constructions have been tied to the rich descriptions of student choice given in qualitative research (i.e., Ball, Maguire, and Macrae, 2000; Broccolichi, 1999; Noyes, 2006; Reay, Crozier, and Clayton, 2009), some using the framework of habitus, some not, which contextualised students' actions within educational systems and society. This connection between the psychological and critical sociological literature informed this study throughout its development and analysis, and led to an attempt to incorporate a more multifaceted indicator of habitus in the survey design and modelling.

In addition to school structure mediating opportunity, this study supports the theory that structure impacts student persistence through affecting the development of students' habitus. That is, this study suggests that student persistence is determined in part by students' embodied, conscious and unconscious identities, as well as heuristics for navigating the world (Bourdieu and Wacquant, 1992; Bourdieu, 1977), school structures, and school mathematics and science in particular, and that these identities and heuristics are also shaped by those structures.

While educational policy makers are unlikely to advocate for school structures designed to promote a particular 'habitus', the prominence of what Heckman (2008) has termed non-cognitive skills, including grit, self-efficacy, the ability to work with others, and notions of character education, are increasingly the foci of education experts (Almlund, Duckworth, Heckman, and Kautz, 2011). In Chapter 3, an argument was given that many of these so-called non-cognitive skills, such as self-efficacy and self-concept, can be considered indicators of habitus. Here, these concepts, which have their origins in psychometric studies, were used to include habitus in models of student persistence. Drawing on the use of the word adaptive from biology, indicated non-cognitive skills represent a collection of adaptive traits, that is traits previous research concludes are related to success as defined by educational and social structures (e.g., as argued by Heckman, 2008)). A selection of these adaptive traits (or non-cognitive skills) were gathered together to form an 'adaptive habitus' variable, an indicator of a habitus positively adapted towards science and mathematics schooling, and theorised to be related to persistence. Next, an overview of the outcomes of using this novel variable for modelling students' intentions to persist

will be given.

## **An overview of the six models and new measures used in this study**

In Chapter 4, a model was fitted to each of the six different samples: three where the habitus variable focuses on mathematics (Finland, Sweden and the United States) and three where the variable was an indicator for science habitus (Finland, Sweden and the United States). These models included several new measures including a measure of Gifted Identification, Family STEM Capital, and Negative Transition, all of which have significant correlations with other key variables in the study. The most experimental variable was the latent variable that aimed to indicate adaptive habitus towards mathematics or science.

Acknowledging the need for further refinement, the original, exploratory structural equation models presented here provide the following insights:

- **There was a uni-dimensionality amongst many of the ‘non-cognitive’ items, evidenced by the exploratory and confirmatory factor analyses, allowing for the formation of a latent variable indicating a positive, ‘adaptive’ habitus.** This suggests that there is a sense in which these traits are clustered, and that the encompassing metaphor of habitus is a helpful one. However, while core indicators loaded significantly to this variable across each of the six settings, it is also curious that this study suggests striking national differences. For example, in the United States samples, belief in meritocracy was intertwined with these positive attributes; in Finland and Sweden it was not, indicating the culturally specific functioning of non-cognitive skills, and of habitus.

My use of this collection of psychometric measures to indicate habitus departs significantly from previous measures of students’ aspirations as indicators of habitus (i.e., Dumais, 2002; Vaisey, 2009), discussed in Chapter 3, and presents a direction in need of further exploration.

- **Common patterns occur across all six models, despite the disparate samples and environments included in this study.** The chart below, Table 10.2, highlights some of the more intriguing patterns across the models. ‘Yes’ means there was a pathway between the two variables with  $p < 0.10$ . These six themes and their implications are discussed further in the next section.

## Key results of the models and their implications

In this section, the key patterns of the SEM models will be recalled and linked with the interviews and wider context of the study. Directions for further analysis and research are indicated. The patterns can also be referenced from Table 10.2 below. See also Table 4.1 and the corresponding discussion in Chapter 4.

**Table 10.2: Patterns of relations in the SEM models, by country and subject.**

Variables	FI Science	FI Math	SE Science	SE Math	US Science	US Math
1.Negative Transition and Habitus	No	Yes	Yes	Yes	Yes	Yes
2.Habitus and Persistence	Yes	No	Yes	Yes	Yes	Yes
3.Extracurricular involvement and persistence	Yes	Yes	Yes	Yes*	Yes	Yes
4.Extracurricular involvement and habitus	Yes	No	Yes	No	Yes	No
5.Gifted Identification and Habitus	Yes	Yes	No	Yes	No	Yes
6.Gender and habitus	Yes	Yes	Yes	Yes	Yes	No

'Yes' indicates a notable effect size,  $p < 0.10$ , exceptions are noted by (\*). 'No' indicates no demonstrated relation.

\* For the Swedish mathematics model, this relationship is not significant; it is included here because of the effect size and the nature of the sample, see Chapter 4, particularly Table 4.1.

### 1. Negative transition and habitus

In five of the six models, there was a significant inverse relationship between negative transition and the adaptive habitus variable. This suggests that the patterns of diffraction across points of transition noted by Jackson, Erikson, Goldthorpe, and Yaish (2007) in England, and attributed to the formation of habitus in mathematics education by Noyes

(2006), also in England, are also important features of school structures in Finland, Sweden and the United States.

That a relationship between negative transition and science habitus is not evident in Finland is curious and suggests need for further validation of this pattern. It might be seen to further confirm Noyes assertion that transition to a more stratified educational structure is important in the development of a students habitus; Upper-secondary science in Finland is perhaps the only of the six structural settings that can be said to be undifferentiated into tracks. Thus, the lack of negative connection might be seen to support the contention that the stratification, and the inherent information such structures give to students, is key in the formation of their habitus. It might also suggest that the transition to science in Finland is a smoother transition, and therefore less important to students' developing identities, implying that the impact of transition might be avoidable. However, further research is needed to understand how this difference arises.

Points of transition, for example between lower and upper secondary, or between upper secondary and tertiary education, are moments when underrepresented groups in particular begin to opt out of future studies in mathematics and science, even if they are qualified to continue. This is exactly the issue behind the concern of the 'leaky pipeline' in STEM education, and furthermore, a problem of increasing inequality as a secondary effect of social class. The models support the idea that such effects might be described as happening through the development of habitus, and in particular through the decrease in positive, adaptive habitus towards mathematics and science. These non-cognitive aspects, then, might also be considered in the design of possible interventions to increase persistence.

## **2. Habitus and persistence**

In all but one of the models, the adaptive habitus variables were linked to persistence. Again, the outlier was a Finnish model, this time for mathematics; there is no significant correlation between the mathematics adaptive habitus variable and STEM persistence. This resonates with the interviews, and coincides with the characterisation of Finland as having a higher degree of permeability and transparency, wherein mathematics courses are not used to differentiate or 'weed out' students for further study. Thus it makes sense that one's identity and conceptions of mathematics would not be as important to future career plans in STEM fields more broadly as they might be in Sweden and the United States, where mathematics is used as a signifier of ability. This highlights the effect of the

more permeable, flexible Finnish system, discussed again in Part Four in this chapter. It also shows how connections between non-cognitive skills and student outcomes are dependent on the school structures and societies that the students inhabit.

### **3. Extracurricular involvement and persistence**

The most consistent relationship across the six models was between extracurricular involvement and persistence. This was unexpected given that extracurricular activities were less varied and less widespread in Finland and Sweden. However, this result also demands further refinement. While the measure of enrichment involvement used in the survey included many different forms of extracurricular activities, analysis of the interviews suggested that particular extracurricular activities are more conducive to persistence than others, as Chapter 7 sets forth, summarised in Part Three below.

While causality is particularly entangled in the relationship between persistence and involvement in extracurricular activities, students' narratives do point to particular enrichment activities as inspiring or solidifying their commitment to pursue STEM fields. Furthermore, the pervasiveness of this connection, as well as the close relationship between enrichment and placement within the school structures (via Gifted Identification and Track) suggests the importance of considering the mechanisms by which students access enrichment. These topics are also discussed in Chapter 7 and summarised again in Part Three below. While further, more narrowly targeted analyses are in order, this study suggests that certain forms of enrichment may play a key role in supporting student persistence in STEM fields.

### **4. Extracurricular involvement and adaptive habitus**

A surprising pattern emerged in the relation between extracurricular involvement and adaptive habitus: the relationship was significant for science but not for mathematics in all three countries examined. Again, the interview data helps to illustrate and point towards a possible explanation of this result. The extracurricular activities that students described as important (activities involving real science or technology problems, working with STEM professionals, open-ended challenges with many possible solutions) are more likely to arise in science or technology activities such as robotics building or biology fieldwork. In contrast, mathematics extracurricular activities were more likely to be centred on competitions or exams. For some students, such as Sakari in Chapter 9, involvement in mathematics competitions provided a sense of community and was key

to fostering his passion for mathematics. Yet for many students, these mathematics enrichment activities were shallow and irrelevant, corresponding to the survey data. Again, this suggests that certain enrichment activities may be more potent than others, and that science and technology oriented programmes may be more effective than mathematics programmes for general STEM persistence. However, this needs further, more subject specific investigation.

## **5. Gifted identification and adaptive habitus**

In contrast, the pattern of relationships between gifted identification before upper-secondary school and adaptive habitus is almost the inverse of that between extracurricular involvement and adaptive habitus. That is, for all countries, there was a relationship between gifted identification and mathematics habitus, but not for science in the Swedish and United States samples. Perhaps this suggests that mathematics performance is used to identify gifted students to a greater extent in Sweden and the United States, or that mathematics has a larger share of student experience relative to science during compulsory school, which is the focus of this retrospective measure. However, it also might suggest that the science oriented schools that dominate the Swedish and United States samples create environments that can supersede the effects of early identification, as the analysis of magnet schools in Chapter 8 suggests. A closer examination is needed, but the contrast with the pattern above is intriguing, and emphasises of the importance of domain-specific understandings of the importance of structure and habitus; while often grouped together in policy discourse, mathematics and science may have strikingly different roles in engendering students' identities and choice in STEM fields, and that these roles are determined in part by wider educational systems and society.

## **6. Gender and Habitus**

Gender presents one of the most puzzling patterns across the six models. There was a stronger negative relationship between being female and having an adaptive habitus towards mathematics or science in Finland and Sweden than in the United States. There was also more of a connection between being female and having a negative transition to upper secondary in Finland and Sweden than in the United States.

While gender was not the primary focus of this study, these contrasts deserve further analysis and research. One intriguing direction is that of questioning whether there is

a trade-off between permeability and the retention of young women in advanced mathematics and science in Finland. In the interviews, it seemed that young men in Finland benefited from being able to choose advanced mathematics and science at age sixteen, when they started upper-secondary school. On the other hand, while students are allowed to try advanced mathematics, teachers and students noted there was little attempt to retain students in these courses, and correspondingly there was a high drop out-rate during the first year of upper-secondary school.

Permeability, then, might be occurring not only in an upward direction, but also downwards, and it seems possible that young women are more vulnerable to the ease of opting-out. It is worthy of noting that Finland has one of the highest levels of gender-segregation in the workforce (European Commission, 2009). Girls may have strong, gendered conceptions of which STEM fields are most open to them. Further research is needed to understand the interaction of gender during this transition, and how certain structures of permeability might lead to increased gender differences, and in particular, why such structures might benefit young men, but not young women within a given cultural context.

## **Implications of the models**

In summary, the models show a strong relationship between adaptive habitus and persistence across the three cases. The models also illustrate how students' experiences and identities in mathematics and science, domains that are often linked together, function differently. Here, students' dispositions towards science in general, compared with mathematics, are more closely linked with intentions to persist in STEM fields. Future research in persistence in STEM education would likely benefit from being targeted to a particular discipline, for example computer science, rather than grouping these very different domains together en masse.

This study suggests that the importance of non-cognitive skills (or adaptive habitus) vary according to the school systems and wider cultures that students inhabit. It also suggests that the development of positive, adaptive habitus is related to key school structures. Two of these structures, specialist magnet schools and extracurricular programmes, will be revisited in the next section.

## **PART III: Magnet schools and extracurricular programmes: cultivating an adaptive habitus**

Magnet schools and extracurricular programmes were the focus of Chapters 8 and 7 respectively. These structures are of particular interest when considering the development of high-level talent in STEM fields. However, the ways in which particular schools and extracurricular programmes seemed to be effective in this study have implications for improving engagement in STEM fields more generally. Both magnet schools and particular extracurricular programmes seemed to promote persistence in part through fostering an adaptive habitus towards STEM fields. This section highlights some of the main findings regarding specialist, magnet schools and enrichment programmes. The discussion covers both how such structures may foster high-level STEM talent, and the ways they are problematic from an equity standpoint, focusing on the mechanisms of selection the rarified environments such structures make possible. Implications for educational policy arising from this study are also suggested.

### **Magnet schools**

The magnet schools in this study were effective for reinforcing retention in part because they fostered school climates in which interest and ambition in mathematics and science was normative, rather than exceptional. Narratives of student participants provided examples of how such schools offer unique opportunities for the incubation of STEM talent. It is of particular note that some of the students who responded most positively to the opportunities these schools provided were not elite students. For other students, such environments were a refuge, and the only inclusive school environment the students had experienced (Saari, 2011). In this way, the magnet schools functioned both to promote mobility for some students, and inclusion for others. If the retention and flourishing of interested students in STEM is a policy goal, the results of this study suggest that specialist schools and programmes may be an important structural tool, particularly if typical school cultures discourage engagement in these subjects.

### **Policy Implications**

One possible contribution to the strength of certain specialist schools in promoting STEM fields might be attributed to their advantage in recruiting teachers. Both the Small Mag-

net Lukio and the Large Magnet Lukio attracted teachers who were strongly identified with their subject (for example mathematics or biology), and who valued the opportunity to teach a more diverse selection of advanced courses in better facilities. These teachers evidenced a genuine subject interest, and better connections to the practice of science and mathematics outside of the classroom. This resonates with the conclusion that interacting with STEM professionals was a key component of effective extracurricular activities, discussed further below. The value of this genuine interest and access to informal, out of school learning environments is increasingly noted (e.g., Falk et al., 2012, in the United Kingdom). However, such benefits are not necessarily exclusive to specialist schools. It is possible that other generalist schools might learn from the environments that inspired these teachers. The Large Magnet School for example, was a school within a school; the specialist courses were available to all students.

Another possible way in which such successful specialist schools encouraged persistence was through concerted cultivation of an adaptive habitus towards STEM fields. At the Small Magnet Lukio in Finland, for example, school leadership concerned themselves with students' habitus (or non-cognitive skill development, although they would not use either term). For example, they created a challenging environment, but combined the environment with stories about former students overcoming failure and rising to become star performers. The strategy recalls interventions promoting a 'growth mindset' (Blackwell, Trzesniewski, and Dweck, 2007), associated with improved learning outcomes and persistence.

As discussed in the introduction, magnet schools may not confer an academic benefit, when looking at value-added measures of academic performance (Finn and Hockett, 2012). Yet, such schools may encourage persistence through the development of non-cognitive skills and an adaptive habitus towards STEM subjects, including increased identification and commitment to STEM careers, at least for the students lucky enough to attend them. When evaluating the outcomes, or the value, of specialist magnet schools then, perhaps these so-called non-cognitive developments should also be considered by policy makers.

## **Magnet schools and access: mechanism of selection**

However, considering the potential of magnet schools to increase inequality (by providing elite provision not accessible to other students), policy makers should consider carefully the mechanism of selection into such schools, and the way the boundaries of the school are

constructed. For example, the contrasting school climates between the Large and Small Magnet Lukios in Finland, discussed in Chapter 8, show how one school was successful in erasing the distinction between the STEM specialist students and other students in the school, which seemed to coincide with greater engagement in science and mathematics for all students.

Furthermore, the inclusion and support of motivated but non-elite students should be considered when designing the mechanisms of selection into such environments. The examples in Finland and Sweden suggest that age 16 is not too late for students to scale-up their interest and engagement in STEM subjects, even to an elite level. Having permeability in the educational structure at such a late stage allows for new opportunities to interest and retain students with genuine commitment and motivation for STEM subjects.

Great caution should be taken when considering the transfer of these findings to different school markets, however. The specialist schools participating in the survey and interviews are part of complicated school markets particular to their local settings. For the most part, magnet schools included in this study were not the most selective or elite schools. This meant that students selected these schools largely due to interest, rather than for any distinction attendance might bestow. In a community where the mathematics or science specialist school would also be among the most elite schools, and where these subjects would confer an added advantage during admissions to tertiary education, other dynamics would surely arise. Here, the element of choice and interest is important. The engaged, passionate students interviewed at these less selective magnet schools provide a contrast with examples of disaffected, unengaged students in elite programmes in the United States (i.e., Fredricks, Alfeld, and Eccles, 2010). Here, exclusivity aligns with interest and passion, not with distinction.

## **Extracurricular programmes**

Access to enrichment was closely related to intentions to persist, both in the survey and interview analyses. The interview data strongly suggests that from students' points of view, enrichment activities have the potential to shape and transform their interest in STEM fields. Students were specific about what type of activities they found most integral to their development:

1. Activities involving authentic, real-life experiences of science and engineering

2. Exposure to STEM professionals and authentic working environments
3. Activities that involved a sense of inclusion into a community of practice
4. Activities that were challenging and open ended, with no predetermined correct solution.

The importance of interaction with practicing STEM professionals should be emphasised, as it is a result that aligns with emerging findings in other contexts, for example in England (as reported by Archer et al. (2010) and Archer et al. (2012)), that students' conceptions of scientists and ability to imagine themselves being a scientist have effects on persistence separate from performance in and enjoyment of the subject. Here, as Chapter 7 sets forth, a sense of induction to the discipline or community of practice was important, which relates directly to the idea of gaining a sense of oneself as a future STEM professional. Again, the measure used to capture involvement in enrichment involvement in the survey included activities that do not meet those criteria. Furthermore, as noted above in Part II of this chapter, the effects of enrichment activities might also be subject specific, and thus more practically useful if tailored to a particular discipline. The construction of a more targeted variable for enrichment that reflects the key elements listed above is warranted in future studies on this topic.

## **Policy implications for extracurricular programmes**

Too often enrichment is offered as a shallow, artificial overlay, perhaps delivered by teachers who may have received only brief training. This research suggests that there might be a distinct value to incorporating enrichment activities that bring students into contact with STEM professionals, and real world problems. Such opportunities would need to be fermented in part at the local level, for example by school-community partnerships, such as those that are cultivated by robotics clubs common in the United States.

It is possible that such programmes need not be long in duration. The students involved in this study recalled even brief experiences of authentic science work as transformative. Another practical solution might be to copy the success of one of the chains of private Swedish schools, which created a single, high-level laboratory to be shared by several schools, and visited for week-long intervals to engage in laboratory work.

In contrast with students who had the opportunity to engage in actual data collection or engineering projects, STEM camps aimed at enticing girls into science were described as fun by participants, but irrelevant to actual persistence. Likewise, standard in-school

lab work was contrasted unfavourably with involvement in actual fieldwork, or real-life laboratory settings. Students clearly pointed to challenging, authentic experiences as igniting and supporting their desire to pursue further STEM studies. However, many of these valuable opportunities were not accessed through schools but through family networks. The mechanisms of access to and selection for valuable STEM enrichment should be carefully considered. This is the focus of the next section.

## **Extracurricular learning and access: the mechanism of selection**

The mechanism by which students access enrichment programmes is often a secondary consideration. However, if widening participation in STEM learning is a goal of policy makers and school leaders, then how students access alternative learning environments should also be carefully considered. In this section, the implications of access through family rather than school and according to age and track placement are highlighted. It is noted that there is a danger of a two-tier system of enrichment existing, with only elite students accessing the authentic, open-ended experiences this study suggests are most effective. However, this study also suggests that such experiences can be fruitful for a wider range of students, and thus that there is an argument for providing broader access.

However, some of the most striking experiences reported by student were accessed through their families, not through schools—even if they were publicly available programmes. This resonates with others' qualitative work pointing to the importance of a family science habitus (Archer et al., 2012) or family disposition towards STEM fields (Aschbacher et al., 2010) as linked with students' capabilities of accessing enrichment. In this study, this connection is also evident in how the new measure of STEM family capital was linked to extracurricular involvement, gifted identification or track placement across the three settings.

Yet, what such families do is also of concern for those interested in education policy. Not only can we learn from the way families mobilise STEM and social capital to shape and support their children's aspirations, but for public education to not aspire to offer some of these rich learning experiences to all students is to concede to a widening gulf between different sectors of society. Noting research in the United States that indicates that the most privileged families have escalated their spending on enrichment activities (Ramey and Ramey, 2009), Reardon (2013) recently advocated in an editorial for policy makers to

consider the strategies of the advantaged, including opportunities that take place outside of formal schooling.

Again, creating such opportunities need not be expensive, but it might involve innovative or contentious programmes, such as enlisting the support and volunteer contributions of local STEM professionals, and fostering local school-community networks, as some robotics teams do quite successfully in the United States. As noted here, the actual duration of key experiences might be quite short; it is the authenticity and quality of the enrichment programme that seem to matter. There should be consideration that more students are given opportunities to experience the authentic enrichment experiences in STEM fields, not only as a colourful add-on to regular school priorities, but as an fundamental part of the structure of education in these disciplines.

The age at which students are offered enrichment programmes should also be considered, as well as who is invited to participate in them. In the United States, there is often a lack of opportunity for older students to enter elite enrichment environments for the first time. This does not reflect the developmental capabilities of older adolescents to form new academic interests and improve their level of performance in mathematics and science, as the trajectories of students in Finland and Sweden after age 16 suggest. Contrary to such potential, the structure of many valuable enrichment activities is aligned with what Dweck (2006) has termed a Fixed Mindset. That is, that ability is fixed and should accordingly be identified as early as possible and set apart, in contrast with a conception of talent as something that might be grown and cultivated, arising later in life. In such a paradigm, selection into enrichment programmes may happen, as described by participants in interviews from the United States, by teachers walking through elite mathematics courses and asking for volunteers for mathematics competitions, or inviting only high performing students to represent the school. In effect, this excludes all other students from the possibility of benefiting from such enrichment programmes. It takes a different ‘mindset’ not only to invite, but to support other sorts of students who may wish to try enrichment activities.

