Edited by
Antero Malin

Associations between age and cognitive foundation skills in the Nordic countries

A closer look at the data

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PROGRAMME FOR THE INTERNATIONAL ASSESSMENT OF ADULT COMPETENCIES PIAAC

UNIVERSITY OF JYVÄSKYLÄ
FINNISH INSTITUTE FOR EDUCATIONAL RESEARCH

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Contents

Preface

Four Nordic countries, including Denmark, Finland, Norway, and Sweden, together with 20 other countries, participated in the first round of the international survey of adults' skills – Programme for the International Assessment of Adult Competencies (PIAAC). The Survey of Adult Skills, a product of PIAAC, is the outcome of collaboration among the participating countries, the OECD Secretariat, the European Commission, and an international consortium led by Educational Testing Service (ETS).

The target population of the survey is adults aged 16–65 years. A major part of the survey is the direct assessment of proficiency in literacy, numeracy, and problem solving in technology-rich environments. These skills are "key information-processing competencies" that are relevant to adults in many social contexts and work situations. They are necessary for fully integrating and participating in the labor market, education, training, and social and civic life, and are also needed for economies to prosper. The international results published in October 2013 showed that the Nordic countries were among the best-performing countries in the survey.

Results from PIAAC as well as from previous studies show that the skills typically are weaker among the elderly than among young people. Age, together with education, is the most important factor explaining the variation between the individuals in their proficiency in literacy, numeracy, and problem solving in the context of technology-rich environments.

This collection of articles is the first product of the research group "Skill acquisition, skill loss, and age (SASLA). A comparative study of Cognitive Foundation Skills in Denmark, Finland, Norway, and Sweden." The group consists of researchers from Denmark, Finland, Norway, and Sweden. The data used in all of the articles is the PIAAC data from the four Nordic countries.

The research group tries to achieve answers to the following questions: What are the associations between age and cognitive foundation skills in literacy, numeracy, and problem solving in technology-rich environments? Are there differences between categories of adults, defined by, e.g., educational level, gender, immigrant status, and educational and labor market experiences? How are the associations between age and foundation skills to be explained? Do the data support the hypothesis that we lose foundation skills as we age? What are the similarities and differences among the Nordic countries with respect to foundation skills and age?

The overarching theme in the collection of articles published in this book is the association between age and the three key skills. Age is found to be associated with skills in several diverse ways. The analyses have shown that both age and skills are associated with various socio-demographic and background characteristics. These associations also have to be identified and their influence has to be controlled when trying to reliably estimate the association between age and skills. These basic findings are presented in this collection of articles. The results also show that much deeper analyses of the data are needed.

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1

Background

1.1 PIAAC and skills

Together with 20 other countries, the Nordic countries Denmark, Finland, Norway and Sweden participated in the first round of the international survey of adults' skills – **Programme for the International Assessment of Adult Competencies (PIAAC)**, conducted by the Organisation for Economic Co-operation and Development (OECD). PIAAC measures and evaluates the key cognitive and workplace skills thought to be needed for individuals to participate in society and for economies to prosper. It provides insights into the availability of some of the key skills and how they are used at work and at home. A major part of PIAAC is the direct assessment of some key information-processing skills: literacy, numeracy and problem solving in the context of technology-rich environments. The international PIAAC-results published November 2013 (OECD, 2013) showed us that the four Nordic countries were ranked between the best five performing countries in prob-

[1] Egil Gabrielsen and Kjersti Lundetræ have written Chapter 1.1., Jan-Eric Gustafsson and Mats Myrberg Chapter 1.2.

lem solving in technology-rich environments; among the seven best performing countries in numeracy skills; and with the exception from Denmark (ranked as 14), the Nordic countries were ranked among the six best performing countries in literacy skills (ibid.).

The Nordic countries have many social, political and cultural common features. They are all welfare states with large public sectors, and characterized by stable parliamentary democracies, organized labor markets and widespread gender equality. The Nordic countries have comprehensive child-care systems and a high proportion of women on the labor market. All countries emphasize free education – they are among the countries with the highest share in higher education – and equal distribution of health care services. Also the citizens in the Nordic countries can benefit from the social security net, including public welfare services as child-, sickness- and disability benefits.

Even though there are a lot of similarities between the Nordic countries, there are also some differences. The countries have some different solutions in e.g. the educational systems (curriculums, age of school entry, teacher education etc.), the labor markets and the welfare services. In this chapter we will explore similarities and differences in the levels and distributions of literacy, numeracy and problem-solving skills in Denmark, Finland, Norway and Sweden. We will also provide break-downs by sub-categories of adults, defined by age, gender, educational level, immigrant status and labor force status.