The case of Sakari from Finland, who became an internationally competitive mathematician after beginning to train at age 16 shows that there can be a benefit for providing even such elite enrichment opportunities to students in later adolescence, and to students who may not begin with an elite academic profile in mathematics and science. As Ericsson, Nandagopal, and Roring (2009) have noted, exceptional performance is a function in part of students’ non-cognitive skills, such as self-regulation and diligence, as well as the passion and interest to sustain the challenging work needed to excel (Duckworth, Kirby,

Tsukayama, Berstein, and Ericsson, 2011). Students with all sorts of academic backgrounds can gain both interest, skill and personal growth from engagement in authentic STEM enrichment programmes. This is not only a matter of equity; casting a wider net increases opportunities to discover and foster exceptional talent.

Furthermore, given the derision of some young women towards ‘fun’ science camps aimed at girls, in contrast with descriptions of the transformative experiences of working in real laboratories with professional scientists, policy makers might want to avoid creating a stratified menu of enrichment offerings, where girls and other underrepresented groups might be presented with fun but ultimately ineffective interventions, and with the most valuable experiences still accessible only to elite, already prepared, students. Rather, more students of all types should be given access to real STEM experience, not only for the production of a future STEM oriented workforce, but because a true understanding of what it is to do science, or create technology, is an important aspect of literacy today.

Across all three sites, specialist schools and extracurricular programmes are two structures that are linked with student persistence, in part through the development of an adaptive habitus towards STEM fields. In this section, I have also highlighted the importance of the mechanism of allocation to each of these structures for equality, but also efficiency, again a common theme that transcends the three contexts. In the next section, Part IV, I revisit the more abstract notions of Transparency and Permeability across the three contexts.

## **Part IV: Transparency and Permeability**

This section focuses on the concepts of transparency and permeability. I give an overview of these concepts within the comparative framework here, and suggest implications for educational policy more broadly that arise from focusing on these two elements of educational structures.

### **Transparency**

There were issues of transparency in each of the three systems included in this study. This is evidenced through hidden structures as well as uses of structures that are not aligned with their stated purpose.

The results of my fieldwork revealed that that familiar forms of stratification, such as ability grouping, are practices in both Sweden and Finland, despite even some local denial of the fact. Furthermore, local structures of stratification function in similar ways to those found in the United States. In Sweden in particular, where ability grouping is widespread (Skolverket, 2006, p. 30), policies for stratification also varied from school to school, contributing to the lack of transparency and differential access; students from more privileged locations seemed to have more access to acceleration and enrichment than students in less advantaged schools at the compulsory school level.

In each of the systems, a lack of transparency is also evidenced when there is a misalignment between the stated purpose of an educational structure and its use. In Finland for example, lower-secondary level specialist programmes in mathematics are increasingly being used strategically to differentiate students socially. Educated families dominate this use of specialist programmes in mathematics during lower secondary school (Hirvenoja, 2000). My study suggests that such programmes are used by active parents to provide a better environment and peer-group for their children, rather than to promote persistence in STEM. From the standpoint of fostering STEM talent, then, they are not a very efficient structure, and may even function in the reverse for students outside those special programmes. The consumption of such programmes is similar in motivation to why students and parents value gifted education in the United States (Hertberg-Davis and Callahan, 2008; Bleske-Rechek, Lubinski, and Benbow, 2004; Saari, 2008); it is the select environment rather than the academic content that is of primary value. This misalignment of use and stated purpose obfuscates the real policy issue (parent's perception of the need to flee certain classrooms, and what happens to the students left behind in those classrooms). It is also an issue of transparency. Students from less-advantaged backgrounds are less likely to be aware of such uses and the corresponding opportunities such strategies provide, or even if they do, have the means to access them. Again, the actual use and benefits might be different from their stated purpose as a mathematics school or gifted programme for example.

Similarly, this study also points to the use of the upper-secondary natural science track in Sweden as the 'academic' track as another point of misalignment and lack of transparency. Students and teachers regarded the natural science track as the de facto choice for diligent, talented, university-bound students. This study suggests such positioning may have a negative effect in retention overall. Less confident students, even students with a strong academic history and interest in STEM, opted out of natural sciences. In this way misalignment resulted in inefficiency, described, for example, in the case of Monica in

Chapter 9. Again, this is also an issue of transparency; the stated purpose and the use of the programme are divergent.

In contrast, in the upper-secondary level in Finland, where advanced mathematics was not used primarily as a signifier of academic distinction, enrolment in advanced mathematics was more aligned with students' intentions to pursue further STEM learning. Thus the system might be considered more efficient than either Swedish system, or that of the United States, where what may seem to be independent courses are in practice bundled into tracks across subjects. Certainly, the use of advanced upper-secondary mathematics seems more aligned with intentions to persist in STEM fields than is the case in Sweden or the United States.

Perhaps, however, there is a benefit in the intentional or, for that matter, earnestly ignorant obfuscating of certain aspects of school structures. This is in effect what Finn and Hockett (2012) suggest when they advocate for elite specialist schools as a policy for securing the support of upper-middle class families in publicly funded school systems. Labaree (2013) has suggested that in the United States, the comprehensive high school has the appearance of promoting broad academic principles while at the same time preserving advantage for more privileged students, thus however, creating an educational institution that is supported by most citizens. That is, a certain obfuscation of the system leads to stability. This is what Souto-Otero (2010) also implies, suggesting that if the concept of schooling as un-meritocratic became widespread, it would lead to instability in educational structures. This is only to note that there might be a purpose in being opaque about what our goals for education really are, and how structures are used in practice. However, if fostering persistence in STEM learning is a policy goal, then it is important to consider that the use of advanced mathematics and science for general academic distinction may coincide with the loss of talented students genuinely interested in pursuing STEM fields. From the standpoint of both equality and efficiency, more transparent structures are likely to promote better outcomes for retention and the production of STEM talent.

## **Permeability**

One of the policy suggestions arising from this research is that the permeability of an educational system should receive more attention. Stratification alone does not define student opportunity. Despite highly stratified systems at the post-16 level, Finland and Sweden can both be characterised as being more permeable than the American system,

and this has important implications for efficiency as well as equality.

An average student at age 16 in Finland or Sweden will probably have the opportunity to attempt advanced mathematics and science. In comparison, the trajectories of participants in the United States reveal how interested students are not able to choose to take more advanced courses, without significant intervention from parents. This creates inefficiency, since the structure cannot respond to an increase in student interest and performance.

One of the surprising outcomes of the analysis here is that rather innocuous structures of bundling courses together may create inflexibility that prohibits permeability. Bundling in the Swedish and United States systems decreases permeability by increasing the barriers to accessing advanced mathematics and science. It means that it is more difficult for students to pursue what may be a specific, strong interest or capability in a particular STEM subject. Furthermore, these effects might be stronger for the most vulnerable students, who might have less confidence and support in confronting the strictures of school policies, or in attempting a more challenging course of study, as Monica in the last chapter demonstrated, when deciding not to pursue the natural science track in Sweden despite her love of mathematics. In contrast, in Finland it is common for students to take advanced mathematics and science together, but it is not required. Such flexibility seemed to encourage students to keep a hand in the game, thus increasing their potential to persist in STEM.

The stratified school structures evidenced in the United States samples were particularly notable for their lack of permeability. It was difficult for students to change their placement in the stratified system to access advanced mathematics and science, even with the help of parents. The difference in permeability compared with Sweden and Finland is made all the starker when considering students' transitions to tertiary education. Making up for lost opportunities to participate in free advanced science and mathematics courses at the secondary level is costly in the United States. This presents yet another barrier to permeability. The lack of permeability at the upper-secondary level in the United States is compounded by the expense of tertiary schooling. Lack of affordable routes into advanced STEM tuition after upper-secondary is yet another hurdle for student persistence in STEM fields, and highlights the importance of viewing the education system as a whole; STEM learning need not stop at age 18. In contrast, the more permeable Finnish system was better able to respond to late blooming students passionate about mathematics and science. This suggests the importance of permeability over time in the retention of talent in STEM fields.

However, there are negative aspects to the high level of permeability in Finland. While the structure allows many to try (for example to take advanced mathematics during upper secondary), in many schools there is no effort to retain those students. Thus many drop out. Considering prominence of secondary effects of class, gender, and ethnicity at those key points of transition, this is possible trade-off in a permeable system that deserves further study.

Transparency and permeability of educational structures must also be considered with regard to their impact on student aspirations. If a system is impermeable, and does not respond to increases of performance, interest and diligence, there is little incentive for students to scale-up their participation and engagement with mathematics and science. Likewise, if the steps needed to move towards further STEM studies involve additional, expensive remedial schooling, such options might seem to be too risky for all but the most committed students to attempt. That is, perhaps the structure of the educational system should reflect the values and ontology of that undergird the non-cognitive skills that are also increasingly of interest in educational policy. A system lacking transparency and permeability may hinder the persistence of students not only through structural road blocks, but by dampening the ambitions of students.

## Conclusion

This research supports the idea that students' habitus and non-cognitive skills are an important factor in student persistence in STEM fields. Policy makers and school leadership are recommended to consider how school policies, both through intentional and unintentional effects, act on the development of a student's habitus.

These results also show the limitations of student agency. Having an adaptive habitus does not ensure persistence. Contrary to views expressed by prominent proponents of non-cognitive skills such as Bandura (2011) and Heckman (e.g., Heckman and Kautz, 2012; Heckman, 2008) this study suggests that fostering adaptive, non-cognitive skills, while important, is not sufficient. Students must also have the real structural possibility of pursuing their goals to become STEM professionals. Increasing the permeability and transparency in educational structures is suggested as one way to promote both equity and efficiency in the promotion of STEM learning.



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# Appendix A

## Interview key by school and pseudonym

This appendix contains a list of the student interviews, sorted first by school and then by pseudonym.

**STUDENT INTERVIEW KEY: Sorted by school, then pseudonym**

PSEUDONYM	SCHOOL	GENDER	Permeability	Perisit	Program	Math track
<b>Alvar</b>	FI Historical Lukio	MALE	Steady/up	YES (biology and physics, maybe in england)	IB	Higher Level
<b>Brigitta</b>	FI Historical Lukio	FEMALE	Steady	YES(Statistics and then Health Sciences)	IB	Higher level
<b>Charles</b>	FI Historical Lukio	MALE	Blocked	YES(Medicine, was really interested in math but couldn't get it)	IB	Higher Level
<b>Emilia</b>	FI Historical Lukio	FEMALE	Down	NO(Economics and Politics)	IB	Standard Level
<b>Hannu</b>	FI Historical Lukio	MALE	Down	NO(International Relations)	IB	Standard Level
<b>Kaj</b>	FI Historical Lukio	MALE	Steady	MAYBE(Chemistry at TKK or Uni or THEATER SCHOOL)	Regular	Long
<b>Sanna</b>	FI Historical Lukio	FEMALE	Steady	NO(Law, mathematics is second choice for temporary)	Regular	Long
<b>Sonia</b>	FI Historical Lukio	FEMALE	Down	NO(Business and management)	IB	Standard Level
<b>Eero</b>	FI Large Magnate School	MALE		MAYBE(Fireman, Biotechnology)	Science Track	Long
<b>Juha</b>	FI Large Magnate School	MALE	Down	YES (Biology, biology teacher)	Science Track	Short
<b>Kaarina</b>	FI Large Magnate School	FEMALE		NO(Sports teacher or daycare teacher)	Normal Track	Short
<b>Minna</b>	FI Large Magnate School	FEMALE		YES (Medicine)	Normal Track	Short
<b>Soila</b>	FI Large Magnate School	FEMALE	Steady	YES(Computer science and math)	Science Track	Long
<b>Vera</b>	FI Large Magnate School	FEMALE	Up	NO(Economics/Business/ school)	Normal Track	Short
<b>Ilmari</b>	FI Small Magnate School	MALE	Down	NO(history, law, geography)	Regular	Short
<b>Johanna</b>	FI Small Magnate School	FEMALE	Steady	YES(Industrial engineering (but may not go in)	Regular	Long
<b>Joonas</b>	FI Small Magnate School	MALE	Steady	YES(TKK industrial engineering)	Math Track	Long +

<b>Laine</b>	FI Small Magnate School	MALE	Steady	MAYBE(Tkk?)	Regular	Long
<b>Sakari</b>	FI Small Magnate School	MALE	Up	YES (mathematics)	Math Track	Long +
<b>Timo</b>	FI Small Magnate School	MALE		YES (Mathematics)	Math Track	Long +
<b>Katri</b>	FI Suburban Lukio	FEMALE	Down	NO		Short
<b>Manu</b>	FI Suburban Lukio	MALE	Down	No (Markinointi)		Short
<b>Rauli</b>	FI Suburban Lukio	MALE	Up, sort of	YES (computer engineering, english)		Long
<b>Sami</b>	FI Suburban Lukio	MALE	Steady, not confident	UNSURE (maybe university with languages, maybe ammatti korkea koulu, going to see oppi)	Required subjects only	Long
<b>Terhi</b>	FI Suburban Lukio	FEMALE	Steady, going better	NO(Physical Therapy)		Short
<b>Veijo</b>	FI Suburban Lukio	MALE	Up	YES(Industrial Engineering)		Long
<b>Frederik</b>	SW Historical Gymnasium	MALE	Down	NO politics	Social Science	Math D
<b>Inga</b>	SW Historical Gymnasium	FEMALE	Steady	YES (Chemistry, chemistry teacher)	NV	Math E
<b>Josefina</b>	SW Historical Gymnasium	FEMALE	Steady	YES (Medicine, Mathematics)	NV	Math E
<b>Lars</b>	SW Historical Gymnasium	MALE	Up	NO (drama, journalism)	Drama Track	Minimum
<b>Pia</b>	SW Historical Gymnasium	FEMALE	Steady	Doesn't know	Social Science	Math E
<b>Sofia</b>	SW Historical Gymnasium	FEMALE	Steady	NO (Journalism law)	NV	Short
<b>Amina</b>	SW International Gymnasium	FEMALE	Steady	MAYBE(But really interested in languages and IR, maybe aiming at economics at Cambridge)	IB	Standard Level
<b>Daniel</b>	SW International Gymnasium	MALE	Down	YES(Medicine)	IB	Standard Level
<b>Efram</b>	SW International Gymnasium	MALE	Steady	NO (Economics)	IB	Higher Level
<b>Richard</b>	SW International Gymnasium	MALE	Steady	YES(Pharmacy and Engineering)	IB	Higher Level

<b>Alma</b>	SW Magnate Gymnasium	FEMALE	Steady	YES(Med school)	NV + Math	E+
<b>Anna</b>	SW Magnate Gymnasium	FEMALE	Steady	YES(KTH(physics))	NV + Math	E+
<b>Bengt</b>	SW Magnate Gymnasium	MALE	Mixed	YES(Math)	NV + LAW	E+
<b>Elisabet</b>	SW Magnate Gymnasium	FEMALE	Steady	YES(Comp. Sci)	NV + Math	E+
<b>Göran</b>	SW Magnate Gymnasium	MALE	Upward	YES(Computers)	NV + Math	E+
<b>Stefan</b>	SW Magnate Gymnasium	MALE	Down	No (economics)	NV + LAW	D
<b>Amir</b>	SW Private Gymnasium	MALE		NO(Law)	Social Sciences	Minimum
<b>Emir</b>	SW Private Gymnasium	MALE	Steady	YES(Medicine engineering and biophysics)	NV	Math E
<b>Lily</b>	SW Private Gymnasium	FEMALE	Steady	YES(Medicine)	NV	Math E
<b>Maj</b>	SW Private Gymnasium	FEMALE	Steady (weak)	YES(Forestry)	Social Sciences	Minimum
<b>Sofia</b>	SW Private Gymnasium	FEMALE	Down	No (Maybe economics)	Social Sciences	Minimum
<b>Tanvi</b>	SW Private Gymnasium	FEMALE	Steady	YES(Biotechnic)	NV	Math E
<b>Alonso</b>	SW Suburban Gymnasium	MALE	Uncertain	YES(Civil Engineering)	NV	Math D, will be taking math e next year.
<b>Belen</b>	SW Suburban Gymnasium	FEMALE		NO (Law, Business Law)	Social Science	Mathematics C
<b>Björn</b>	SW Suburban Gymnasium	MALE	DOWN	NO(Psychology)	Social Science	Math C
<b>David</b>	SW Suburban Gymnasium	MALE	Steady	YES(Medicine)	NV	Math E next year
<b>Elijah</b>	SW Suburban Gymnasium	MALE	Steady	YES (Engineering)	NV	Math E
<b>Manuel</b>	SW Suburban Gymnasium	MALE	Steady	Architecture or Engineering or Dentistry	NV	Math E

<b>Monika</b>	SW Suburban Gymnasium	FEMALE	Up	YES (NV ground course, engineering)	Social Science	Mathematics C
<b>Alex</b>	US Robotics Team	MALE	Up, but blocked	YES (computer engineering)	Normal track	Not advanced
<b>Alison</b>	US Robotics Team	FEMALE	Steady	YES (Biology, engineering)	Normal	Not advanced
<b>Gregory</b>	US Robotics Team	MALE	Steady/Down	YES( Engineering)	Normal	Not advanced
<b>Adrienne</b>	US Suburban Elite (Columbia)	FEMALE			High Honors AP	Advanced
<b>Fiona</b>	US Suburban Elite (Columbia)	FEMALE		NO High rate of extracurricular involvement	High Honors AP	Advanced
<b>Hugh</b>	US Suburban Elite (Columbia)	MALE		YES Switched districts (despite this being against normal policy)	High Honors AP	Advanced
<b>Sandra</b>	US Suburban Elite (Columbia)	FEMALE		NO High rate of extracurricular involvement	High Honors AP	Advanced
<b>Alexander</b>	US Suburban High (Cougar)	MALE	Down		High Honors	Advanced
<b>Bethany</b>	US Suburban High (Cougar)	FEMALE			High Honors	Advanced
<b>Damien</b>	US Suburban High (Cougar)	MALE			High Honors	Advanced
<b>Lydia</b>	US Suburban High (Cougar)	FEMALE			High Honors	Advanced
<b>Shannon</b>	US Suburban High (Cougar)	FEMALE			High Honors AP	Advanced
<b>Christopher</b>	US Suburban IB (Sahale)	MALE	Up, with help from parents		IB	Advanced
<b>Cory</b>	US Suburban IB (Sahale)	MALE	Up, with help from parents	YES, computer science/engineering	IB	Advanced
<b>Elizabeth</b>	US Suburban IB (Sahale)	FEMALE			IB	Advanced
<b>George</b>	US Suburban IB (Sahale)	MALE		YES	IB	Advanced
<b>Joan</b>	US Suburban IB (Sahale)	FEMALE			IB	Advanced
<b>Katherine</b>	US Suburban Poor (Olympus)	FEMALE		NO	High Honors AP	Advanced
<b>Nicole</b>	US Suburban Poor (Olympus)	FEMALE	Up, with testing	MAYBE(Engineering or Law)	High Honors AP	Advanced



# Appendix B

## Questionnaires

This appendix includes version of the questionnaire instruments for the science domain for each country. The mathematics domain questionnaires are identical except for the domain specific questions, as outlined in Chapter 3.

**Opiskelijoiden pysyvyys TTTM - aloilla:**  
Koulujen rakenteet ja opiskelijoiden valinnat Suomessa, Ruotsissa ja Yhdysvalloissa

## Opiskelijakysely TIETEEN alalla

### JOHDANTO

Tämä kysely käsittelee sitä, miten koulukokemukset vaikuttavat opiskelijoiden päätöksiin opiskella tiede-, teknologia-, tekniikka- tai matemaattisia aloja (TTTM) lukion jälkeen. Osallistuminen tähän kyselyyn on vapaaehtoista. Vastauksesi pidetään ehdottoman luottamuksellisina. Kyselyn vastaukset raportoidaan tilastollisessa muodossa, jotta yksilöitä ja kouluja ei pystytä tunnistamaan vastauksista.

**Kiitos kyselyyn käyttämästäsi ajasta ja harkinnasta. Osallistumisesi tähän tutkimukseen on erittäin tärkeää opiskelukokemusten ymmärtämisen kannalta Yhdysvalloissa, Suomessa ja Ruotsissa**

### OHJEET

Tämä kysely keskittyy kokemuksiisi tieteestä. Osa-alueita on yhdeksän:

- I. Tulevaisuudensuunnitelmat
- II. Nykyiset opintosi
- III. Sinusta opiskelijana
- IV. Koulun ulkopuoliset ja elämää rikastuttavat harrastukset
- V. Tieteen arvo
- VI. Menestyminen
- VII. Luokkahuonekokemuksesi
- VIII. Ennen lukiota
- IX. Taustasi ja toiveesi tulevaisuudelle

Kyselyssä on 27 kysymystä. Suurimpaan osaan kysymyksistä voit vastata rastimalla ruudun, esimerkiksi:

Erittäin epätodennäköistä	Epätodennäköistä	Todennäköistä	Erittäin todennäköistä
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Vältä käyttämästä liikaa aikaa yhteen kysymykseen – tämä ei ole koe eikä väriä vastauksia ole!

Tutkimusta rahoittaa Gates Cambridge Trust.

**Jos sinulla on kysymyksiä tähän kyselyyn liittyen, ole hyvä ja soita tai lähetä sähköpostia minulle:**

Jennifer von Reis Saari Email: xxx@cam.ac.uk FIN/SWE: +358 (0)xx xxx xxxx

Faculty of Education, University of Cambridge, 184 Hills Road, Cambridge, CB2 8PQ, United Kingdom

### Osa-alue I: TULEVAISUUDENSUUNNITELMAT

Tämä osa-alue koskee suunnitelmiasi lukion jälkeen. Ensimmäinen sivu käsittelee sitä, miten todennäköisesti opiskelisit tiede-, teknologia-, tekniikka- tai matemaattisia aloja (TTTM) lukion jälkeen. Seuraava sivu käsittelee opintosuunnitelmiasi ja sitä, mitä aiot tehdä ensi vuonna.

1. Kuinka todennäköistä on tällä hetkellä, että opiskelisit seuraavia aineita lukion jälkeen opiskelusi PÄÄaineena? Toisin sanoen, kuinka todennäköistä on, että opiskelisit seuraavia aloja pää- tai sivuaineena, tai päätoimisesti?

	Erittäin epätodennäköistä	Epätodennäköistä	Todennäköistä	Erittäin todennäköistä
<b>A. Kemia</b> , mukaan lukien biokemia, uusien materiaalien ja lääkkeiden kehittämiseen käytettävä kemia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>B. Tilastotiede</b> , mukaan lukien teoreettinen tilastotiede, kokeellinen mallinnus, biologinen tilastotiede, aktuaarinen tiede, väestötiede	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>C. Matematiikka</b> , mukaan lukien teoreettinen ja sovellettu matematiikka, todellisten ongelmien mallinnus, salaustekniikka ja turvallisuus	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>D. Biologia</b> , mukaan lukien neurotiede, kasvit, eläimet, ihmiset, solut, taudit, ekosysteemit, genetiikka	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>E. Maapalloa koskevat tieteet</b> , mukaan lukien geologia, valtameritiede, maanjäristykset ja fossiilit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>F. Tekniikka</b> , mukaan lukien maa- ja vesirakennustekniikka, kemiantekniikka, sähkötekniikka, turvatekniikka tai teollisen tuotannon tekniikka	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>G. Tietojenkäsittelytiede</b> , mukaan lukien ohjelmistojen ja koneiden luominen ja suunnittelu ja teoreettinen tietojenkäsittelytiede	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>H. Terveystieteet</b> , mukaan lukien lääketiede, sairaanhoito, farmasia, hammaslääketiede, ravitsemustiede ja eläinlääketiede	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>I. Maatalous</b> , mukaan lukien puutarhantalous, elintarviketiede, maataloustekniikka ja ekologia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## TULEVAISUUDENSUUNNITELMAT

### 2. Kuinka korkeasti aiot kouluttautua ottaen huomioon nykyisen tilanteesi?

- En enempää, ylioppilas
- Ammattikoulututkinto
- Yliopisto- tai ammattikorkeakouluopintoja
- Kandidaatin tutkinto (Esimerkiksi HuK, LuK)
- Maisterin tutkinto, jatko-opinnot tai tohtorin tutkinto (Esimerkiksi KTM, FM, FT, OTT, LT)
- En tiedä

### 3. Aiotko olla koulussa tai opiskella ensi syksynä (lokakuu 2012 mennessä)?

- EN (ole hyvä ja vastaa kysymyksiin 3A)
- KYLLÄ (ole hyvä ja vastaa kysymyksiin 3B)

#### 3A) JOS EI, valitse väittämä, joka parhaiten kuvaa suunnitelmiasi ensi syksylle:

- Olen armeijassa
- Olen kokopäivätyössä
- Huolehdin perheenjäsenestäni
- Pidän välivuoden ja matkustelen tai teen vapaaehtoistyötä
- Pidän välivuoden muista syistä

#### 3B) JOS KYLLÄ, valitse väittämä, joka parhaiten kuvaa suunnitelmiasi ensi syksylle:

- Opiskelen lukiossa
- Opiskelen ammattikorkeakoulussa
- Opiskelen yliopiston pääsykoetta varten
- Opiskelen luonnontieteitä vuoden ennen yliopistotutkinnon aloittamista
- Opiskelen yliopistossa tai ammattikorkeakoulussa MUTTA aion vaihtaa toiseen tiedekuntaan tai yliopistoon myöhemmin
- Opiskelen yliopistossa tai ammattikorkeakoulussa JA minulle ei ole aikomusta vaihtaa tiedekuntaa tai yliopistoa tässä vaiheessa

Mikä on (mitkä ovat) pääaineesi ensi vuonna?

## Osa-alue II: NYKYISET OPINTOSI

Tämä osa-alue käsittelee nykyisiä ja viimeisimpiä matematiikan- ja tiedekurssejasi, niiden arvosanoja ja miksi käyt tai et käy tällä hetkellä tiedekursseja.

### 4. Oletko valinnut pitkän matematiikan?

- EN
- KYLLÄ

### Oletko tällä hetkellä matematiikan kursilla?

- EN
- KYLLÄ

Mikä oli VIIMEISIN matematiikan kurssi, jonka otit lukiossa? Ole hyvä ja kirjoita kurssin nimi alla olevaan tilaan. Jos olit samaan aikaan useammalla kuin yhdellä kurssilla, kirjoita sinulle tärkeemmän matematiikan kurssin nimi.

### Minkä arvosanan sait kurssista?

- 10
- 9
- 8
- 7
- 6
- 5
- 4

Jos OLET tässä jaksossa matikankurssilla, millä kurssilla (millä kurseilla) olet? Ole hyvä ja kirjoita kurssi(e)n nimi alla olevaan tilaan.

### 5. Kuinka monta TIEDEKURSSIA (kemia, biologia, fysiikka tai maantiede) olet suorittanut lukion loppuun mennessä?

- 0–4 kurssia (yksi vuosi tieteitä)
- 5–8 kurssia (yhdestä kahteen vuotta tieteitä)
- 9–12 kurssia (kahdesta kolmeen vuotta tieteitä)
- Enemmän kuin 12 kurssia (enemmän kuin kolme vuotta tieteitä)

### 6. Oletko tällä hetkellä tiedekursilla?

- EN Ole hyvä ja siirry seuraavalle sivulle ja vastaa kysymyksiin 7A ja 8A sivulla 5
- KYLLÄ Ole hyvä ja hyppää seuraavan sivun yli ja vastaa kysymyksiin 7B ja 8B sivulla 6

Vastaa sivun kysymyksiin jos ET OLE tällä hetkellä TIEDEKURSSILLA

Jos olet tässä jaksossa tiedekurssilla, hyppää sivun yli ja jatka kysymyksestä 7B seuraavalla sivulla.

7A. Jos ET OLE TIEDEKURSSILLA tässä jaksossa, mikä oli viimeisin tiedekurssi, jonka lukiossa suoritit?

Minkä arvosanan sait kurssista?

10  9  8  7  6  5  4

8A. Kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa siitä, miksi ET OLE TIEDEKURSSILLA tässä jaksossa?

	Täysin eri mieltä	Eri mieltä	Sama mieltä	Täysin sama mieltä
A. En tarvinnut sitä valmistuakseni	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Minut sijoitettiin automaattisesti toiselle kurssille	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Lukujärjestyksessä ei ollut tilaa tiedekurssille	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Opettaja tai opinto-ohjaaja neuvoi minua olemaan ottamatta kurssia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Tiedekurssi ei kuulu tämän jakson opintosuunnitelmaani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Perheenjäsen suositteli minua olemaan ottamatta kurssia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Tiedekurssi, jonka halusin ottaa, ei ollut saatavilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. En uskonut saavani hyvää arvosanaa kurssista	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. En ole kiinnostunut tieteestä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Halusin ottaa toisen aineen kurssin mieluummin kuin tiedekurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. En itseasiassa ole varma, miksi en ottanut tiedekurssia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Kukaan muu ei vaikuttanut päätökseeni, päätin itse, että en ota kurssia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. En tarvitse kurssia siihen, mitä aion tehdä tulevaisuudessa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Ystävä neuvoi minua olemaan ottamatta kurssia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. En muista päättäneeni, että en ota kurssia tässä jaksossa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Ole hyvä ja jatka kysymyksestä 9 sivulla 7

Vastaa sivun kysymyksiin, jos OLET tällä hetkellä tiedekurssilla

Jos et ole tässä jaksossa tiedekurssilla, hyppää sivun yli ja jatka kysymyksestä 9 seuraavalla sivulla.

7B. Jos OLET TIEDEKURSSILLA, millä kurssilla tai kurseilla olet tässä jaksossa? Ole hyvä ja kirjoita kurssi(e)n nimi alla olevaan tilaan:

Kuinka monta tuntia käytit TIEDEAINEEN kotiläksyihin tai tieteen opiskeluun koulun ulkopuolella viime viikolla?

0 tuntia  1–2 tuntia  3–4 tuntia  5–6 tuntia  yli 6 tuntia

Mikä oli viimeisin tiedekurssi, jonka otit lukiossa? Ole hyvä ja kirjoita kurssin nimi alla olevaan tilaan. Jos olit yhtä aikaa useammalla kurssilla, kirjoita sinulle tärkeimmän kurssin nimi.

Minkä arvosanan sait kurssista?

10  9  8  7  6  5  4

8B. Kuinka hyvin seuraavat väittämät kuvailevat sitä, miksi olet tässä jaksossa TIEDEKURSSILLA?

	Täysin eri mieltä	Eri mieltä	Sama mieltä	Täysin sama mieltä
A. Tarvitsen sen valmistuakseni	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Minut sijoitettiin kurssille automaattisesti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Tämä kurssi auttaa minua pääsemään parempaa koulun tai opinto-ohjelmaan lukion jälkeen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Opettaja tai opinto-ohjaaja neuvoi minua ottamaan kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Tämä kurssi on pakollinen opintosuunnitelmassani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Perheenjäsen suositteli minua ottamaan kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Kurssi, jonka olisin halunnut ottaa, ei ollut saatavilla, joten otin tämän	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Ajattelin, että saan kurssista hyvän arvosanan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Olen kiinnostunut tieteestä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Halusin ottaa mieluummin tiedeaineen kurssin, kuin muun aineen kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. En itseasiassa ole varma, miksi otin tämän kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Kukaan muu ei vaikuttanut päätökseeni, päätin itse ottaa tämän kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Tarvitsen tätä kurssia siihen, mitä aion tehdä tulevaisuudessa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Ystävä neuvoi minua ottamaan kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. En muista valinneeni, että otan tämän kurssin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Ole hyvä ja jatka kysymyksestä 9 sivulla 7

### Osa-alue III: SINUSTA OPISKELIJANA

Tämä osa-alue käsittelee sitä, miten itse kuvailisit itseäsi opiskelijana, ja erityisesti matematiikan ja tieteen opiskelijana.

9. Kun ajattelet itseäsi opiskelijana yleisesti, KAIKKIEN aineiden kannalta, kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Sama mieltä	Täysin sama mieltä
A. Opin useimpien aineiden asiat nopeasti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Olen hyvä useimmissa kouluaineissa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Menestyn useimpien oppiaineiden kokeissa hyvin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Yritän todella oppia, koska haluan olla parhaiden joukossa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Opin eniten, kun työskentelen toisten oppilaiden kanssa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Teen mielelläni ryhmätöitä muiden oppilaiden kanssa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Yritän todella aina menestyä paremmin kuin luokkatoverini	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Turhaudun, kun joudun auttamaan muita opiskelijoita	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Epävarmoina aikoina odotan kaiken sujuvan kuitenkin parhain päin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Jos jokin asia voi mennä elämässäni pieleen, se myös menee pieleen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Suhtaudun tulevaisuuteeni optimistisesti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. En yleensä odota asioiden sujuvan hyvin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Luotan harvoin siihen, että minulle tapahtuu hyviä asioita	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Yleisesti ottaen oletan, että minulle tapahtuu enemmän hyviä kuin huonoja asioita	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Saan hyviä arvosanoja useimmista kouluaineista	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. Minun on vaikeaa nähdä tarpeeksi vaivaa koulunkäyntini eteen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Ajatellen MATEMATIIKAN tuntejasi, kuinka paljon olet samaa mieltä alla olevien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Sama mieltä	Täysin sama mieltä
A. Minä en yksinkertaisesti ole hyvä matematiikassa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Saan hyviä arvosanoja matematiikassa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Matematiikan tunteillani ymmärrän vaikeimmatkin tehtävät	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Olen aina uskonut, että matematiikka on yksi parhaita aineitani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Minun on helppo ymmärtää uusia ideoita matematiikassa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Opin matematiikan aiheita nopeasti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Menestyn matematiikan kokeissa hyvin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### SINUSTA OPISKELIJANA

11. Ajatellen TIEDETUNTEJASI, kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Sama mieltä	Täysin sama mieltä
A. Kun opiskelen, teen töitä mahdollisimman ahkerasti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Opiskellessani jatkan työskentelyä, vaikka asia olisi vaikeakin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Opiskellessani yritän parhaani mukaan omaksua opettavat tiedot ja taidot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Jos opiskellessani en ymmärrä jotain seikkaa, etsin lisätietoja selvittääkseni asian	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Minun on vaikeaa nähdä tarpeeksi vaivaa tiedeaineiden eteen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Teen kotitehtäväni ajallaan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Olen varma, että ymmärrän vaikeimmatkin tekstissä esitetyt asiat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Olen varma, että ymmärrän vaikeasekoisimmatkin opettajan esittämät asiat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Olen varma, että pystyn hallitsemaan opettavat taidot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Kun paneudun opettelemaan jonkin oikein vaikean asian, pystyn oppimaan sen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Jos päätän olla saamatta huonoja arvosanoja, minä todellakin pystyn siihen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Jos päätän, että en tee tehtäviä väärin, pystyn todellakin siihen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Jos haluan oppia jonkin asian hyvin, minä pystyn siihen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Tiedän usein tiedeaiheista ennen kuin opiskelemme niistä tunnilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Olen edistynyt tiedeaineissa pidemmälle, kuin useimmat opiskelijat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. En itseasiassa juuri koskaan opiskele tiedetunteja varten	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. Olen usein huolissani siitä, että minulle tulee vaikeuksia	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R. Jännitän, kun minun pitää tehdä tieden kotitehtävät	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S. Hermostun kovasti tehdessäni tieden tehtäviä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T. Pelkään, että saan huonoja arvosanoja tieteissä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U. Opiskellessani yritän parhaani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V. Minä en yksinkertaisesti ole hyvä tieteissä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
W. Saan hyviä arvosanoja tiedeaineista	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X. Tiedetunteillani ymmärrän vaikeimmatkin tehtävät	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Y. Olen aina uskonut, että tieteet ovat parhaimpia aineitani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Z. Minun on helppo ymmärtää uusia ideoita tieteissä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ä. Opin tiedeaiheita nopeasti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ö. Menestyn tiedekokeissa hyvin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Osa-alue IV: KOULUN ULKOPUOLISET JA ELÄMÄÄ RIKASTUTTAVAT HARRASTUKSET

Tämä osa-alue käsittelee TTTM -aineisiin liittyviä koulun ulkopuolisia harrastuksia ja elämää rikastuttavia harrastuksia, joihin osallistut, sekä muita harrastuksia ja työkokemuksia.

### 12. Kuinka usein olet osallistunut seuraaviin toimintoihin?

	En koskaan	Kerran tai kahdesti	Useita kertoja
A. Osallistunut tutkimusprojektiin (liittyen tieteeseen, teknologiaan, tekniikkaan tai matematiikkaan) messuilla, näyttelyssä tai kilpailussa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Osallistunut matematiikka-, tiede-, tekniikka- tai teknologiakilpailuun	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Katsonut matematiikka- tai tiedevideoita Internetistä (esimerkiksi Kahn Academy)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Katsonut ilmaisia matematiikka- tai tiedevideoita tai podcasteja yliopistojen luennoilta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Ottanut ylimääräisiä tiede-, teknologia-, tekniikka- tai matematiikkakursseja lukiossa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Vierailut tutkimuskeskuksessa (esimerkiksi yliopistossa, voimalaitoksessa, sairaalassa tai yrityksessä)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Opettanut muille matematiikkaa tai tiedettä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Käyttänyt verkkofoorumeita keskustellaksesi matematiikan tai tieteen ongelmista	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Suorittanut kenttätutkimusta tai laboratoriotutkimusta itsenäistä tai ammattimaista tutkimusta varten	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Opetellut uutta ohjelmointikieltä, kuten Python tai C++, tai kehittänyt uusia tietokoneohjelmia koulun ulkopuolella	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Vastaanottanut matematiikan tai tieteen opetusta koulun ulkopuolella	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Ollut vapaaehtoistyössä sairaalassa tai terveysasemalla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Osallistunut matematiikan tai tieteen kesäohjelmiin tai leireille	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Osallistunut tiede-, teknologia-, tekniikka- tai matematiikkakerhoon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 13. Oletko osallistunut johonkin seuraavista tarkoista harrasteista? Ole hyvä ja rasti KAIKKI harrasteet, joihin olet osallistunut.

- |  |  |
|--|--|
| <input type="checkbox"/> Suomen kansallinen matematiikkakilpailu | <input type="checkbox"/> Viksu-tiedekilpailu                   |
| <input type="checkbox"/> International Mathematical Olympiad     | <input type="checkbox"/> X-Sarja klubi tai Summamutikka-klubi  |
| <input type="checkbox"/> Kenguru-kilpailu                        | <input type="checkbox"/> Summamutikan kesän leiri              |
| <input type="checkbox"/> Peruskoulun matematiikkakilpailu        | <input type="checkbox"/> F2k-klubi (ent. Kondensaattori-klubi) |
| <input type="checkbox"/> Lukion matematiikkakilpailu             | <input type="checkbox"/> Lukion fysiikkakilpailu               |
| <input type="checkbox"/> Lukion kemiakilpailu                    | <input type="checkbox"/> Datatähti tietotekniikkakilpailu      |

## KOULUN ULKOPUOLISET JA ELÄMÄÄ RIKASTUTTAVAT HARRASTUKSET

### 14. Oletko osallistunut muihin tiede-, teknologia- tai tekniikkaharrasteisiin, kuin mitä edellisellä sivulla oli lueteltu?

- KYLLÄ  EN

Jos KYLLÄ, ole hyvä ja listaa harrasteet tähän:

### 15. Osallistutko muihin kerhoihin, kilpailuihin tai harrasteisiin (kuten musiikki, liikunta tai nuorisoseura), jotka eivät suoraan liity tieteeseen tai matematiikkaan?

- KYLLÄ  EN

Jos KYLLÄ, kuinka usein osallistuit pääharrastukseesi viime vuoden aikana?

- Kerran tai kahdesti  Joka viikko  
 Useita kertoja  Melkein joka päivä

### 16. Oletko käynyt töissä nykyisen tai viime lukuvuoden aikana?

- KYLLÄ  EN

Jos KYLLÄ, kuinka monta tuntia viikossa suurin piirtein käyt (tai kävit) töissä?

- Korkeintaan 5 tuntia  Yli 5, korkeintaan 10 tuntia  
 Yli 10, korkeintaan 20 tuntia  Yli 20 tuntia

## Osa-alue V: TIETEEN ARVO

Tämä osa-alue käsittelee mielipidettäsi tieteën ja lääketieteen merkityksestä koulun ulkopuolella.

17. Kuinka paljon olet samaa mieltä seuraavien väittämien kanssa TIETEESTÄ (biologia, kemia, fysiikka, geologia)?

	Täysin eri mieltä	Eri mieltä	Samaa mieltä	Täysin samaa mieltä
A. Tiede auttaa meitä ymmärtämään maailmaa ympärillämme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Tieteelliset innovaatiot voivat pelastaa henkemme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Tieteelliset löydöt voivat hyödyttää yrityksiä ja taloutta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Tiede ei itseasiassa ole kovinkaan hyödyllistä useimmille ihmisille koulun ulkopuolella	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Ihmisiä, jotka opiskelevat tieteitä, arvostetaan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. On helpompaa päästä yliopistoon, jos aikoo opiskella tieteitä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Minuun ei itseasiassa tee vaikutusta, jos joku opiskelee tiedeainetta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Olettais, että tiedettä opiskeleva olisi hyvä opiskelija	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

18. Kuinka paljon olet samaa mieltä seuraavien väittämien kanssa LÄÄKETIETEESTÄ?

	Täysin eri mieltä	Eri mieltä	Samaa mieltä	Täysin samaa mieltä
A. Lääketieteentutkimus auttaa meitä ymmärtämään maailmaa ympärillämme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Lääketieteen innovaatiot voivat pelastaa henkemme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Lääketieteelliset löydöt voivat hyödyttää yrityksiä ja taloutta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Lääketiede ei itseasiassa ole kovinkaan hyödyllistä useimmille ihmisille koulun ulkopuolella	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Ihmisiä, jotka opiskelevat lääketiedettä, arvostetaan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. On helpompaa päästä yliopistoon, jos aikoo opiskella lääketiedettä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Minuun ei itseasiassa tee vaikutusta, jos joku opiskelee lääketiedettä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Olettais, että lääketiedettä opiskeleva olisi hyvä opiskelija	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Osa-alue VI: MENESTYMINEN

Tämä osa-alue käsittelee sitä, mitä sinun mielestäsi ihminen tarvitsee menestyäkseen elämässä yleisesti, ja erityisesti tieteën maailmassa.

19. Ajatellen menestystä kaikilla elämän osa-alueilla, kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Samaa mieltä	Täysin samaa mieltä
A. Kaikilla on mahdollisuus päästä arvostettuun asemaan yhteiskunnassa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Joskus yksilön on vain mahdotonta päästä etenemään elämässä, riippumatta siitä kuinka paljon hän yrittää	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Jos vain on halukas tekemään ahkerasti töitä, kenellä tahansa on hyvä mahdollisuus menestyä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Tiettyihin ryhmiin kuuluvilla yksilöillä on vaikeaa saavuttaa korkeaa asemaa tässä maassa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Jos ihmiset tekevät tarpeeksi ahkerasti töitä, he voivat luoda itselleen hyvän elämän	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20. Ajatellen TIEDETTÄ, kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Samaa mieltä	Täysin samaa mieltä
A. Sinulla on tietty määrä lahjakkuutta tiedeaineissa etkä voi itse juurikaan muuttaa asian tilaa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Lahjakkuutta tieteissä ei voida juurikaan muuttaa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Rehellisesti sanoen et voi oikeastaan muuttaa sitä, kuinka hyvä olet siinä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Riippumatta siitä, kuka olet, voit parantaa merkittävästi osaamistasi tiedeaineissa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Riippumatta siitä, kuinka lahjakas olet tieteissä, voit aina muuttaa sitä melko paljon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Sinulla on pakko olla erityislahjakkuutta menestyäksesi tiedeaineissa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Ahkeruus ei itseasiassa ole tärkeää tieteissä, jotkut vain ovat hyviä niissä.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Jos käytät paljon aikaa tieteiden opiskeluun, voit parantaa osaamistasi melko paljon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Mitä enemmän teet töitä tiedeaineiden eteen, sen paremmaksi tulet niissä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Totta puhuakseni minusta tuntuu, että en ole kovin älykäs, kun joudun työskentelemään ahkerasti tiedeaineiden eteen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Jos et ole hyvä tieteissä, ahkera opiskelu ei tee sinusta hyvää	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Kaikki voivat menestyä tieteissä, jos he opiskelevat ahkerasti	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Kuka tahansa, joka työskentelee ahkerasti, voi olla yksi luokan älykkäimmistä opiskelijoista	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Osa-alue VII: LUOKKAHUONEKOKEMUKSESI

Tämä osa-alue käsittelee kokemuksiasi viimeisimmästä tiedekurssistasi.