As we see in Table 1, the skills to be explored in this chapter are significantly correlated in the Nordic countries, which mean that they share a lot of variance. In all countries we find the highest correlations between literacy and numeracy skills (Pearson's r = .85 on average) and the lowest correlations between problem-solving and numeracy (Pearson's r = .75 on average).

Table 1. *Correlations between literacy, numeracy and problem-solving skills in the Nordic countries*

		Literacy	Numeracy
Denmark	Literacy	-	-
	Numeracy	.84	-
	Problem-solving	.82	.76
Finland	Literacy	-	-
	Numeracy	.82	-
	Problem-solving	.81	.71
Norway	Literacy	-	-
	Numeracy	.87	-
	Problem-solving	.80	.76
Sweden	Literacy	-	-
	Numeracy	.86	-
	Problem-solving	.79	.75
Nordic	Literacy	-	-
	Numeracy	.85	-
	Problem-solving	.80	.75

1.1.1 Literacy

Literacy is defined as the ability to understand, evaluate, use and engage with *written texts* to participate in society, to achieve one's goals, and to develop one's knowledge and potential (OECD, 2013). In the PIAAC, literacy includes a range of skills – from the decoding of written words and sentences to the comprehension, interpretation and evaluation of complex texts. It does not include writing. The literacy framework used in the PIAAC is defined in terms of:

Content: The literacy tasks are connected to different types of text. Texts are characterized by their medium (print-based or digital) and by their format:

- Continuous texts
- Non-continuous texts
- Mixed texts
- Multiple texts

Cognitive strategies: The processes that adults must activate to respond to or use given content in an appropriate way:

- Access and identify
- Integrate and interpret (relating parts of text to each other)
- Evaluate and reflect

Context: The different situations in which adults have to read:

- Work-related
- Personal
- Society and community
- Education and training

The proficiency levels in literacy is described in Table 2 (taken from OECD, 2013, p. 64)

Table 2. *Description of proficiency levels in literacy*

Level	Score range	Percentage of adults scoring at each level (average)	Types of tasks completed successfully at each level of proficiency
Below Level 1	Below 176 points	3.3%	The tasks at this level require the respondent to read brief texts on familiar topics to locate a single piece of specific information. There is seldom any competing information in the text and the requested information is identical in form to information in the question or directive. The respondent may be required to locate information in short continuous texts. However, in this case, the information can be located as if the text were non-continuous in format. Only basic vocabulary knowledge is required, and the reader is not required to understand the structure of sentences or paragraphs or make use of other text features. Tasks below Level 1 do not make use of any features specific to digital texts.
1	176 to less than 226 points	12.2%	Most of the tasks at this level require the respondent to read relatively short digital or print continuous, non-continuous, or mixed texts to locate a single piece of information that is identical to or synonymous with the information given in the question or directive. Some tasks, such as those involving non-continuous texts, may require the respondent to enter personal information onto a document. Little, if any, competing information is present. Some tasks may require simple cycling through more than one piece of information. Knowledge and skill in recognising basic vocabulary determining the meaning of sentences, and reading paragraphs of text is expected.

2	226 to less than 276 points	33.3%	At this level, the medium of texts may be digital or printed, and texts may comprise continuous, non-continuous, or mixed types. Tasks at this level require re-spondents to make matches between the text and infor-mation, and may require paraphrasing or low-level inferences. Some competing pieces of information may be present. Some tasks require the respondent to • cycle through or integrate two or more pieces of information based on criteria; • compare and contrast or reason about information requested in the question; or • navigate within digital texts to access and identify information from various parts of a document.
3	276 to less than 326 points	38.2%	Texts at this level are often dense or lengthy, and include continuous, non-continuous, mixed, or multiple pages of text. Understanding text and rhetorical structures become more central to successfully completing tasks, especially navigating complex digital texts. Tasks require the respondent to identify, interpret, or evaluate one or more pieces of information, and often require varying levels of inference. Many tasks require the respondent to construct meaning across larger chunks of text or perform multi-step operations in order to identify and formulate responses. Often tasks also demand that the respondent disregard irrelevant or inappropriate content to answer accurately. Competing information is often present, but it is not more prominent than the correct information.
4	326 to less than 376 points	11.1%	Tasks at this level often require respondents to perform mul-tiple-step operations to integrate, interpret, or synthesise information from complex or lengthy continuous, non-continuous, mixed, or multiple type texts. Complex infer-ences and application of background knowledge may be needed to perform the task successfully. Many tasks require identifying and understanding one or more specific, non-central idea(s) in the text in order to interpret or evaluate subtle evidence-claim or persuasive discourse relationships. Conditional information is frequently present in tasks at this level and must be taken into consideration by the respondent. Competing information is present and sometimes seemingly as prominent as correct information.
5	Equal to or higher than 376 points	0.7%	At this level, tasks may require the respondent to search for and integrate information across multiple, dense texts; construct syntheses of similar and contrasting ideas or points of view; or evaluate evidence based arguments. Application and evaluation of logical and conceptual mod-els of ideas may be required to accomplish tasks. Evaluat-ing reliability of evidentiary sources and selecting key information is frequently a requirement. Tasks often require respondents to be aware of subtle, rhetorical cues and to make high-level inferences or use specialised back-ground knowledge.