21. Ajatellen tämän hetkistä tai viimeisintä TIEDEKURSSIASI, kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Samaa mieltä	Täysin samaa mieltä
A. Tunnen itseni syrjäytyneeksi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Oloni tuntuu hankalalta ikään kuin olisin väärässä paikassa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Tunnen kuuluvani joukkoon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. En usein halua käydä kurssilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Minun on helppoa pyytää opettajaa selittämään asioita	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Useimmat ystäväni ovat samalla tiedekurssilla kanssani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Minulla on paljon yhteistä tiedekurssin muiden opiskelijoiden kanssa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Minun tiedekurssini ovat olleet helppoja	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Tunnit ovat usein haasteellisia minulle	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Ei ole itseasiassa vaikeaa saada hyvä arvosana	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Opiskelijoille annetaan tehtäviä tai projekteja, joiden tekemiseen menee useita päiviä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Tuntuu usein tylsältä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Minun on tarvinnut pinnistellä, että pystyn tekemään kaikki tehtäväni	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Opettaja osoittaa olevansa kiinnostunut jokaisen oppilaan oppimisesta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Opettaja antaa oppilaille mahdollisuuden ilmaista mielipiteitään	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. Opettaja antaa lisäapua, kun oppilaat tarvitsevat sitä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. Opettaja joutuu odottamaan kauan oppilaiden hiljentymistä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R. Meitä pyydetään tutkimaan tai kokeilemaan omia ideoitamme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S. Opettaja pyrkii kovasti tekemään aineistoista kiinnostavia meille	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T. Opettaja ärsyyntyy tai turhautuu usein luokkaamme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U. Opettajamme kannustaa luovuutta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V. Ei ole selvää, mitä pitäisi tehdä menestyäkseen tällä kurssilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
W. Tiedekurssini opiskelijat työskentelevät ahkerammin, kuin useimmat opiskelijat tässä koulussa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X. Opettaja odottaa luokaltamme paljon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Y. Opiskelijat kysyvät enemmän kysymyksiä, kuin muilla tunneilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Z. Luokkatoverini innoittavat minua työskentelemään ahkerammin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ä. Kouluni parhaat opiskelijat ovat tiedekurssillani	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ö. Tiedekurssini opiskelijat ovat erittäin kilpailuhenkisiä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Å. Autamme toisiamme tunneilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ø. Jaamme ideoita tunneilla	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Osa-alue VIII: ENNEN LUKIOTA

Tämä on toiseksi viimeinen osa-alue! Tämä osa-alue käsittelee kokemuksiasi matematiikasta ja tieteistä ENNEN lukiota ja siirtymäsi yläkoulun matematiikan ja tieteen opetuksesta lukion kurssille.

22. Koitko mitään seuraavista peruskoulussa tai yläkoulussa?

A. Antoiko opettaja sinulle ylimääräisiä tehtäviä matematiikan tunneilla?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
B. Suositteletko opettajasi, että osallistuisit tiedekilpailuun tai tiedekerhoon?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
C. Pyydettiinkö sinua koskaan auttamaan muita opiskelijoita matematiikan tunneilla?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
D. Etenitkö koskaan nopeammin, kuin muut opiskelijat matematiikan tunneilla?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
E. Olitko koskaan lahjakkaiden opiskelijoiden erityisryhmässä/ tasoryhmässä	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
F. Suositteletko opettaja, että otat pitkän matematiikan lukiossa?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
G. Kävitkö luokkaa tai koulua, jossa painotettiin erityisesti <b>tiedeaineita</b> ? (Esimerkiksi, jossa opiskeltiin tiedeaineita useampia tunteja, kuin tavallisella luokalla)	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
H. Kävitkö luokkaa tai koulua, jossa painotettiin erityisesti <b>matematiikkaa</b> ? (Esimerkiksi, jossa opiskeltiin matematiikkaa useampia tunteja, kuin tavallisella luokalla)	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
I. Suositteletko opettajasi, että osallistut matematiikkakilpailuun tai -kerhoon?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ
J. Antoiko opettajasi sinulle ylimääräisiä tehtäviä tiedetunneilla?	<input type="checkbox"/>	EI	<input type="checkbox"/>	KYLLÄ

23. Monille opiskelijoille siirtymä yläkoulun tiedetunneilta lukion kurseille voi olla haastavaa. Jos ajattelet omaa kokemustasi siirtymästä yläkoulusta lukioon, kuinka paljon olet samaa tai eri mieltä seuraavien väittämien kanssa?

	Täysin eri mieltä	Eri mieltä	Samaa mieltä	Täysin samaa mieltä
A. Tiedeaineet ovat minulle helpompia lukiossa, kuin ne olivat yläkoulussa.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Kun tulin lukioon, muut opiskelijat tuntuivat osaavan tieteitä paremmin kuin minä	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Minusta tuntui, etten ollut valmis lukion tiedekursseille	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Kun aloitin lukion, halusin ottaa enemmän tiedekursseja, mutta muttin mieleni, kun minulle selvisi minkälaisia kurssit ovat.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Olen kiinnostuneempi tieteestä nyt, kuin olin ennen lukiota	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Osa-alue IX: TAUSTASI JA TOIVEESI TULEVAISUUDELLE

**Tämä on kyselyn viimeinen osa-alue. Kysymykset A ja B ovat sinusta ja taustastasi. Kuten kyselyn kaikkien muidenkin kysymysten vastaukset, myös nämä vastaukset ovat täysin luottamuksellisia. Niitä ei käytetä sinun tai koulusi tunnistamiseen. Vastauksesi auttavat vertailemaan kokemuksiasi opiskelijoiden kokemuksiin muissa maissa. Viimeiset kysymykset seuraavalla sivulla, C ja D, koskevat tulevaisuuden toiveitasi.**

**A. Tämä kysymys koskee vanhempiesi tai huoltajiesi työtä, koulutusta ja suhdetta TTTM-aloihin. Ole hyvä ja rasti vastaava ruutu oikealla, jos mikään vasemmalla olevista väittämistä sopii vanhempiisi tai huoltajiiisi.**

	Äiti/ Holhoojia 1	Isä/ Holhoojia 2
Valmistunut lukiosta	<input type="checkbox"/>	<input type="checkbox"/>
Valmistunut ammattikoulusta	<input type="checkbox"/>	<input type="checkbox"/>
Kävi yliopistoa	<input type="checkbox"/>	<input type="checkbox"/>
Valmistunut yliopistosta (HuK, LuK tai vastaava)	<input type="checkbox"/>	<input type="checkbox"/>
Valmistunut ammattikorkeakoulusta (alempi korkeakoulututkinto tai vastaava)	<input type="checkbox"/>	<input type="checkbox"/>
Maisterin tutkinto (FM, DI tai vastaava)	<input type="checkbox"/>	<input type="checkbox"/>
Tohtorin tutkinto (FT tai vastaava)	<input type="checkbox"/>	<input type="checkbox"/>
Lisensiaatin tutkinto lääketieteestä tai muusta terveydenhuoltoon liittyvästä alasta (esimerkiksi LT, HLT tai vastaava)	<input type="checkbox"/>	<input type="checkbox"/>
Liiketalouden tai oikeustieteen korkeakoulututkinto (esimerkiksi KTM tai OT)	<input type="checkbox"/>	<input type="checkbox"/>
Työskentelee lääketieteen alan tai terveydenhuollon ammattilaisena (esimerkiksi sairaanhoitaja tai ensihoitaja)	<input type="checkbox"/>	<input type="checkbox"/>
Omistaa oman yrityksen	<input type="checkbox"/>	<input type="checkbox"/>
Työskentelee itsenäisesti (yrittäjä, ammatinharjoittaja)	<input type="checkbox"/>	<input type="checkbox"/>
On kiinnostunut tieteestä, teknologiasta, tekniikasta tai matematiikasta	<input type="checkbox"/>	<input type="checkbox"/>
Työskentelee tieteen, teknologian, tekniikan tai matematiikan parissa	<input type="checkbox"/>	<input type="checkbox"/>
Opiskeli tiedettä, teknologiaa, tekniikkaa tai matematiikkaa	<input type="checkbox"/>	<input type="checkbox"/>
Kannustaa minua opiskelemaan tiedettä ja matematiikkaa	<input type="checkbox"/>	<input type="checkbox"/>

**B. Tämä on viimeinen kysymys taustastasi. Näitä tietoja käytetään kokemuksiesi vertailussa muissa maissa koulunsa käyvien opiskelijoiden kokemuksiin.**

- Sukupuolesi?  Nainen  Mies
- Mikä on kansallisuutesi?  Suomalainen  Muu maa
- Synnyitkö Suomen ulkopuolella?  Kyllä  En

**Miten kuvaisit etnistä ryhmääsi tai taustaasi? Ole hyvä ja rasti kaikki, jotka sopivat.**

- Suomalainen  Venäläinen  Arabialainen/Lähi-Itä
- Suomenruotsalainen  Virolainen  Aasialainen
- Romani  Afrikkalainen  Muu:

## TAUSTASI JA TOIVEESI TULEVAISUUDELLE

**C. Kuinka korkealle HALUAISIT ideaalitalanteessa kouluttautua lukion jälkeen?**

- En enempää, ylioppilas
- Ammattikoulututkinto
- Yliopisto- tai ammattikorkeakouluopintoja
- Kandidaatin tutkinto (Esimerkiksi HuK, LuK)
- Maisterin tutkinto, jatko-opinnot tai tohtorin tutkinto (Esimerkiksi KTM, FM, FT, OTT, LT)
- En tiedä

**D. Jos voisit opiskella mitä tahansa ainetta haluat (ammatillinen tai akateeminen), mitä ainetta opiskelisit?**

**KIITOS!**

**Studenters förmåga och vilja att fortsätta studera NTIM ämnen:**  
Skolstrukturer och elevers val i Finland, Sverige och USA

**Studentformulär avseende NATURVETENSKAP**

**INLEDNING**

Det här frågeformuläret handlar om hur utbildningsrelaterade erfarenheter påverkar elevers beslut att studera områden knutna till naturvetenskap, teknik, ingenjörsvetenskap eller matematik (NTIM) efter gymnasiet. Deltagande i enkäten är frivilligt. Dina svar kommer att behandlas strikt konfidentiellt. Resultatet av undersökningen kommer att rapporteras i statistisk form, så att varken individer eller skolor kan identifieras.

Tack för att du bidrar med din tid och ditt engagemang till den här enkäten. Ditt deltagande i studien är avgörande för att vi ska kunna öka förståelsen för studenters erfarenheter i USA, Finland och Sverige.

**INSTRUKTIONER**

Detta frågeformulär fokuserar på dina erfarenheter av naturvetenskap/NO. Det innehåller nio sektioner:

- I. Planer inför framtiden
- II. Dina pågående studier
- III. Om Dig som student
- IV. Fritidssysselsättningar och aktiviteter utanför skoltid
- V. Naturvetenskapens värde och betydelse
- VI. Konsten att lyckas
- VII. Dina klassrumserfarenheter
- VIII. Tiden innan gymnasiet
- IX. Din bakgrund och dina förhoppningar inför framtiden

Formuläret innehåller 27 frågor. De flesta av frågorna kan besvaras genom att en ruta markeras, t ex:

Mycket osannolikt	Osannolikt	Sannolikt	Mycket sannolikt
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Undvik att tillbringa för mycket tid på varje enskild fråga – det här är inget test och det finns inga felaktiga svar!

Denna studie stöds av the Gates Cambridge Trust.

Om du har några frågor gällande frågeformuläret, tveka inte att ringa eller maila:

Jennifer von Reis Saari Email: xxxxx@cam.ac.uk FIN/SWE: +358 (0)xx xxx xxx

Faculty of Education, University of Cambridge, 184 Hills Road, Cambridge, CB2 8PQ, United Kingdom

**Sektion I: PLANER INFÖR FRAMTIDEN**

Den här sektionen handlar om dina planer för tiden efter gymnasiet. Den första sidan handlar om hur sannolikt det är att du skulle studera ämnen knutna till naturvetenskap, teknik, ingenjörsvetenskap och matematik (STEM) efter gymnasiet. Nästa sida handlar om dina utbildningsplaner och vad du kommer att göra nästa år.

1. Som situationen ser ut idag, hur troligt är det att du kommer att studera något av följande områden som HUVUDÄMNE efter gymnasiet?

	Mycket osannolikt	Osannolikt	Sannolikt	Mycket sannolikt
<b>A. Kemi</b> , omfattande biokemi, kemi i syfte att utveckla nya material och mediciner	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>B. Statistik</b> , omfattande teoretisk statistik, experimentell design, biologisk statistik, försäkringsrelaterad matematik/riskbedömning, demografi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>C. Matematik</b> , omfattande tillämpad matematik, utformning av verklighetsrelaterade problem, kryptografi och säkerhet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>D. Biologi</b> , omfattande studier med inriktning på neurovetenskap, växter, djur, människor, celler, sjukdomar, ekosystem, genetik	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>E. Geovetenskap</b> , omfattande studier med inriktning på geologi, oceanografi, jordbävningar och fossiler	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>F. Ingenjörsvetenskap</b> , med inriktning mot civilingenjör, kemi- och elektroingenjör, säkerhetsingenjör och ingenjörsvetenskap med inriktning mot industriproduktion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>G. Datavetenskap</b> , omfattande skapande och design av mjukvara och maskiner, samt teoretisk datavetenskap/datalogi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>H. Läkarvetenskap</b> , omfattande medicin, omvårdnad, farmaci, tandvård, näringslära och veterinärmedicin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>I. Jordbruk</b> , omfattande trädgårdsodling, livsmedelsvetenskap, jordbruksteknik och ekologi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## PLANER INFÖR FRAMTIDEN

2. Så som din situation ser ut idag, vilken utbildningsnivå planerar du att uppnå?

- Gymnasieexamen, inte mer
- Yrkesskoleexamen
- Studier på någon typ av universitet eller yrkeshögskola
- Kandidatexamen (t ex fil. kand., jur.kand.)
- Magisterexamen, masterexamen, forskarutbildning eller doktorsexamen (T ex fil mag, tek mag, jur)
- Vet ej

3. Planerar du att gå i skolan/studera nästa höst (omkring oktober 2012)?

- NEJ (Var vänlig och svara på fråga 3A)     JA (Var vänlig och svara på fråga 3B)

3A) OM NEJ, välj det påstående som bäst beskriver vad du planerar att göra nästa höst:

- Jag kommer att göra militärtjänst
- Jag kommer att arbeta heltid
- Jag kommer att ta hand om en familjemedlem
- Jag kommer att ta ett sabbatsår för att resa eller arbeta som volontär
- Jag kommer att ta ett sabbatsår av andra skäl

3B) OM JA, välj det påstående som bäst beskriver vad du planerar att göra nästa höst:

- Jag kommer att studera på en gymnasieskola
- Jag kommer att studera på en yrkesskola
- Jag kommer att studera inför ett inträdesprov till högskola/universitet
- Jag kommer att studera naturvetenskap i ett år (t ex Naturvetenskapligt basår på Stockholms Universitet eller KTH) innan jag påbörjar ett universitetsprogram
- Jag kommer att studera på ett universitet eller en yrkeshögskola MEN jag planerar att byta till en annan fakultet eller universitet senare
- Jag kommer att studera på ett universitet eller en yrkeshögskola OCH jag har i nuläget inga planer på att byta fakultet eller universitet

Vilket/vilka kommer att vara ditt/dina huvudämne/n nästa år?

## Sektion I: DINA PÅGÅENDE STUDIER

Den här sektionen handlar om dina pågående och senast lästa matematik- och naturvetenskapliga kurser, vilka betyg du har erhållit och varför du läser eller inte läser naturvetenskaplig kurs just nu.

4. Läser du för närvarande på ett NATURVETENSKAPLIGT PROGRAM?

- NEJ
- JA

Vad är namnet på ditt program?

5. Är du registrerad på någon MATEMATIKKURS för närvarande?

- NEJ
- JA

Vilken var den SENASTE MATEMATIKKURSEN du läste på gymnasiet? Var vänlig och skriv namnet på kursen i utrymmet nedan. Om du deltog i mer än en kurs samtidigt, skriv namnet på den kurs som var viktigast för dig.

Vilket betyg erhöLL du i den kursen?

- MVG     VG     G     IG

Om du läser en MATEMATIKKURS denna termin, vilken kurs (eller vilka kurser) läser du? Var vänlig och skriv namnet (eller namnen) på kurserna i utrymmet nedan.

5. När gymnasiet är avslutat, hur många terminer (alltså höst- och vårterminer) kommer du att ha studerat NATURVETENSKAP?

OBS: En del elever kommer att ha fullgjort mer än en naturvetenskaplig kurs per termin. Om du t ex läste biologi och kemi under samma år, både höst- och vårtermin, då ska du räkna två terminer för varje kurs, så att det blir fyra totalt.

- 0–2 terminer (upp till ett år av naturvetenskapliga studier)
- 3–4 terminer (mer än ett år och upp till två år av naturvetenskapliga studier)
- 5–6 terminer (mer än två år och upp till tre år av naturvetenskapliga studier)
- Mer än 6 terminer (mer än tre ordinarie skolår av naturvetenskapliga studier)

6. Läser du för tillfället någon NATURVETENSKAPLIG kurs?

- NEJ    Var vänlig gå vidare till nästa sida och svara på frågorna 7A och 8A på sidan 5
- JA    Var vänlig hoppa över nästa sida och svara på frågorna 7B och 8B på sidan 6

Fyll i denna sida om du INTE läser någon NATURVETENSKAPLIG kurs för tillfället

Om du läser en naturvetenskaplig kurs denna termin, hoppa över denna sida och fortsätt med fråga nummer 7B på nästa sida.

7A. Om du INTE läser en NATURVETENSKAPLIG kurs denna termin, vilken var den senaste naturvetenskapliga kursen du läste i gymnasiet?

Vilket betyg erhöll du i den kursen?

MVG  VG  G  IG

8A. I vilken grad instämmer du i nedanstående påståenden gällande orsaken till att du INTE läser en NATURVETENSKAPLIG kurs denna termin?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Jag behövde den inte för min examen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Jag placerades automatiskt i en annan kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Det fanns inte utrymme för en naturvetenskaplig kurs på mitt schema	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. En lärare eller studievägledare rekommenderade mig att inte läsa naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Det ingår ingen naturvetenskaplig kurs i mitt studieprogram denna termin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. En familjemedlem rekommenderade mig att inte läsa naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Den naturvetenskapliga kurs som jag ville läsa var inte tillgänglig	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Jag trodde inte att jag skulle få ett bra betyg i den kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Jag är inte intresserad av naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Det fanns ett ämne jag hellre ville läsa än naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Egentligen vet jag inte varför jag inte läser en naturvetenskaplig kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Det var ingen som egentligen påverkade mitt beslut, jag valde själv att inte läsa en naturvetenskaplig kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Jag behöver inte den kursen för det jag planerar att göra i framtiden	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. En vän rekommenderade mig att inte läsa den kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Jag minns inte när och hur jag fattade mitt beslut att inte läsa naturvetenskap den här terminen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Var vänlig och fortsätt med fråga 9 på sidan 7

Fyll i denna sida om du LÄSER en naturvetenskaplig kurs just nu

Om du inte läser en naturvetenskaplig kurs denna termin, hoppa över denna sida och fortsätt med fråga 9 på nästa sida.

7B. Om du LÄSER EN NATURVETENSKAPLIG KURS just nu, vilken naturvetenskaplig kurs (eller kurser) läser du? Var vänlig och skriv namnet/namnen på kursen/kurserna i utrymmet nedan:

Ungefär hur många timmar har du lagt ner på läxläsning eller studier i NATURVETENSKAP utanför skolan den senaste veckan?

0 timmar  1–2 timmar  3–4 timmar  5–6 timmar  mer än 6 timmar

Vilken var den senaste naturvetenskapliga kursen du läste i gymnasiet? Var vänlig och skriv namnet på den kursen i utrymmet nedan. Om du läste mer än en kurs samtidigt, skriv namnet på den kurs du upplevde som viktigast.

Vilket betyg erhöll du i den kursen?

MVG  VG  G  IG

8B. Hur väl stämmer följande påståenden in på varför du har valt att läsa en NATURVETENSKAPLIG kurs den här terminen?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Jag behöver den för min examen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Jag placerades automatiskt i den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Den här kursen kommer att hjälpa mig komma in på en bättre skola eller ett bättre studieprogram efter gymnasiet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. En lärare eller studievägledare rekommenderade mig att välja den	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Den här kursen är obligatorisk på mitt program	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. En familjemedlem rekommenderade mig att välja den	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Kursen jag ville läsa var inte tillgänglig så jag blev tvungen att välja den här	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Jag trodde att jag skulle kunna få ett bra betyg i den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Jag är intresserad av naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Jag ville läsa en naturvetenskaplig kurs mer än något annat ämne	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Egentligen vet jag inte varför jag läser den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Det var egentligen ingen som påverkade mitt beslut; jag valde själv att läsa den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Jag behöver den här kursen för det jag har planerat att göra i framtiden	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. En vän rekommenderade mig att välja kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Jag minns inte när eller hur jag valde att läsa den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Var vänlig och fortsätt med fråga 9 på sidan 7

### Sektion III: OM DIG SOM STUDENT

Den här sektionen handlar om hur du skulle beskriva dig själv som student i allmänhet, och som student när det gäller matematik och naturvetenskap i synnerhet.

9. Om du tänker på dig själv som student i allmänhet, OAVSETT ÄMNE, i vilken grad instämmer du i följande påståenden?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Jag lär mig saker snabbt i de flesta skolämnena	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Jag är bra i de flesta skolämnena	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Jag presterar bra på proven i de flesta skolämnena	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Jag anstränger mig verkligen, för jag vill vara en av de bästa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Jag lär mig mest när jag arbetar tillsammans med andra elever	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Jag tycker om att arbeta med andra elever i grupp	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Jag försöker alltid prestera bättre än de andra eleverna i min klass	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Jag blir frustrerad när jag måste hjälpa andra studenter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. När livet känns ovisst förväntar jag mig oftast att saker ska lösa sig till det bästa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Om någonting kan gå illa för mig så gör det det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Jag är optimistisk när det gäller min framtid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Jag förväntar mig nästan aldrig att saker ska gå som jag vill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Jag räknar sällan med att någonting bra ska hända mig	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. På det hela taget förväntar jag mig snarare att bra saker ska hända mig än dåliga	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Jag får bra betyg i de flesta skolämnen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. Jag har svårt att anstränga mig tillräckligt i skolan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Med avseende på dina MATEMATIKKURSER, i vilken grad instämmer du i följande påståenden?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Jag är helt enkelt inte bra i matematik	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Jag får bra betyg i matematik	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Jag förstår även de svåraste uppgifterna på matematiklektionerna	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Jag har alltid tyckt att matematik är ett av mina bästa ämnen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Jag har lätt för att förstå nya idéer i matematik	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Jag lär mig matematiska ämnen snabbt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Jag presterar bra på matematikproven	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### OM DIG SOM STUDENT

11. Med avseende på dina NATURVETENSKAPLIGA kurser, i vilken grad instämmer du i följande påståenden?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. När jag studerar, arbetar jag så hårt som möjligt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. När jag studerar fortsätter jag att arbeta även om materialet är svårt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. När jag studerar försöker jag att göra mitt bästa för att tillgodogöra mig de kunskaper och färdigheter som lärs ut	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. När jag studerar, anstränger jag mig till det yttersta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. När jag studerar och det är något jag inte förstår, ser jag efter om det finns någon annan information som kan hjälpa mig att förstå	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. När det gäller naturvetenskap har jag svårt att verkligen anstränga mig tillräckligt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Jag gör mina läxor i tid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Jag är säker på att jag kan förstå det svåraste materialet som framställs i texter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Jag är säker på att jag kan få utmärkt resultat på uppgifter och prov	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Jag är säker på att jag kan förstå de färdigheter som lärs ut	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. När jag slår mig ner för att lära mig något verkligt svårt, så kan jag det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Om jag bestämmer mig för att inte få några dåliga betyg, så kan jag klara det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Om jag bestämmer mig för att inte missuppfatta några uppgifter, så kan jag faktiskt klara det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Om jag vill lära mig någonting bra, så kan jag det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Jag känner ofta till om naturvetenskapliga ämnena innan vi lär oss om dem kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. Jag har kommit längre i naturvetenskapliga ämnen än de flesta studenter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. Jag pluggar faktiskt nästan aldrig i mina naturvetenskapliga kurser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R. Jag oroar mig ofta över att det kommer att bli svårt för mig	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S. Jag blir väldigt spänd när jag måste göra hemuppgifter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T. Jag blir mycket nervös när jag löser uppgifter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U. Jag oroar mig över att jag skall få dåliga betyg	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V. Jag är helt enkelt inte bra på naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
W. Jag får bra betyg i naturvetenskapliga kurser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X. Jag förstår även de svåraste uppgifterna på naturvetenskapliga lektionerna	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Y. Jag har alltid tyckt att naturvetenskap är ett av mina bästa ämnen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Z. Jag har lätt för att förstå nya naturvetenskapliga idéer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Å. Jag lär mig naturvetenskapliga ämnen snabbt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ä. Jag presterar bra på naturvetenskap proven	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Sektion IV: FRITIDSSYSSLSÄTTNINGAR OCH AKTIVITETER UTANFÖR SKOLTID

Den här sektionen handlar om de STEM-relaterade fritidsaktiviteter och sysselsättningar som du har deltagit i utanför skoltid, samt andra aktiviteter och arbetslivserfarenheter.

### 12. Hur ofta har du deltagit i nedanstående aktiviteter?

	Aldrig	Ibland	Många gånger
A. Gått med i ett forskningsprojekt (relaterat till naturvetenskap, teknik, ingenjörsvetenskap eller matematik) i tävlingssyfte	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Deltagit i en tävling inom matematik, naturvetenskap, ingenjörsvetenskap eller teknik	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Tittat på internet matematik eller naturvetenskapliga videosändningar från Kahn Academy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Tittat på gratis matematik- eller naturvetenskapliga videoinspelningar, eller poddsändningar från universitetsföreläsningar	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Läst extra kurser inom naturvetenskap, teknik, ingenjörsvetenskap eller matematik utanför gymnasiekurserna	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Besökt ett naturvetenskapligt forskningscenter (t ex på ett universitet, kraftverk, sjukhus eller företag)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Väglett andra inom matematik eller naturvetenskap/NO	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Använt olika forum på nätet för att diskutera matematik eller naturvetenskapliga problem	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Utfört fältarbete eller laboratoriearbete för en oberoende eller fackmässig forskningsstudie	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Lärt in ett nytt programmeringsspråk, t ex Python eller C++, eller utvecklat nya dataprogram utanför skolan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Fått handledning inom matematik eller naturvetenskap utanför skoltid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Arbetat som volontär på ett sjukhus eller hälsocenter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Deltagit i sommarkurser eller läger inom matematik eller naturvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Deltagit i klubbar/föreningar med inriktning på naturvetenskap, teknik, ingenjörsvetenskap eller matematik	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 13. Har du deltagit i någon av följande aktiviteter? Var vänlig och markera ALLA aktiviteter som du har deltagit i.

- |  |  |
|--|--|
| <input type="checkbox"/> Skolornas matematiktävling  | <input type="checkbox"/> Internationella matematikolympiaden |
| <input type="checkbox"/> KTH Matematisk cirkel       | <input type="checkbox"/> Vetenskapens Hus                    |
| <input type="checkbox"/> Projektarbete i matematik   | <input type="checkbox"/> Olympiad i naturvetenskap           |
| <input type="checkbox"/> Nordiska Matematiktävlingen | <input type="checkbox"/> Projektarbete i naturvetenskap      |

## FRITIDSSYSSLSÄTTNINGAR OCH AKTIVITETER UTANFÖR SKOLTID

### 14. Har du deltagit i andra aktiviteter inom naturvetenskap, teknik eller ingenjörsvetenskap som inte finns med i listan på föregående sida?

- JA  NEJ

Om svaret är JA, var vänlig och skriv ned dessa aktiviteter här:

### 15. Deltar du i andra klubbar/föreningar, tävlingar eller aktiviteter (t ex inom musik, sport eller en ungdomsgrupp) som inte är direkt knuten till naturvetenskap eller matematik?

- JA  NEJ

Om JA, hur ofta deltog du i din huvudsakliga aktivitet under förra året?

- |  |   |
|--|---|
| <input type="checkbox"/> En eller två gånger | <input type="checkbox"/> Varje vecka      |
| <input type="checkbox"/> Många gånger        | <input type="checkbox"/> Nästan varje dag |

### 16. Har du arbetat under det innevarande eller förra skolåret?

- JA  NEJ

Om JA, ungefär hur många timmar arbetar (eller arbetade) du per vecka?

- |   |  |
|---|--|
| <input type="checkbox"/> upp till 5 timmar                    | <input type="checkbox"/> mer än 5 timmar, upp till 10 timmar |
| <input type="checkbox"/> mer än 10 timmar, upp till 30 timmar | <input type="checkbox"/> mer än 30 timmar                    |

## Sektion V: NATURVETENSKAPENS VÄRDE OCH BETYDELSE

Den här sektionen handlar om hur du ser på betydelsen av naturvetenskap och läkarvetenskap, utanför skolans värld.

17. I vilken grad instämmer du i följande påståenden om NATURVETENSKAP (Biologi, Kemi, Fysik, Geologi)?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Naturvetenskapen hjälper oss förstå världen omkring oss	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Naturvetenskapliga uppfinningar kan rädda liv	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Naturvetenskapliga upptäckter kan gynna affärliv och ekonomi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Utanför skolans värld är naturvetenskapen egentligen inte särskilt användbar för de flesta människor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Människor som studerar naturvetenskap respekteras högt av andra	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Det är lättare att komma in på högskolan om man planerar att läsa naturvetenskapliga kurser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Det imponerar faktiskt inte på mig om någon ägnar sig åt naturvetenskapliga studier	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Om någon studerar naturvetenskap antar jag genast att han/hon är en framgångsrik student	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

18. I vilken utsträckning instämmer du i nedanstående påståenden om LÄKARVETENSKAP?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Läkarvetenskaplig forskning hjälper oss att förstå världen omkring oss	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Läkarvetenskapliga uppfinningar kan rädda liv	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Läkarvetenskapliga upptäckter kan gynna affärliv och ekonomi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. I själva verket är läkarvetenskapen egentligen inte särskilt användbar för de flesta människor utanför skolans värld	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Människor som studerar läkarvetenskap respekteras högt av andra	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Det är lättare att komma in på högskolan om man planerar att studera läkarvetenskap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Det imponerar faktiskt inte på mig om någon ägnar sig åt läkarvetenskapliga studier	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Om någon studerar läkarvetenskap antar jag genast att han/hon är en framgångsrik student	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Sektion VI: KONSTEN ATT LYCKAS

Den här sektionen handlar om vad du tycker människor behöver för att vara framgångsrika i livet i allmänhet, och inom det naturvetenskapliga området i synnerhet.

19. Om du tänker på framgång inom livets alla områden, i vilken utsträckning instämmer du i följande påståenden?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Alla har möjligheten att uppnå högre status i samhället	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. En del människor är helt enkelt oförmögna att ta sig fram i världen, oavsett hur hårt de anstränger sig	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Vem som helst som är villig att arbeta hårt har goda chanser att lyckas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Enskilda medlemmar ur vissa grupper har svårt att uppnå högre status i det här landet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Om människor arbetar tillräckligt hårt kan de skapa sig goda liv	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20. Om du tänker på NATURVETENSKAP/NO, i vilken utsträckning instämmer du i följande påståenden?

	Instämmer inte alls	Instämmer till viss del	Instämmer till stor del	Instämmer helt
A. Man har en viss begåvning inom det naturvetenskapliga området och det är inte mycket man kan göra för att förändra denna	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Naturvetenskaplig begåvning är något som inte kan förändras särskilt mycket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Ärligt talat kan du inte förändra din förmåga på det naturvetenskapliga området	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Oavsett vem du är så kan du avsevärt förbättra din förmåga inom det naturvetenskapliga området	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Oavsett hur begåvad du är inom det naturvetenskapliga området kan du alltid förbättra dig en hel del	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Du måste ha en speciell talang för att kunna prestera riktigt bra i en naturvetenskaplig kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Det är faktiskt inte så viktigt att arbeta hårt inom naturvetenskapliga kurser, en del människor är helt enkelt bra på det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Om du verkligen lägger ned tid på dina naturvetenskapliga studier kan du förbättra dina prestationer ganska mycket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Ju hårdare du arbetar inom naturvetenskapliga kurser, desto bättre presterar du	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Ärligt talat, när jag måste arbeta hårt inom naturvetenskapliga kurser känner jag mig inte särskilt smart	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Om du inte redan är bra på naturvetenskap kommer inte heller hårt arbete att göra dig bättre	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Alla kan lyckas med naturvetenskapliga studier om de arbetar hårt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Vem som helst som arbetar hårt kan bli en av de smartaste i klassen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Sektion VII: DINA KLASSRUMSERFARENHETER

Den här sektionen handlar om dina erfarenheter från den naturvetenskapliga kurs du senast deltog i.

21. Om du tänker på din pågående naturvetenskapliga kurs, eller den du senast deltog i, i vilken utsträckning instämmer du i följande påståenden?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Jag känner jag mig utanför	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Jag känner mig dum och missanpassad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Jag känner att jag hör hemma	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Jag går mot min vilja	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Jag känner mig bekväm med att be mina lärare förklara teorier och begrepp	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. De flesta av mina vänner läser samma naturvetenskapliga kurs som jag	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Jag har mycket gemensamt med de andra studenterna på min naturvetenskapliga kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Mina lektioner inom naturvetenskap har varit lätta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Jag känner mig ofta utmanad under lektionerna	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Det är faktiskt inte särskilt svårt att få ett bra betyg	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Eleverna ges problem eller projekt som tar flera dagar att fullborda	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Jag är ofta uttråkad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Jag har tvingats pressa mig själv för att hänga med i arbetstakten	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Läraren visar intresse för varje elevs lärande	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Läraren ger eleverna tillfälle att uttrycka åsikter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. Läraren ger extra stöd när eleverna behöver det	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. Läraren måste vänta en lång stund på att eleverna skall bli tysta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R. Vi uppmanas att göra undersökningar eller experiment för att testa våra egna idéer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S. Läraren gör sitt bästa för att göra materialet intressant för oss	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T. Läraren blir ofta irriterad eller frustrerad över vår klass	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U. Vår lärare uppmuntrar kreativitet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V. Det framgår inte vad vi behöver göra för att lyckas i den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
W. Eleverna i min naturvetenskapliga kurs arbetar hårdare än de flesta studenter på den här skolan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X. Läraren har höga förväntningar på oss i den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Y. Eleverna ställer fler frågor än de gör i andra kurser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Z. Mina kurskamrater inspirerar mig att arbeta hårdare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Å. De bästa studenterna på skolan går i min naturvetenskapliga kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ä. Eleverna är väldigt tävlingsinriktade i min naturvetenskapliga kurs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ö. Vi hjälper varandra i den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ø. Vi delger varandra idéer i den här kursen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Sektion VIII: TIDEN INNAN GYMNASIET

**Detta är den näst sista sektionen!** Denna sektion handlar om de erfarenheter inom matematik och naturvetenskapliga kurser/NO som du har från tiden INNAN du började gymnasiet, och om din övergång från grundskolan till gymnasiets matematik- och naturvetenskapliga kurser.

22. I låg-, mellan- eller högstadiet, upplevde du någonsin något av det följande?

	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
A. Brukade din lärare ge dig extrauppgifter innehållande matematiska problem och aktiviteter?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
B. Rekommenderade din lärare dig att delta i en NO-tävling eller klubb/förening med naturvetenskaplig profil?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
C. Blev du någonsin ombedd att hjälpa andra elever i matematik?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
D. Låg du före de andra eleverna i din klass när det gällde matematik?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
E. Har du någonsin varit inskriven på ett program för elever med särskild talang eller begåvning?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
F. Har du blivit rekommenderad av någon lärare att läsa avancerad matematik (eller det Naturvetenskapliga programmet) på gymnasiet?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
G. Gick du i en klass eller skola med <b>naturvetenskaplig</b> profil? (Där du t ex hade fler lektioner inom naturvetenskapliga kurser än en genomsnittlig klass)	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
H. Gick du i en klass eller skola med <b>matematikprofil</b> ? (Där du t ex hade fler matematiklektioner än en genomsnittlig klass)	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
I. Blev du rekommenderad av din lärare att delta i någon matematiktävling eller klubb/förening med inriktning på matematik?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA
J. Erböd din lärare dig extra problem att lösa eller andra aktiviteter som rör det naturvetenskapliga området?	<input type="checkbox"/>	NEJ	<input type="checkbox"/>	JA

23. För många elever kan övergången från grundskolans naturvetenskapliga kurser/NO till gymnasiets kurser upplevas som en utmaning. Om du tänker tillbaka på dina egna erfarenheter gällande övergången från grundskola till gymnasium, i vilken utsträckning instämmer du i följande påståenden?

	Håller absolut inte med	Håller inte med	Håller med	Håller absolut med
A. Naturvetenskap är lättare för mig på gymnasienivå än det var i grundskolan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. När jag kom till gymnasiet verkade de andra eleverna kunna mer om naturvetenskapliga ämnen än jag gjorde	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Jag kände mig inte förberedd för gymnasiets naturvetenskapliga kurser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. När jag började gymnasiet ville jag läsa fler naturvetenskapliga kurser, men ändrade mig när jag fick reda på hurdana kurserna var	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Jag är mer intresserad av naturvetenskap nu än jag var innan gymnasiet	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Sektion IX: DIN BAKGRUND OCH DINA FÖRHOPNINGAR INFÖR FRAMTIDEN

**Detta är den sista sektionen i frågeformuläret. Frågorna A och B handlar om dig och din bakgrund. Dina svar kommer, precis som resten av den här enkäten, att hållas strikt konfidentiella. De kommer inte att användas i syfte att identifiera dig eller din skola. Dina svar kommer att vara till hjälp för en jämförelse av dina erfarenheter med erfarenheterna hos studenter i andra länder. De sista frågorna, C och D på nästa sida, handlar om dina förhoppningar inför framtiden.**

A. Den här frågan handlar om dina föräldrars eller vårdnadshavares arbete, utbildning och delaktighet i STEM-relaterade områden. Var vänlig och markera motsvarande ruta till höger, om några av påståendena till vänster stämmer in på dina föräldrar eller vårdnadshavare.

	Moder/ Vårdnads- havare 1	Fader/ Vårdnads- havare 2
Innehar gymnasieexamen	<input type="checkbox"/>	<input type="checkbox"/>
Innehar yrkesskoleexamen	<input type="checkbox"/>	<input type="checkbox"/>
Har genomgått en del av en högskole- eller universitetsutbildning	<input type="checkbox"/>	<input type="checkbox"/>
Innehar universitetsexamen (fil kand eller motsvarande)	<input type="checkbox"/>	<input type="checkbox"/>
Innehar (teknisk) yrkeshögskoleexamen (fil kand eller motsvarande)	<input type="checkbox"/>	<input type="checkbox"/>
Innehar magisterexamen (fil mag eller motsvarande)	<input type="checkbox"/>	<input type="checkbox"/>
Innehar doktorsexamen (fil dr eller motsvarande)	<input type="checkbox"/>	<input type="checkbox"/>
Innehar en medicinsk examen eller annan avancerad examen inom hälsorelaterade områden (t ex med dr, farm dr)	<input type="checkbox"/>	<input type="checkbox"/>
Innehar en avancerad examen inom affärsliv eller juridik	<input type="checkbox"/>	<input type="checkbox"/>
Är yrkesmässigt verksam inom medicin eller friskvård (t ex sjuksköterska eller ambulanssjukvårdare)	<input type="checkbox"/>	<input type="checkbox"/>
Äger en affärsverksamhet	<input type="checkbox"/>	<input type="checkbox"/>
Är egen företagare (är sin egen chef)	<input type="checkbox"/>	<input type="checkbox"/>
Är intresserad av naturvetenskap, teknik, ingenjörsvetenskap eller matematik	<input type="checkbox"/>	<input type="checkbox"/>
Arbetar inom naturvetenskap, teknik, ingenjörsvetenskap eller matematik	<input type="checkbox"/>	<input type="checkbox"/>
Har studerat naturvetenskap, teknik, ingenjörsvetenskap eller matematik	<input type="checkbox"/>	<input type="checkbox"/>
Uppmuntrar mig att läsa naturvetenskap och matematik	<input type="checkbox"/>	<input type="checkbox"/>

B. Detta är den sista frågan om din bakgrund. Den här informationen kommer att användas för att jämföra dina erfarenheter med erfarenheter hos studenter i andra länder med andra skolsystem.

Vilket kön tillhör du?	<input type="checkbox"/> Kvinna	<input type="checkbox"/> Man
Vilken nationalitet tillhör du?	<input type="checkbox"/> Svensk	<input type="checkbox"/> Annat land
Föddes du utanför Sverige	<input type="checkbox"/> Ja	<input type="checkbox"/> Nej

Hur skulle du beskriva din etnicitet eller bakgrund? **Var vänlig markera allt som stämmer in på dig:**

- |  |                                       |  |
|--|---------------------------------------|--|
| <input type="checkbox"/> Svensk          | <input type="checkbox"/> Romani       | <input type="checkbox"/> Asiatisk        |
| <input type="checkbox"/> Finsk           | <input type="checkbox"/> Afrikansk    | <input type="checkbox"/> Latinamerikansk |
| <input type="checkbox"/> Samisk          | <input type="checkbox"/> Mellanöstern |  |
| <input type="checkbox"/> Annat ursprung: |                                       |  |

## DIN BAKGRUND OCH DINA FÖRHOPNINGAR INFÖR FRAMTIDEN

C. Under de allra bästa omständigheter, vilken utbildningsnivå skulle du själv VILJA uppnå efter gymnasiet?

- Gymnasieexamen, inte mer
- Yrkesskoleexamen
- Studier på någon typ av universitet eller yrkeshögskola
- Kandidatexamen (t ex fil. kand., jur.kand.)
- Magisterexamen, masterexamen, forskarutbildning eller doktorsexamen (T ex fil mag, tek mag, jur mag, MD, fil dr, jur dr)
- Vet ej

D. Om du fick möjligheten att studera vilket ämne du ville (yrkesinriktat eller akademiskt), vilket ämne skulle du välja?

**TACK!**

**Student persistence in STEM fields:**

School structures and student choices in Finland, Sweden and the United States

**Student Questionnaire for SCIENCE**

**INTRODUCTION**

This questionnaire is about how students' educational experiences affect their decisions to study science, technology, engineering or mathematics (STEM) related fields after high school. Participation in this questionnaire is voluntary. Your answers will be kept strictly confidential. Results from this survey will be reported in a statistical form such that individuals and schools will not be identifiable.

**Thank you for contributing your time and consideration to this survey. Your participation in this research is crucial for improving understanding of student experiences in the United States, Finland and Sweden.**

**DIRECTIONS**

This questionnaire focuses on your experiences with science. It has nine sections:

- I. Plans for the future
- II. Your current studies
- III. About you as a student
- IV. Extracurricular and enrichment activities
- V. The value of science
- VI. Being successful
- VII. Your classroom experience
- VIII. Before high school
- IX. Your background and hopes for the future

There are 27 questions in the questionnaire. Most of the questions can be answered by marking a box, for example:

<b>Very Unlikely</b>	<b>Unlikely</b>	<b>Likely</b>	<b>Very Likely</b>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Avoid spending too much time on any question- this is not a test and there are no wrong answers!

This research is supported by the Gates Cambridge Trust.

**If you have any questions about this questionnaire, please feel free to call or email:**

Jennifer von Reis Saari Email: xxxxx@cam.ac.uk US: 1-xxx-xxx-xxxx FIN/SWE: +358 (0)xx xxx xxxxx  
Faculty of Education, University of Cambridge, 184 Hills Road, Cambridge, CB2 8PQ, United Kingdom

**Section I: PLANS FOR THE FUTURE**

*This section is about your plans for after high school. The first page is about how likely you would be to study science, technology, engineering and mathematics (STEM) related fields after high school. The next page is about your educational plans, and what you will be doing next year.*

1. As of right now, how likely is it you will study each of the following subjects after high school as a MAIN subject of study? That is, how likely would you be to get a major, concentration, or minor in one of the following areas?

	<b>Very Unlikely</b>	<b>Unlikely</b>	<b>Likely</b>	<b>Very Likely</b>
<b>A. Chemistry</b> , including biochemistry, chemistry for developing new materials and medicines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>B. Statistics</b> , including theoretical statistics, experimental design, biological statistics, actuarial science, demography	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>C. Mathematics</b> , including pure and applied mathematics, modeling real world problems, cryptography and security	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>E. Biology</b> , including the study of neuroscience, plants, animals, humans, cells, diseases, ecosystems, genetics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>F. Earth sciences</b> , including the study of geology, oceanography, earthquakes, and fossils	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>G. Engineering</b> , including civil, chemical and electrical engineering, engineering for safety or industrial production	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>H. Computer science</b> , including creating and designing software and machines and theoretical computer science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>I. Health sciences</b> , including medicine, nursing, pharmacy, dentistry, nutrition and veterinary sciences	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>J. Agriculture</b> , including horticulture, food science, agricultural engineering and ecology	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## PLANS FOR THE FUTURE

2. Given how things are right now, how much education are you planning to complete?

- No further; high school graduate
- Technical or vocational school
- Associates degree (For example, AA degree)
- College graduate (For example, BA, BS or other 4 year degree)
- Post-graduate degree, training, or professional school (For example, MBA, MA, PhD, JD, MD)
- Don't know

3. Are you planning to be in school or studying next fall (by October 2012)?

- NO (please answer question 2A)
- YES (please answer question 2B)

3A) IF NO, please select the statement best describes what you plan to be doing next fall:

- I will be in the military
- I will be working full time
- I will be caring for a family member
- I will be taking a year off to travel or volunteer
- I will be taking a year off for other reasons

3B) IF YES, select the statement that best describes what you plan to be doing next fall:

- I will be in high school
- I will be studying at a technical school or community college
- I will be studying at a university or college BUT I plan to transfer to another school or university later
- I will be studying at a university or college AND I have no plans to change my school or university at this time

What will be your main subject(s) of study next year?

## Section II: YOUR CURRENT STUDIES

*This section is about your current and most recent math and science courses, what grades you have received, and why you are, or are not, currently taking a math course.*

4. Are you currently enrolled in a MATH course?

- NO
- YES

What was the LAST math course you took in high school? Please write the name of the course in the space below. If you were taking more than one course at the same time, write the name of course most important to you.

What grade did you receive in that course?

- A
- B
- C
- D
- F

If you ARE taking a math course this term, what course (or courses) are you taking? Please write the name (or names) of the courses in the space below.

5. By the end of high school, how many semesters of SCIENCE (where a semester is a Fall or Spring term) will you have completed?

*NOTE: Some students will have completed more than one science course per term. For example, if you took biology and chemistry during the same year, for both Fall, and Spring semesters, then please count two semesters for each course, for a total of four semesters for that year.*

- 0–2 semesters (up to one year of math)
- 3–4 semesters (more than one year and up to two years of math)
- 5–6 semesters (more than two years and up to three years of math)
- 7–8 semesters (more than three years and up to four years of math)
- More than 8 semesters (more than four regular school years of math)

6. Are you currently enrolled in a SCIENCE course?

- NO Please go to the next page and answer questions 7A and 8A on page 5
- YES Please skip the next page and answer questions 7B and 8B on page 6

**Complete this page if you ARE NOT currently taking a SCIENCE course**

If you are taking a science course this term, skip this page continue to question number 7B on the next page.

7A. If you ARE NOT taking a science course this term, what was the last SCIENCE course you took in high school?

What grade did you receive in that course?

- A       B       C       D       F

8A. How much do you agree or disagree with the following statements about why you ARE NOT taking a SCIENCE course this term?

	Strongly disagree	Disagree	Agree	Strongly agree
A. I didn't need it to graduate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. I was automatically placed in another class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. There wasn't room for a science course in my schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. A teacher or councillor advised me to not to take it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. A science course is not part of my study program this term	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. A family member recommended I don't take it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. The science course I wanted to take wasn't available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. I didn't think I could get a good grade in this course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. I am not interested in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. I wanted to take a class in another subject more than in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Actually, I am not sure why I'm not taking a course in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. No one else really influenced my decision; I chose not to take a course on my own	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. I don't need a course for what I am planning to do in the future	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. A friend advised me not to take it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. I don't remember choosing to not take a course this term	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please continue with question 9 on page 7

**Complete this page if you ARE currently taking a SCIENCE course**

If you are not taking a science course this term, skip this page and continue with question 9 on the next page.

7B. If you ARE TAKING a science course this term, what SCIENCE course (or courses) are you currently taking? Please write the name(s) of your course(s) in the space below:

In the last week, about how many hours did you spend doing SCIENCE homework or studying science outside of school?

- 0 hours       1–2 hours       3–4 hours       5–6 hours       more than 6

What was the LAST science course you took in high school? Please write the name of the course in the space below. If you were taking more than one course at the same time, write the name of course most important to you.

What grade did you receive in that course?

- A       B       C       D       F

8B. How well do the following statements describe why you are taking a SCIENCE course this term?

	Strongly disagree	Disagree	Agree	Strongly agree
A. I need it to graduate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. I was placed automatically in this class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. This course will help me get into a better school or program of study after high school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. A teacher or councillor advised me to take it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. The course is required for my study program	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. A family member recommended I take it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. The course I wanted to take wasn't available, so I had to take this one	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. I thought I could get a good grade in this course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. I am interested in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. I wanted to take a class in science more than in another subject	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Actually, I'm not sure why I am taking this course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. No one else really influenced my decision; I chose to take this course on my own	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. I need this course for what I am planning to do in the future	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. A friend advised me to take it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. I don't remember choosing to take this course	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please continue with question 9 on page 7

### Section III: ABOUT YOU AS A STUDENT

This section is about how you would describe yourself as a student, and as a student in mathematics and science in particular.

9. Thinking about yourself as a student in general, across ALL subjects, how much do you agree or disagree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. I learn things quickly in most school subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. I am good at most school subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. I do well in tests in most school subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. I make a real effort because I want to be one of the best	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. I learn most when I work with other students in my class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. I enjoy working with other students in groups	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. I always try to do better than other students	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. I get frustrated when I have to help other students	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. In uncertain times, I usually expect the best	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. If something can go wrong for me, it will	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. I'm optimistic about my future	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. I hardly ever expect things to go my way	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. I rarely count on good things happening to me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Overall, I expect more good things to happen to me than bad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. I get good grades in most school subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. It is hard for me to really put enough effort in school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Thinking about your MATH classes, how much do you agree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. I am just not good at math	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. I get good grades in math	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. In my math class, I understand even the most difficult work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. I have always believed math is one of my best subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. I can easily understand new ideas in math	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. I learn math topics quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. I do well on math tests	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### ABOUT YOU AS A STUDENT

11. Thinking about your SCIENCE classes, how much do you agree or disagree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. When studying, I work as hard as possible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. When studying, I keep working even if the material is difficult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. When studying, I try to do my best to acquire the knowledge and skills taught	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. When studying, I put forth my best effort	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. When I study and I don't understand something, I try to look for additional information to clarify this	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. It's hard for me to really put in enough effort in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. I complete my homework on time	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. I am certain I can understand the most difficult material presented in readings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. I am confident I can do an excellent job on assignments and tests	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. I am certain I can master the skills being taught	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. When I sit myself down to learn something really hard, I can learn it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. If I decide not to get any bad grades, I can really do it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. If I decide not to get any problems wrong, I can really do it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. If I want to learn something well, I can	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. I often know about science topics before we learn them in class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. I am further along in science than most students	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. Actually, I rarely ever study for my science classes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R. I often worry it will be difficult for me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S. I get very tense when I have to do the homework	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T. I get very nervous doing problems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U. I worry that I will get bad grades	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V. I am just not good at science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
W. I get good grades in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X. In my science class, I understand even the most difficult work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Y. I have always believed science is one of my best subjects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Z. I can easily understand new ideas in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ä. I learn science topics quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ö. I do well on science tests	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Section IV: EXTRACURRICULAR AND ENRICHMENT ACTIVITIES

This section is about the STEM related extracurricular or enrichment activities in which you may have participated, as well as other activities and work experience.

12. How often have you participated in the following activities?

	Never	Once or twice	Several times
A. Entered a research project (related to science, technology, engineering or mathematics) in a fair or competition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Participated in a math, science, engineering technology competition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Watched math or science videos from the Kahn Academy online	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Watched free math or science videos or podcasts of university lectures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Taken extra courses in science, technology, engineering or mathematics outside of high school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Visited a science research center (for example, at a university, power plant, hospital or company)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Tutored others in mathematics or science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Used online forums to discuss math or science problems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Conducted fieldwork or laboratory work for an independent or professional research study	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Learned a new programming language, such as Python or C++, or developed new computer programs outside of school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Received tutoring in math or science outside of class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Volunteered in a hospital or health care center	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Attended summer programs or camps for math or science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. Participated in science, technology, engineering or math clubs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. Have you participated in any of the following specific activities? Please check ALL activities in which you have participated.

- |  |   |
|--|---|
| <input type="checkbox"/> OMSI/ Portland Mathematics Circle         | <input type="checkbox"/> MathCounts competition                       |
| <input type="checkbox"/> Center for Talented Youth summer program  | <input type="checkbox"/> Oregon Invitational Mathematics Tournament   |
| <input type="checkbox"/> Robotics Competitions                     | <input type="checkbox"/> Mathematics Olympiad                         |
| <input type="checkbox"/> Science Bowl                              | <input type="checkbox"/> Science Olympiad                             |
| <input type="checkbox"/> Math at a community college or university | <input type="checkbox"/> Science at a community college or university |

## EXTRACURRICULAR AND ENRICHMENT ACTIVITIES

14. Have you participated in other science, technology, or engineering activities not listed on the previous page?

- YES  NO

If YES please list the activities here:

15. Do you participate in other clubs, competitions or activities (such as music, sports, or a youth group) not directly related to science or mathematics?

- YES  NO

If YES, how often did you participate in your main activity during the last year?

- One or twice  Every week  
 Several times  Almost every day

16. Have you had a job during the current or last school year?

- YES  NO

If YES, about how many hours do (or did) you work per week?

- up to 5 hours  more than 5 hours, up to 10 hours  
 more than 10 hours, up to 20 hours  more than 20 hours

## Section V: THE VALUE OF MATHEMATICS

This section is about what you think of the importance of mathematics and technology and engineering outside of school.

17. How much do you agree with the statements below for SCIENCE (including biology, chemistry, physics and geology)?

	Strongly disagree	Disagree	Agree	Strongly agree
A. Science research helps us to understand the world around us	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Scientific innovations can save lives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Discoveries in science can benefit businesses and the economy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Actually, outside of school, science is not useful to most people	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. People who study science get a lot of respect from others	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. It is easier to get into college if you plan to study science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Actually, it doesn't impress me if someone is studying science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. If someone is studying science, I would assume they are a good student	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

18. How much do you agree with the statements below for MEDICINE (including health sciences and medical research)?

	Strongly disagree	Disagree	Agree	Strongly agree
A. Medical research helps us to understand the world around us	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Medical innovations can save lives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Discoveries in medicine can benefit businesses and the economy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Actually, outside of school, medicine is not useful to most people	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. People who study medicine get a lot of respect from others	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. It is easier to get into college if you plan to study medicine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Actually, it doesn't impress me if someone is studying medicine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. If someone is studying medicine, I would assume they are a good student	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Section VI: BEING SUCCESSFUL

This section is about what you think people need to be successful in life in general, and in math in particular.

19. Thinking about success across all areas of life, how much do you agree or disagree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. Everyone has the chance to achieve higher status in society	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Sometimes individuals are just unable to get ahead in the world, no matter how hard they try	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Anyone who is willing to work hard has a good chance of succeeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Individual members of certain groups have difficulty achieving higher status in this country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. If people work hard enough, they can make a good life for themselves	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20. Thinking about SCIENCE, how much do you agree or disagree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. You have a certain amount of ability in science, and you can't really do much to change it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. Ability in science is something that can't be changed very much	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. To be honest, you can't really change how good you are at it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. No matter who you are, you can significantly improve your abilities in science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. No matter how much science ability you have, you can always change it quite a bit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. You have to have a special talent to do really well in a science class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. Actually, working hard isn't that important in science, some people are just good at it.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. If you really put time into studying science, you can improve your performance quite a bit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. The harder you work in science, the better you will be at it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. To tell the truth, when I have to work hard in science, it makes me feel like I'm not very smart	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. If you're not good at science, working hard won't make you good	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Everyone can do well in science if they work hard	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. Anyone who works hard could be one of the smartest in the class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Section VII: YOUR CLASSROOM EXPERIENCE

This section is about your experiences in your most recent math class.

21. Thinking about your current or most recent SCIENCE class, how much do you agree or disagree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. I feel left out of things	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. I feel awkward and out of place	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. I feel like I belong	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. I often don't want to go to class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. I feel comfortable asking my teachers to explain ideas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Most of my friends are in the same science course as I am	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. I have a lot in common with the other students in my science class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. My science classes have been easy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. I am often challenged during class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Actually, it isn't too hard to get a good grade	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Students are given problems or projects that take several days to complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. I often feel bored	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. I have had to push myself to keep up with the work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. The teacher shows an interest in every students' learning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. The teacher gives students an opportunity to express opinions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. The teacher gives extra help when students need it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. The teacher has to wait a long time for students to quiet down	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
R. We are asked to do investigations or experiments to test out own ideas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
S. The teacher tries hard to make the material interesting for us	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T. The teacher often gets irritated or frustrated with our class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U. Our teacher encourages creativity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V. It isn't clear what we need to do to succeed in this class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
W. Students in my science class work harder than most students at this school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X. The teacher has high expectations for our class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Y. Students ask more questions than in other classes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Z. My classmates inspire me to work harder	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ä The best students in my school are in my science class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ö Students are very competitive in my science class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Å We help each other in class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ø We share ideas in class	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Section VIII: BEFORE HIGH SCHOOL

**This is the second to last section!** This section is about experiences in math and science you may have had BEFORE high school, and about your transition from middle school to high school math and science courses.

22. In elementary school or middle school/junior high, did you experience any of the following?

A. Did your teacher give you extra problems or activities in math?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
B. Did your teacher recommend that you take part in a science competition or science club?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
C. In math class, where you ever asked to help other students?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
D. Did you work ahead of other students in your class in mathematics?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
E. Where you ever in a Gifted or Talented program?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
F. Did a teacher recommend for you to take advanced math or science in high school?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
G. Did you attend a class or school with a special emphasis on <b>science</b> ? (For example, where you studied science for more hours than an average class)	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
H. Did you attend a class or school with a special emphasis on <b>math</b> ? (For example, where you studied math for more hours than a normal class)	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
I. Did your teacher recommend that you take part in a math competition or math club?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>
J. Did your teacher give you extra problems or activities in science?	<input type="checkbox"/>	<b>NO</b>	<input type="checkbox"/>	<b>YES</b>

23. For many students, the transition from middle school science courses to high school courses can be challenging. Thinking back to your own experience moving from middle school to high school, how much do you agree or disagree with the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
A. Science is easier for me in high school than in was in middle school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. When I came to high school, other students seemed to know more about science than I did	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. I didn't feel I was prepared for high school science classes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. I started high school wanting to take more science classes, but changed my mind after I found out what the classes were like.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. I am more interested in science now than I was before high school	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Section IX: YOUR BACKGROUND AND HOPES FOR THE FUTURE

**This is the last section of the questionnaire. Questions A and B are about you and your background. Your answers, like the rest of this survey, will be completely confidential. They will not be used to identify you or your school. Your answers will help compare your experience with students in other countries. The last questions, C and D on the next page, are about your hopes for the future.**

**A. This question is about your parents' or guardians' work, education, and involvement in STEM fields. Please check the corresponding box on the right if any of the statements on the left applies to your parents or guardians.**

	Mother/ Guardian 1	Father/ Guardian 2
Graduated from high school	<input type="checkbox"/>	<input type="checkbox"/>
Graduated from a vocational school	<input type="checkbox"/>	<input type="checkbox"/>
Attended some college or university	<input type="checkbox"/>	<input type="checkbox"/>
Graduated from a community college (AA or AS degree or equivalent)	<input type="checkbox"/>	<input type="checkbox"/>
Graduated from college (BA or BS or equivalent)	<input type="checkbox"/>	<input type="checkbox"/>
Has a master's degree (MA, MS, MEng or equivalent)	<input type="checkbox"/>	<input type="checkbox"/>
Has a doctorate (PhD or equivalent)	<input type="checkbox"/>	<input type="checkbox"/>
Has a doctorate of medicine or other healthcare related field (for example, MD, DDS, PharmD, DO)	<input type="checkbox"/>	<input type="checkbox"/>
Has an advanced business or law degree (for example, MBA or JD)	<input type="checkbox"/>	<input type="checkbox"/>
Works as medical or health professional (for example, a nurse or paramedic)	<input type="checkbox"/>	<input type="checkbox"/>
Owns his or her own business	<input type="checkbox"/>	<input type="checkbox"/>
Works for herself or himself (self-employed)	<input type="checkbox"/>	<input type="checkbox"/>
Is interested in science, technology, engineering or mathematics	<input type="checkbox"/>	<input type="checkbox"/>
Works with science, technology, engineering or mathematics	<input type="checkbox"/>	<input type="checkbox"/>
Studied science, technology, engineering or mathematics	<input type="checkbox"/>	<input type="checkbox"/>
Encourages me to study science and mathematics	<input type="checkbox"/>	<input type="checkbox"/>

**B. This is the last question about your background. This information will be used to help compare your experience to students in school systems in other countries.**

- What is your gender?  Female  Male
- What is your nationality?  United States  Any other country
- Where you born outside the US?  Yes  No
- How do you describe your ethnicity or background? **Please check all that apply.**
- African American/ Black  American Indian/ Alaska Native  Arab American/ Middle Eastern
- Hawaiian Native/ Pacific Islander  Latino/ Hispanic  White

## H: YOUR BACKGROUND AND HOPES FOR THE FUTURE

**C. In an ideal situation, how much education would you WANT after high school?**

- No further; high school graduate
- Technical or vocational school
- Associates degree (For example, AA degree)
- College graduate (For example, BA, BS or other 4 year degree)
- Post-graduate degree, training, or professional school (For example, MBA, MA, PhD, JD, MD)
- Don't know

**D. If you could study any subject you wanted (vocational or academic), what would that subject be?**

**THANK YOU!**



# Appendix C

## Example Consent forms

This appendix includes example participant consent forms, and parent and guardian permission forms.

**Student persistence in STEM fields:**  
School structures and student choices in Finland, Sweden and the United States

**About the Interviews**

Dear Participant,

You are invited to be interviewed as part of a study investigating how different educational structures impact students' persistence in science, technology, engineering and mathematics (STEM) related fields. This research takes place in Finland, Sweden and the United States, and is part of my work as a PhD student at the University of Cambridge.

In this interview you will be asked to reflect on your experiences and choices within the educational system, particularly with regards to mathematics and science education. Your participation is an important contribution to increasing understanding of how different educational policies influence students' choices.

The interview will occur at your school, and will take up to 45 minutes. Interviews normally take place during regular school hours, but can also be scheduled immediately before and after school if that works best for you and your school. The interview will be audio recorded and transcribed. All audio recordings will be destroyed by 31 December 2012.

Your interview will be treated as strictly confidential. Your name, and that of your school and your city, will be withheld in any research reporting, and aliases will be used. Your participation in this study is completely voluntary. You can withdraw your participation from this study at any time, without needing to give a reason.

The following sheet is a consent form, which must be signed prior to participation in the interview. If you have any questions or concerns at any point in the interview or research process, please do not hesitate to let me know. Again, even after signing the consent form, you are free to withdraw your participation at anytime without question.

Thank you very much for your contribution and your time!

Sincerely,

Jennifer von Reis Saari  
Faculty of Education, University of Cambridge, 184 Hills Road  
Cambridge, CB2 8PQ, United Kingdom  
US: 1 (xxx) xxx xxxx  
FIN/SWE: +358 (0)xx xxx xxxx  
xxxxx@cam.ac.uk

**Student persistence in STEM fields:**  
School structures and student choices in Finland, Sweden and the United States

## Consent Form

Interviews will be treated as confidential. Your participation in this project is greatly appreciated. To ensure your informed consent to participate, please answer each statement concerning the collection and use of the research data.

- |  |     |    |
|--|-----|----|
| I have been given the opportunity to ask questions about the study.                                | Yes | No |
| If I have had questions, my questions were answered satisfactorily.                                | Yes | No |
| I understand that I can withdraw from the study at any time without having to give an explanation. | Yes | No |
| I agree to the interview being audiorecorded and to its contents being used for research purposes. | Yes | No |

## Participation Consent

By signing this form, I give my consent to be interviewed as part of the research project 'Student persistence in STEM fields'. My participation is voluntary and I am aware I can withdraw my participation at any time.

**Name (printed):** \_\_\_\_\_

**Signature:** \_\_\_\_\_ **Date:** \_\_\_\_\_

If you have any questions or concerns, please contact:

Jennifer von Reis Saari  
Faculty of Education, University of Cambridge, 184 Hills Road  
Cambridge, CB2 8PQ, United Kingdom  
US: 1 (xxx) xxx xxxx  
FIN/SWE: +358 (0)xx xxx xxxx  
xxxxx@cam.ac.uk



## **Student persistence in STEM fields:** School structures and student choices in Finland, Sweden and the United States

### **About the Interviews**

Dear Parent or Guardian,

Your student has been invited to be interviewed as part of a study investigating how different educational structures impact students' persistence in science, technology, engineering and mathematics (STEM) related fields. This research takes place in Finland, Sweden and the United States, and is part of my work as a PhD student at the University of Cambridge.

In this interview your student will be asked to reflect on his or her experiences and choices within the educational system, particularly with regards to mathematics and science education. Your students' participation is an important contribution to increasing understanding of how different educational structures influence students' choices.

The interview will occur at your student's school and take up to 45 minutes. Interviews take place during school hours (or in some cases immediately before or after school) at the time best for you, your student and your student's school.

Your child's interview will be treated as strictly confidential. The interview will be audio recorded and transcribed. All audio recordings will be securely destroyed by 31 December 2012 at the latest. Students' names, and that of their schools and cities will be withheld in any research reporting, and aliases will be used.

Participation in this study is completely voluntary. You, or your student, can withdraw participation from this study at any time, without needing to give a reason. You are very welcome to contact me, the interviewer (Jennifer Saari) regarding any questions or concerns you may have about the interviews.

The following sheet is a parent and guardian permission form, which must be signed and returned prior to your student's participation in the interview. Again, even after signing the permission form, you are free to withdraw your students' participation at any time. If you have any questions or concerns at any point, please do not hesitate to let me know.

Thank you very much for your consideration and your time!

Sincerely,

Jennifer von Reis Saari  
Faculty of Education, University of Cambridge, 184 Hills Road  
Cambridge, CB2 8PQ, United Kingdom  
US: 1 (xxx) xxx xxxx  
FIN/SWE: +358 (0)xx xxx xxxx  
xxxx@cam.ac.uk

**Student persistence in STEM fields:**  
School structures and student choices in Finland, Sweden and the United States

**Parent/Guardian Permission form**

Interviews will be treated as confidential. Your student's participation in this project is greatly appreciated. You may withdraw your child from this study at any time, without explanation. If you have any questions regarding your student's participation in this study please do not hesitate to contact:

Jennifer von Reis Saari  
Faculty of Education, University of Cambridge  
184 Hills Road  
Cambridge, CB2 8PQ, United Kingdom  
US: 1 (xxx) xxx xxxx  
FIN/SWE: +358 xx xxx xxxx  
xxxxx@cam.ac.uk

**Permission to Participate**

By signing this form, I give my permission for

**Student's name (printed):** \_\_\_\_\_

to be interviewed as part of the research project 'Student persistence in STEM fields'. Participation is voluntary and I am aware I can withdraw my student's participation at any time. Please have your student return this form by **2011**.

**Parent or Guardian Name (printed):** \_\_\_\_\_

**Signature:** \_\_\_\_\_ **Date:** \_\_\_\_\_



**Student persistence in STEM fields:**

School structures and student choices in Finland, Sweden, and the United States

**Survey Participation Form for Parents and Guardians**

Your student's class has been chosen to participate in the survey 'Student Persistence in STEM Fields', a study investigating how different educational structures impact students' decisions to study science, technology, engineering, or mathematics (STEM) fields. This survey takes place in Finland, Sweden, and the United States and will be administered by Jennifer Saari, a PhD candidate at the Faculty of Education, University of Cambridge.

The survey will ask questions about students' future educational plans, current enrollment, attitudes towards science and mathematics education, involvement in extracurricular activities, experiences in the classroom, and brief demographic background information. The questionnaire is anonymous and will not be linked with students' names or school records. Schools and locations will be kept strictly confidential.

Students will be asked to fill out a paper questionnaire that takes about 20 minutes to complete. The survey will take place during regular class time.

Participation is voluntary and you, or your student may refuse or withdraw participation from this study at any time, without explanation. If you have any questions regarding your student's participation in this study please do not hesitate to contact:

Jennifer von Reis Saari  
Faculty of Education, University of Cambridge, 184 Hills Road  
Cambridge, CB2 8PQ, United Kingdom  
US: 1-xxx-xxx-xxxx FIN/SWE: +358 xx xxx xxxx xxxxx@cam.ac.uk

**If you do not want your student to take part in the survey check the box, sign, date and return this form to your student's teacher before XX November 2011.** Signing and dating this form will mean your student will be omitted from the survey and will work on another task during the duration of the survey. If you do not have any objections to your student taking part in the survey, you do not need to sign this form.

Student's name (printed): \_\_\_\_\_

My child **may not** take part in the survey 'Student Persistence in STEM Fields'

Name (printed): \_\_\_\_\_

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

# Appendix D

## Logistic regressions

In addition to the structural equation models presented in Chapter 4, I also conducted logistic regression using a different indicator for persistence in STEM fields. The purpose of this primarily to explore the connection between this variable, which was a binary variable that I constructed by coding students' answers to an open question regarding what career or study they would like to pursue after secondary school. The logistic regression was a way of checking if that binary measure coincided with the persistence variable that was created from the Likert scales as described in Chapter 2. In particular, the regressions concerned the following questions:

- Would similar effects hold for this alternate, binary outcome variable?
- What would the connection be between the two variables?

Since this alternate variable was binary, analysing it implied the use of logistic regression. Furthermore, while structural equation modelling packages usually deal with missing data automatically, this further analysis entailed making decisions about how to deal with the missing data in my survey directly. For the analysis here, I did a multiple imputation of the raw survey data using a program in R called Amelia II Honaker et al. (2009) , creating five new data sets, described below.

### D.1 Multiple imputation

Multiple imputation involves adding estimated values to the data set, for example, in this case I used five imputations, which means I created 5 data sets where the observed values were the same in each imputed data set, but which contained 5 different estimates

of the missing. The differences in the imputed values reflect the degree of uncertainty of the estimate (King et al., 2001, p. 53). To use this method correctly, one must run the analysis on *each* of these sets, and then combine the results to provide estimates that reflect the uncertainty of this procedure. The benefit is that it allows for the retention of partial responses. Comparisons strongly suggest the benefit of this form of estimation over methods such as list wise deletion or imputing the mean of the given variable.

The particular method I used involves an advance on the traditional expectation-maximisation algorithm, known as the EM Algorithm (Dempster et al., 1977). It uses the idea of posterior probabilities, and thus takes what some might term a partially Bayesian procedure, that is, the shape of prior distributions is considered.

While the idea of imputing new values into a data set might make some uncomfortable, multiple imputation is an improvement over more primitive imputation techniques, such as entering the variable mean, and which, among other things, underestimate the uncertainty of the resulting models (Gelman and Hill, 2007, p. 532–533).

Similarly, discarding incomplete responses leads to removal of valuable data (Hox, 2010, p. 106–107). Such methods assume that the data is missing completely at random (MCAR) (Little and Rubin, 2002), that is, that there is no pattern to missingness, and that removal of the individual cases would not bias the model estimates, which is rarely the case in survey data, and was not the case with my data set here.

Furthermore, simulations and comparisons have repeatedly shown that multiple imputation is an improvement over other estimation methods (See, e.g., Van Ginkel, 2010, for a recent example with low-quality questionnaire data).

Given the complexity of my questionnaire relative to my sample size (about 350 observations for a total sample size  $n=673$ ), I first needed to make a subset of the data. I removed items I am not using in the analysis at this time, but retained all items, including those without missing data, which would be used to improve the imputation model (King et al., 2001, p. 57). Furthermore, I did the imputation at an item-level, rather than with sum scores. This was done because recent work by Gottschall et al. (2012) suggests that while the parameter estimates of imputing scales versus items are comparable, the error is greatly increased.

To do the multiple implementation, I made use of a program in R called Amelia II, which uses a bootstrap-based Expectation-Maximisation procedure. The method, and its recent improvements that allow for the imputation of more variables are described in detail by Honaker and King (2010). For the analyses here, I chose to use five imputed data

sets, which is considered an acceptable lower bound for producing meaningful estimates Gelman and Hill (2007); King et al. (2001).

After the imputation ran successfully and reported normal convergence, I went through diagnostics to make sure there was convergence. This is, I ran some diagnostics to take a look whether the estimates were similar, and fit with the observed distributions, which I did visually. I used diverse starting points on the etiolation algorithm to check for convergence.

Since these diagnostics suggested a successful imputation, I went ahead and used the five imputed data sets for the generalised linear models discussed here. One dire mistake that researchers can make is to use a single imputed data set for estimation, thus failing to take into account the uncertainty captured by multiple imputations. I ran each of the analyses separately on each imputed data set, and then combined the estimates according to widely accepted formula developed in Rubin (1987) , as presented by Gelman and Hill (2007, p. 542). This formula is:

Given  $M$  multiply imputed data sets, then the estimated parameter (i.e., regression coefficient)  $\hat{\beta}$  is:

$$\hat{\beta} = \frac{1}{m} \sum_{m=1}^M \hat{\beta}_m$$

Here each  $\hat{\beta}_m$  represents the estimated coefficient of the model for the  $m$ th imputed data frame. A variance estimate is obtained by the following formula:

$$V_{\beta} = W + (1 + \frac{1}{m})B,$$

where

$$W = \frac{1}{m} \sum_{m=1}^M s_m^2,$$

where  $s_m$  is the estimated standard error for each  $\hat{\beta}_m$  in each imputed data set and

$$B = \frac{1}{m-1} \sum_{m=1}^M M(\hat{\beta}_m - \hat{\beta})^2.$$

That is,  $W$  is the sum of the errors squared divided by the number of imputations, and  $B$  is the sum of the difference between each estimated coefficient and the average coefficient squared, divided by the number of imputations minus one, a familiar distance function. Significance tests are then calculated in the normal way. I programmed this in R, and these calculations are the basis of the estimates discussed here.

## D.2 Regression on the persistence variables: relating the two measures

In order to shed light on the relationship between the two measures of intentions to persist in my survey, I created a simple logistic model, regressing the binary outcome of my coding of the open responses (1= intending to persist; 0= all other responses). Overall, about a third of the students reported plans to pursue further STEM education, see Figure D.1 for the proportions by country. In Sweden, the proportion approached nearly half, and this was probably due the science emphasis of the participating schools, as well as the smaller sample size.

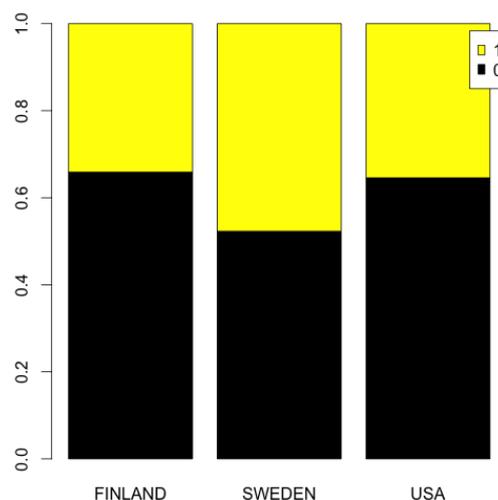


Figure D.1: Proportion of plans to continue in STEM by open response question; 1 = intending to persist (in yellow), 0 = all other answers (in black).

For each country, I regressed this binary outcome against the rescaled (i.e., mean centred z-scores of the) subject specific responses on a simple multilevel logistic model. I indicate

t- values (e.g., Dalgaard, 2002, p. 82) and the effects that were significant, although in this case, the null-hypothesis, that the regression coefficient would be zero is not particularly meaningful.

In the US sample, there was a strong relationship between the subject specific measures and the open coding, which is a good sign in terms of the validity. Furthermore, there was a particularly strong connection between health sciences, biology, and engineering and students' plans. This suggests that these are the areas with STEM fields of the most interest (in terms of concrete planning) to the students. It also suggests that students are more aware of the possibilities these fields provide. This is likely due, in part, to the focus on health science in part of the school curriculums at two of the three schools; students at those schools have had more choices in terms of biology and health related courses, as well as more opportunities to learn about work in those fields.

The interesting revelation is how linked students ambitions are to careers that are being promoted to them (health and engineering in particular). It goes against the notion, a bit, that students are *unaware* of these sorts of opportunities. It also highlights that not all STEM careers are really of interest to all stakeholders.

**Table D.1: Logistic regression on STEM subjects, United States**

Subject	Coeff $\hat{\beta}$	$SE = \sqrt{V_{\hat{\beta}}}$	t value	sig
(Intercept)	-0.81	0.15	-5.4	***
Health and medicine	1.52	0.37	4.1	***
Mathematics	0.68	0.36	1.9	*
Computer science	0.18	0.36	0.5	
Chemistry	0.05	0.38	0.1	
Biology	0.95	0.40	2.4	**
Agricultural science	-0.48	0.32	-1.5	
Engineering	0.94	0.38	2.5	**
Earth sciences	-0.13	0.33	-0.4	
Statistics	-0.22	0.34	-0.7	
Statistical significance codes: 0 *** 0.001 ** 0.01 * 0.05 .				

**Table D.2: Logistic regression on STEM subjects, Finland**

Subject	Coeff $\hat{\beta}$	$SE = \sqrt{V_{\hat{\beta}}}$	t value	sig
(Intercept)	-0.80	0.16	-5.2	***
Health and Medicine	0.98	0.41	2.4	**
Mathematics	0.33	0.42	0.8	
Computer science	0.24	0.39	0.6	
Chemistry	0.72	0.39	1.8	
Biology	0.97	0.48	2.0	*
Agricultural science	-0.56	0.35	-1.6	
Engineering	0.83	0.42	2.0	*
Earth science	-0.52	0.39	-1.3	
Statistical science	0.02	0.38	0.04	
Statistical significance codes: 0 *** 0.001 ** 0.01 * 0.05				

**Table D.3: Logistic regression on STEM subjects, Sweden**

Subject	Coeff $\hat{\beta}$	$SE = \sqrt{V_{\hat{\beta}}}$	t value	sig
(Intercept)	-0.11	0.19	-0.6	
Health and medicine	-0.05	0.47	-0.1	
Mathematics	-0.24	0.50	-0.47	
Computer science	-0.37	0.46	-0.8	
Chemistry	-0.51	0.44	-1.2	
Biology	1.5	0.60	2.6	**
Agricultural science	-0.38	0.46	-0.8	
Engineering	0.98	0.47	2.1	*
Earth science	-0.46	0.49	-0.9	
Statistical science	0.48	0.45	1.1	
Statistical significance codes: 0 *** 0.001 ** 0.01 * 0.05				

### D.3 Logistic models of persistence by country

This section displays regression models of persistence by country, using binary-coded open response as the dependent variable. This variable was regressed on key independent variables from the models in Chapter 4. The models are both presented visually to give an easier interpretation, as advised by, e.g., Gelman and Hill (2007), and in tables. These models provide a reference and counterpoint to the more complicated models displayed in Chapter 4 and Appendix E.

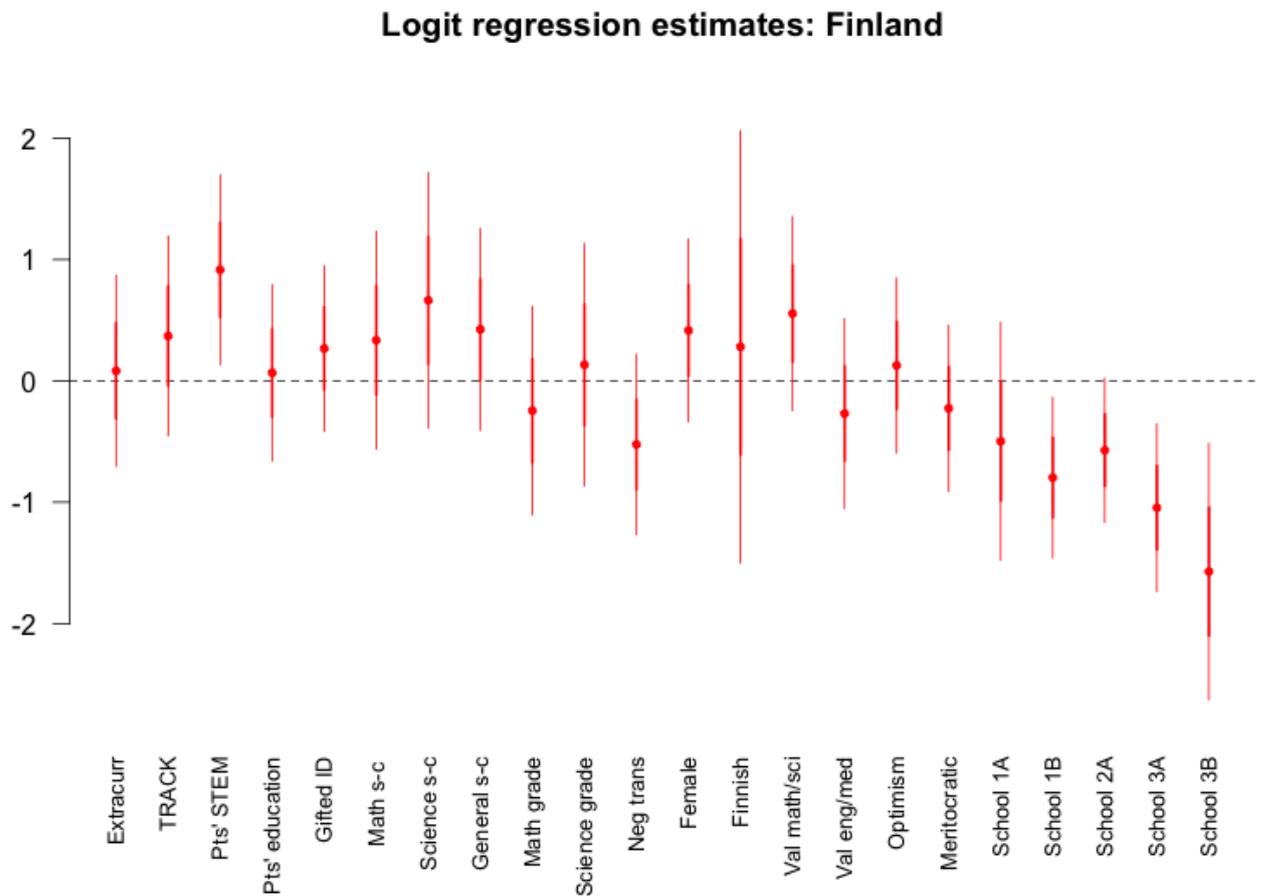


Figure D.2: Finland: logistic model of persistence using a binary coding of an open response question.

**Table D.4: Logistic model of persistence, Finland**

Subject	Coeff $\hat{\beta}$	$SE = \sqrt{V_{\hat{\beta}}}$	t value	sig
Extracurriculars	0.08	0.39	0.2	
Track	0.37	0.41	0.9	
Parents' STEM capital	0.92	0.39	2.3	*
Parents' education	0.07	0.36	0.2	
Gifted ID	0.27	0.34	0.8	
Math self-concept	0.34	0.45	0.8	
Science self-concept	0.66	0.53	1.3	
General self-concept	0.42	0.42	1.0	
Math grade	-0.25	0.43	-0.6	
Science grade	0.13	0.50	0.3	
Negative transition	-0.52	0.37	-1.4	
Female	0.42	0.38	1.1	
Finnish	0.28	0.89	0.3	
Value math/sci	0.56	0.40	1.4	
Value eng/med	-0.27	0.39	-0.7	
Optimism	0.13	0.36	0.6	
Meritocratic	-0.23	0.34	-0.7	
(SCHOOL)FI1A	-0.50	0.49	-1.0	
(SCHOOL)FI1B	-0.80	0.33	-2.4	*
(SCHOOL)FI2A	-0.57	0.30	-1.9	*
(SCHOOL)FI3A	-1.05	0.35	-3.0	**
(SCHOOL)FI3B	-1.57	0.53	-3.0	**
Statistical significance codes: 0 *** 0.001 ** 0.01 * 0.05				

### Logit regression estimates: SWEDEN

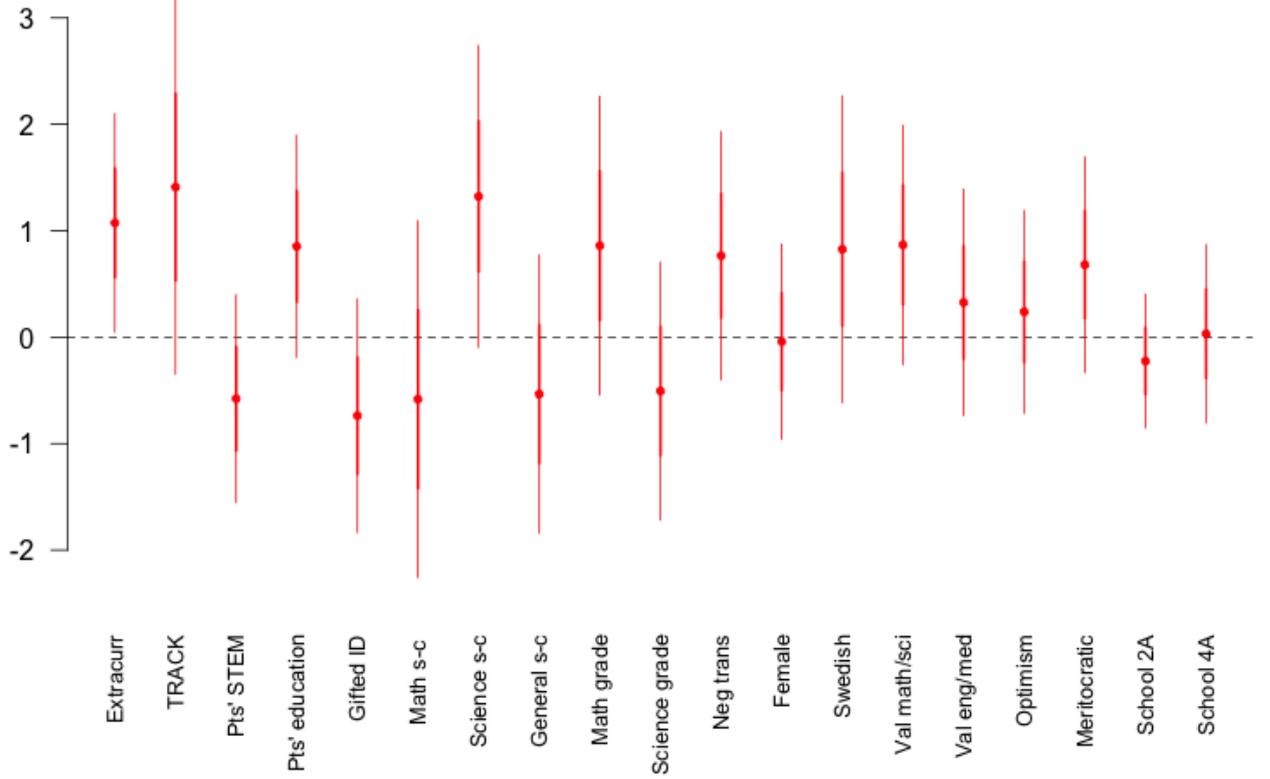


Figure D.3: Sweden: logistic model of persistence using a binary coding of an open response question.

**Table D.5: Logistic model of persistence, Sweden**

Subject	Coeff $\hat{\beta}$	$SE = \sqrt{V_{\hat{\beta}}}$	$t$ value	sig
Extracurriculars	1.07	0.51	2.1	*
Track	1.41	0.88	1.6	
Parents' STEM capital	-0.58	0.49	-1.2	
Parents' education	0.85	0.52	1.6	
Gifted ID	-0.74	0.55	-1.3	
Math self-concept	-0.58	0.84	-0.7	
Science self-concept	1.32	0.71	1.9	
General self-concept	-0.54	0.65	-0.8	
Math grade	0.86	0.70	1.2	
Science grade	-0.51	0.61	-0.8	
Negative transition	0.77	0.58	1.3	
Female	-0.04	0.46	-0.1	
Swedish	0.83	0.72	1.2	
Value math/sci	0.87	0.56	1.5	
Value eng/med	0.33	0.53	0.6	
Optimism	0.24	0.48	0.5	
Meritocratic	0.68	0.51	1.3	
(SCHOOL)SW2A	-0.23	0.31	-0.7	
(SCHOOL)SW4A	0.03	0.42	0.1	
Statistical significance codes: 0 *** 0.001 ** 0.01 * 0.05				

### Logit regression estimates: United States

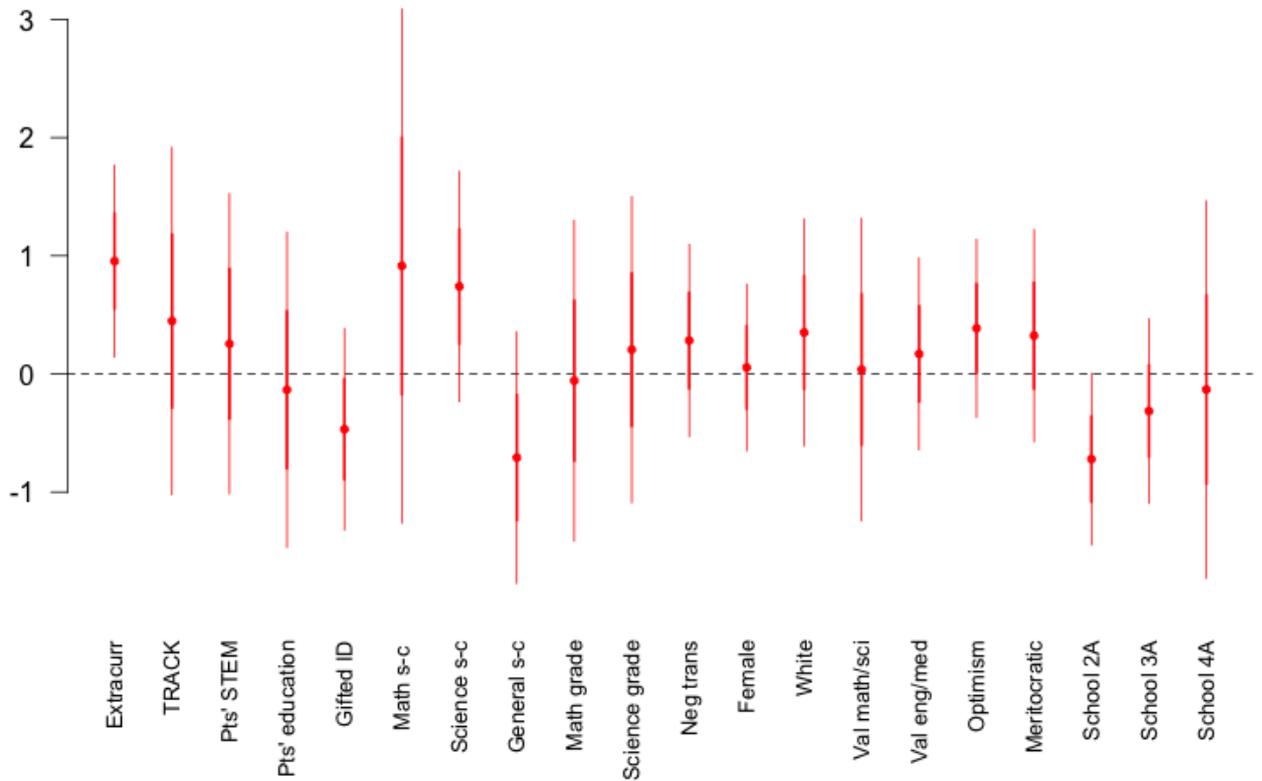


Figure D.4: United States: logistic model of persistence using a binary coding of an open response question.

**Table D.6: Logistic model of persistence, United States**

Subject	Coeff $\hat{\beta}$	$SE = \sqrt{V_{\hat{\beta}}}$	$t$ value	sig
Extracurriculars	0.96	0.37	2.6	**
Track	0.21	0.35	0.6	
Parents' STEM capital	0.52	0.41	1.3	
Parents' education	-0.41	0.36	-1.1	
Gifted ID	-0.431	0.40	-1.1	
Math self-concept	1.3	0.42	3.1	**
Science self-concept	0.68	0.37	1.8	
General self-concept	-0.82	0.42	-2.0	*
Math grade	-0.27	0.35	-0.8	
Science grade	0.405	0.38	1.08	
Negative transition	0.22	0.32	0.7	
Female	0.04	0.32	0.1	
White	0.32	0.37	0.9	
Value math/sci	-0.20	0.40	-0.5	
Value eng/med	0.16	0.37	0.4	
Optimism	0.48	0.33	1.5	
Meritocratic	0.18	0.33	0.6	
(SCHOOL)US2A	-0.84	0.17	-4.9	***
(SCHOOL)US3A	-0.42	0.30	-1.4	
(SCHOOL)US4A	-0.39	0.41	-0.9	
Statistical significance codes: 0 *** 0.001 ** 0.01 * 0.05				

## D.4 Summary

### Drawbacks and directions for future analysis

The data should be further coded as planning to not continue in STEM, not sure and no plans, and planning to persist, a three rather than two categorical variable. This might be best modelled by fitting three different logistic regressions, since the outcomes are not truly ordered (Gelman and Hill, 2007, p. 124): one with the outcome as modelled in this chapter, one modelling the ‘unsure/undecided’ response, and a third modelling the responses coded as planning not to continue in STEM fields.

### Key themes in this model

1. STEM fields are not a uniform area that is of interest to everyone; in that way the policy dialogue surrounding them is simplistic.
2. These models suggest that students are aware of the vocational aspects of studying STEM fields, an attuned to the fields which look most promising for future job prospects.
3. The logistic regression supports the use of the composite persistence variable and corresponding models regarding general patterns across STEM fields.



# Appendix E

## Tables relating to the structural equation models

This appendix contains the tables of factor loadings, regressions, and  $R^2$  estimates for the models presented in Chapter 4. Each of the models is domain specific for either science or mathematics, so that adaptive habitus latent variables are using indicators (self-concept, diligence, assurance, value and so on) that are specified to either science or mathematics. See Chapter 3 for more details. The persistence variable is a measure of intentions to persist across all STEM fields after upper-secondary education. More information on the persistence variable can be found in Chapters 2, 3, and 4, as well as Appendix D.

**Table E.1: Finland, mathematics: latent variable loadings**

<i>LATENT VARIABLE</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Adaptive indicated by:</i>					
Math self-concept	1.000				0.751
Assurance	1.012	0.128	7.904	0.000	0.761
Extreme self-concept	0.725	0.135	5.364	0.000	0.544
Misfit (rev)	0.523	0.165	3.166	0.002	0.392
Anxiety (rev)	0.700	0.128	5.471	0.000	0.526
Value Subject	0.414	0.141	2.930	0.003	0.311
Mindset (effort/change)	0.498	0.139	3.580	0.000	0.374

**Table E.2: Finland, mathematics: coefficient estimates using robust standard errors**

<i>REGRESSIONS</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Persistence by:</i>					
Extracurricular	0.407	0.079	5.124	0.000	0.405
FI1B	0.202	0.064	3.145	0.002	0.202
<i>Adaptive by:</i>					
Negative transition	- 0.263	0.061	-4.320	0.000	- 0.349
Gifted identification	0.091	0.053	1.731	0.083	0.122
Female	- 0.204	0.055	- 3.720	0.000	- 0.274
Family STEM capital	0.156	0.058	2.672	0.008	0.209
Mathematics grade	0.289	0.075	3.878	0.000	0.384
<i>Extracurricular involvement by:</i>					
Family STEM capital	0.164	0.076	2.149	0.032	0.165
Gifted identification	0.143	0.073	1.968	0.049	0.144
High Track	0.342	0.085	4.030	0.000	0.342
FI3A	0.085	0.069	1.240	0.215	0.085
FI3B	0.124	0.077	1.606	0.108	0.124
FI2A	- 0.141	0.085	-1.649	0.099	- 0.141
<i>Gifted identification by:</i>					
Family STEM capital	0.094	0.079	1.195	0.232	0.094
High Track	0.256	0.087	2.927	0.003	0.255
<i>Family STEM capital by:</i>					
High Track	0.230	0.096	2.403	0.016	0.230
FI1B	0.112	0.088	1.273	0.203	0.112
<i>Mathematics grade by:</i>					
Negative transition	- 0.337	0.094	- 3.599	0.000	- 0.337

**Table E.3: Finland, mathematics: coefficient estimates continued (covariances)**

<i>COVARIANCES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
Extreme self-confidence with Mindset (effort/change)	-0.228	0.067	-3.380	0.001	-0.296
Misfit with Anxiety (rev)	0.175	0.070	2.499	0.012	0.225

**Table E.4: Finland, mathematics: R-square estimates of key variables**

<i>R-SQUARE</i>	
Variable	$R^2$
Persistence	0.242
Extracurricular involvement	0.265
Gifted identification	0.088
Adaptive	0.547

**Table E.5: Finland, science: latent variable factor loadings**

<i>LATENT VARIABLE</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Standardised Estimate $B$
<i>Adaptive habitus indicated by</i>					
Science self-concept	1.000			0.000	0.808
Assurance	0.779	0.177	4.397	0.000	0.663
Mindset (effort/change)	0.421	0.124	3.390	0.001	0.352
Extreme self-concept	0.719	0.125	5.734	0.000	0.610
Misfit (rev)	0.658	0.141	4.673	0.000	0.558
Diligence	0.502	0.167	3.006	0.003	0.424
Value science	0.563	0.192	2.939	0.003	0.476

**Table E.6: Finland, science: coefficient estimates using robust standard errors.**

<i>REGRESSIONS</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Persistence by:</i>					
Adaptive	0.345	0.172	2.013	0.044	0.287
Extracurricular	0.218	0.119	1.837	0.066	0.216
Eth. Majority	0.205	0.063	3.278	0.001	0.202
Gifted identification	-0.122	0.138	-0.885	0.376	-0.120
Family STEM capital	0.192	0.089	2.164	0.030	0.188
<i>Adaptive habitus by:</i>					
Gifted identification	0.189	0.102	1.852	0.064	0.224
Female	-0.397	0.084	-4.722	0.000	-0.471
Teacher	0.210	0.100	2.097	0.036	0.249
Family STEM capital	0.090	0.086	1.052	0.293	0.107
Parents' Education	0.165	0.081	2.040	0.041	0.196
High Track	0.192	0.101	1.897	0.058	0.227
Science grade	0.264	0.076	3.486	0.000	0.317
<i>Extracurricular involvement by:</i>					
Adaptive	0.433	0.120	3.605	0.000	0.363
Family STEM capital	0.088	0.081	1.084	0.278	0.087
High Track	0.387	0.098	3.955	0.000	0.386
Science grade	-0.286	0.084	-3.421	0.001	-0.288
Parents' Education	0.170	0.089	1.904	0.057	0.169
<i>Science grade by:</i>					
High Track	0.338	0.116	2.904	0.004	0.334
Female	0.261	0.119	2.196	0.028	0.258
<i>Gifted identification by:</i>					
Family STEM capital	0.205	0.099	2.066	0.039	0.204
High Track	0.461	0.096	4.800	0.000	0.461
<i>Family STEM capital by:</i>					
High Track	0.301	0.108	2.780	0.005	0.302

**Table E.7: Finland, science: coefficient table continued (covariances).**

<i>COVARIANCES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
Mindset (effort/change) with Extreme self-concept	- 0.234	0.090	-2.607	0.009	-0.319
Assurance with with Mindset (effort/change)	0.188	0.112	1.679	0.093	0.271

**Table E.8: Finland, science: R-square estimates of key variables**

<i>R-SQUARE</i>	
Variable	$R^2$
Persistence	0.293
Extracurricular involvement	0.483
Gifted identification	0.311
Adaptive	0.676

**Table E.9: Sweden, mathematics: latent variable factor loadings**

<i>LATENT VARIABLE</i>					
Variable	Estimate	Std.err	Z-value	$P(>  z )$	Std.all
<i>Adaptive habitus, indicated by</i>					
Math self-concept	1.000				0.847
Assurance	0.941	0.153	6.156	0.000	0.800
Extreme self-concept	0.697	0.176	3.963	0.000	0.581
Misfit (rev)	0.788	0.128	6.147	0.000	0.670
Diligence	0.507	0.156	3.239	0.001	0.425
Value mathematics	0.568	0.140	4.055	0.000	0.477
Value professional	0.482	0.134	3.601	0.000	0.404
Anxiety (rev)	0.637	0.140	4.546	0.000	0.535

**Table E.10: Sweden, mathematics: coefficient estimates using robust standard errors**

<i>REGRESSIONS</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Persistence by</i>					
Adaptive	0.420	0.173	2.433	0.015	0.352
Family STEM capital	0.164	0.115	1.423	0.155	0.166
Extracurricular involvement	0.143	0.150	0.952	0.341	0.147
High Track	0.145	0.117	1.242	0.214	0.146
<i>Adaptive habitus by</i>					
Gifted identification	0.163	0.096	1.697	0.090	0.195
Female	- 0.161	0.059	- 2.729	0.006	- 0.192
Negative transition	-0.305	0.080	- 3.833	0.000	- 0.366
Elite environment	0.245	0.072	3.428	0.001	0.293
Mathematics grade	0.436	0.075	5.847	0.000	0.522
<i>Extracurricular involvement by</i>					
Gifted identification	0.515	0.125	4.120	0.000	0.503
High Track	0.168	0.097	1.740	0.082	0.165
Adaptive	- 0.231	0.131	- 1.767	0.077	- 0.189
<i>Gifted identification by</i>					
Parents' Education	0.142	0.124	1.150	0.250	0.143
Family STEM capital	0.238	0.112	2.119	0.034	0.240

**Table E.11: Sweden, mathematics: coefficient estimates continued (covariances)**

<i>COVARIANCES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
Value Subject with Value professional	0.402	0.100	4.019	0.000	0.510
Misfit (rev) with Anxiety (rev)	0.171	0.084	2.038	0.042	0.284
Assurance with Misfit (rev)	- 0.157	0.053	- 2.990	0.003	- 0.372
Extreme self-concept with Misfit (rev)	- 0.239	0.071	- 3.375	0.001	- 0.406

**Table E.12: Sweden, mathematics: R-square for key variables**

<i>R-SQUARE</i>	
Variable	$R^2$
Persistence (STEM)	0.275
Extracurricular involvement	0.255
Gifted Identification	0.094
Adaptive	0.709

**Table E.13: Sweden, science: latent variable factor loadings**

<i>LATENT VARIABLE</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Adaptive habitus indicated by</i>					
Science self-concept	1.000				0.911
Assurance	0.846	0.098	8.643	0.000	0.779
Extreme self-concept	0.994	0.092	10.767	0.000	0.904
Misfit (rev)	0.659	0.179	3.672	0.000	0.610
Anxiety (rev)	0.701	0.136	5.145	0.000	0.645

**Table E.14: Sweden, science: coefficient estimates using robust standard errors**

<i>REGRESSIONS</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Persistence by</i>					
Extracurricular	0.233	0.131	1.784	0.074	0.233
Value science	0.290	0.112	2.599	0.009	0.290
Diligence	0.277	0.131	2.119	0.034	0.277
Family STEM capital	0.115	0.114	1.010	0.313	0.116
<i>Value science</i>					
Adaptive	0.323	0.161	2.006	0.045	0.299
Family STEM capital	0.171	0.120	1.427	0.154	0.172
<i>Diligence</i>					
Adaptive	0.315	0.188	1.672	0.095	0.292
Parents' education	- 0.136	0.128	-1.065	0.287	- 0.137
<i>Adaptive habitus by</i>					
Science grade	0.347	0.107	3.236	0.001	0.373
Negative transition	- 0.453	0.089	- 5.112	0.000	- 0.486
Female	- 0.255	0.098	- 2.604	0.009	- 0.276
Family STEM capital	0.134	0.096	1.398	0.162	0.146
<i>Extracurricular involvement by</i>					
Gifted identification	0.284	0.167	1.695	0.090	0.283
Adaptive	0.269	0.129	2.092	0.036	0.249
<i>Gifted identification by</i>					
Parents' Education	0.413	0.113	3.672	0.000	0.417
Family STEM capital	0.125	0.113	1.098	0.272	0.125

**Table E.15: Sweden, science: coefficient estimates using robust standard errors**

<i>COVARIANCES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
Misfit (rev) with Anxiety (rev)	0.189	0.115	1.651	0.099	0.316
Extreme self-concept with Misfit (rev)	- 0.139	0.052	- 2.679	0.007	- .0413

**Table E.16: Sweden, science: R-square estimates for key variables**

<i>R-SQUARE</i>	
Variable	$R^2$
Persistence	0.273
Extracurricular involvement	0.147
Gifted identification	0.214
Adaptive	0.597
Value subject	0.130
Diligence	0.102

**Table E.17: United States, mathematics: latent variable factor loadings**

<i>LATENT VARIABLES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>'Personal' component of adaptive habitus indicated by</i>					
Math self-concept	1.000				0.866
Assurance	0.842	0.110	7.624	0.000	0.734
Extreme self-concept	0.700	0.113	6.224	0.000	0.601
Misfit (rev)	0.775	0.132	5.857	0.000	0.676
Diligence	0.818	0.115	7.104	0.000	0.711
Anxiety (rev)	0.847	0.113	7.494	0.000	0.732
<i>'Ontological' component of adaptive habitus indicated by</i>					
Value mathematics	1.000				0.652
Value professional	0.955	0.188	5.084	0.000	0.626
Meritocratic	0.916	0.271	3.378	0.001	0.604
Mindset (effort/change)	1.108	0.269	4.122	0.000	0.720

**Table E.18: United States, mathematics: coefficient estimates using robust standard errors**

<i>REGRESSIONS</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Persistence by</i>					
Ont. adaptive habitus	0.786	0.239	3.298	0.001	0.519
Extracurricular involvement (b)	0.392	0.115	3.405	0.001	0.392
Gifted identification (c)	-0.311	0.122	-2.542	0.011	-0.310
<i>'Personal' component of adaptive habitus by</i>					
Gifted identification	0.288	0.098	2.930	0.003	0.336
Negative transition	-0.290	0.094	-3.067	0.002	-0.337
Teacher	0.257	0.091	2.840	0.005	0.302
<i>'Ontological' component of adaptive habitus by</i>					
Gifted identification	0.176	0.097	1.803	0.071	0.265
US3A	0.182	0.095	3.247	0.001	0.473
<i>Extracurricular involvement by</i>					
Family STEM capital	0.251	0.133	1.888	0.059	0.261
Gifted identification	0.275	0.111	2.463	0.014	0.273
US3A	0.182	0.089	2.037	0.042	0.183
<i>Family STEM capital by</i>					
US3A	0.377	0.165	2.286	0.022	0.365
<i>Gifted Identification by</i>					
Family STEM capital	0.421	0.114	3.683	0.000	0.440
<i>Mathematics track by</i>					
Gifted identification	0.331	0.091	3.643	0.000	0.328

**Table E.19: United States, mathematics: coefficient estimates continued (Covariances)**

<i>COVARIANCES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
Personal component with Ontological	0.218	0.058	3.752	0.000	0.612
Assurance with Extreme self-concept	0.227	0.102	2.221	0.026	0.440
Value mathematics with Value professional	0.194	0.098	1.975	0.048	0.330
Personal with Persistence	0.042	0.067	0.630	0.529	0.042
High Track	-0.067	0.066	-1.011	0.312	-0.067
Persistence with High Track	0.031	0.085	0.368	0.713	0.044

**Table E.20: United States, mathematics: R-square estimates of key variables.**

<i>R-SQUARE</i>	
Variable	$R^2$
Persistence	0.415
Extracurricular	0.290
Family STEM capital	0.133
Gifted identification	0.193
Personal	0.366
Ontological	0.334

**Table E.21: United States, science: latent variable factor loadings**

<i>LATENT VARIABLES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>'Personal' component of adaptive habitus, indicated by</i>					
Science self-concept	1.000	0.811			
Assurance	0.860	0.106	8.141	0.000	0.701
Extreme self-concept	0.741	0.092	8.039	0.000	0.605
Misfit (rev)	0.535	0.137	3.895	0.000	0.436
Diligence	0.558	0.139	4.028	0.000	0.454
Anxiety (rev)	0.716	0.107	6.727	0.000	0.585
<i>'Ontological' component of adaptive habitus, indicated by</i>					
Value science	1.000			0.628	
Value professional	0.853	0.127	6.705	0.000	0.535
Meritocratic beliefs	0.616	0.185	3.339	0.001	0.384
Mindset (effort/change)	0.952	0.230	4.140	0.000	0.594

**Table E.22: United States, science: coefficient estimates using robust standard errors**

<i>REGRESSIONS</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
<i>Persistence by</i>					
Extracurricular	0.175	0.083	2.107	0.035	0.176
Personal	0.214	0.099	2.166	0.030	0.174
Gifted identification	-0.063	0.071	-0.883	0.377	-0.063
US3A	0.151	0.057	2.620	0.009	0.151
<i>Personal portion of adaptive habitus by</i>					
Negative transition	-0.318	0.064	4.998	0.000	-0.394
Extracurricular involvement	0.177	0.063	2.815	0.005	0.220
Female	-0.150	0.056	-2.680	0.007	-0.185
Teacher	0.160	0.063	2.545	0.011	0.196
US3A	0.107	0.056	1.921	0.055	0.131
Science grade	0.226	0.071	3.176	0.001	0.277
<i>Ontological portion of adaptive habitus by</i>					
Teacher	0.335	0.064	4.899	0.000	0.535
Negative transition	-0.230	0.059	-3.911	0.000	-0.370
Gifted identification	0.110	0.072	1.526	0.127	0.175
US3A	-0.087	0.055	-1.596	0.111	-0.140
<i>Extracurricular involvement by</i>					
Gifted identification	0.490	0.088	5.548	0.000	0.484
US3A	0.203	0.061	3.334	0.001	0.202
<i>Teacher (positive) by</i>					
Gifted identification	0.268	0.078	3.422	0.001	0.267
Negative transition	-0.241	0.093	-2.577	0.010	-0.243
Female	0.137	0.070	1.960	0.050	0.138
<i>Science grade by</i>					
Gifted identification	0.286	0.095	3.002	0.003	0.285
Negative transition	-0.149	0.079	-1.883	0.060	-0.150
Female	0.116	0.079	1.464	0.143	0.116
<i>Gifted Identification by</i>					
Family STEM capital	0.252	0.079	3.185	0.001	0.253

**Table E.23: United States, mathematics: coefficient estimates continued (covariances)**

<i>COVARIANCES</i>					
Variable	Estimate $\beta$	SE	Z-value	$P(>  z )$	Std. All $B$
Personal component with Ontological	0.218	0.058	3.752	0.000	0.612
Assurance with Extreme self-concept	0.227	0.102	2.221	0.026	0.440
Value mathematics with Value professional	0.194	0.098	1.975	0.048	0.330
Personal with Persistence (STEM)	0.042	0.067	0.630	0.529	0.042
High Track	-0.067	0.066	-1.011	0.312	-0.067
Persistence with High Track	0.031	0.085	0.368	0.713	0.044

**Table E.24: United States, science, R-Square.**

<i>R-SQUARE</i>	
Variable	$R^2$
R-Square:	
Persistence	0.112
Extracurricular involvement	0.271
Gifted identification	0.064
Personal	0.500
Ontological	0.620