Note: The percentage of adults scoring at different levels of proficiency adds up to 100% when the 1.2% of literacy-related non-respondents across countries are taken into account. Adults in this category were not able to complete the background questionnaire due to language difficulties or learning and mental disabilities.

1.1.2 Numeracy

Numeracy is defined as the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life.

To this end, numeracy involves managing a situation or solving a problem in a real context, by responding to mathematical content/information/ideas represented in multiple ways (OECD, 2013, p. 59).

Content: mathematical content, information and ideas:
- Quantity and number
- Dimension and shape
- Pattern, relationships and change
- Data and chance

Representations of mathematical information:
- Objects and pictures
- Numbers and symbols
- Visual displays (e.g. diagrams, maps, graphs, tables)
- Texts
- Technology-based displays

Cognitive strategies: are the processes that adults must activate to respond to or use given content in an appropriate way:
- Identify, locate or access
- Act upon and use (order, count, estimate, compute, measure, model)
- Interpret, evaluate and analyse
- Communicate

Context: is the different situations in which adults have to read:
- Work-related
- Personal
- Society and community
- Education and training

The proficiency levels in numeracy is described in Table 3 (taken from OECD, 2013, p. 76).

Table 3. *Description of profiency levels in numeracy*

Level	Score range	Percentage of adults scoring at each level (average)	The types of tasks completed successfully at each level of proficiency
Below Level 1	Below 176 points	5%	Tasks at this level require the respondents to carry out simple processes such as counting, sorting, performing basic arithmetic operations with whole numbers or money, or recognising common spatial representations in concrete, familiar contexts where the mathematical content is explicit with little or no text or distractors.
1	176 to less than 226 points	14.0%	Tasks at this level require the respondent to carry out basic mathematical processes in common, concrete contexts where the mathematical content is explicit with little text and minimal distractors. Tasks usually require one-step or simple processes involving counting, sorting, performing basic arithmetic operations, understanding simple percents such as 50%, and locating and identifying elements of simple or common graphical or spatial representations.
2	226 to less than 276 points	33.0%	Tasks at this level require the respondent to identify and act on mathematical information and ideas embedded in a range of common contexts where the mathematical content is fairly explicit or visual with relatively few distractors. Tasks tend to require the application of two or more steps or processes involving calculation with whole numbers and common decimals, percents and fractions; simple measurement and spatial representation; estimation; and interpretation of relatively simple data and st atistics in texts, tables and graphs.
3	276 to less than 326 points	34.4%	Tasks at this level require the respondent to understand mathematical information that may be less explicit, embedded in contexts that are not always familiar and represented in more complex ways. Tasks require several steps and may involve the choice of problem-solving strategies and relevant processes. Tasks tend to require the application of number sense and spatial sense; recognising and working with mathematical relationships, patterns, and proportions expressed in verbal or numerical form; and interpretation and basic analysis of data and statistics in texts, tables and graphs.
4	326 to less than 376 points	11.4%	Tasks at this level require the respondent to understand a broad range of mathematical information that may be complex, abstract or embedded in unfamiliar contexts. These tasks involve undertaking multiple steps and choosing relevant problem-solving strategies and processes. Tasks tend to require analysis and more complex reasoning about quantities and data; statistics and chance; spatial relationships; and change, proportions and formulas. Tasks at this level may also require understanding arguments or communicating well-reasoned explanations for answers or choices.

5	Equal to or higher than 376 points	1.1%	Tasks at this level require the respondent to understand complex representations and abstract and formal mathematical and statistical ideas, possibly embedded in complex texts. Respondents may have to integrate multiple types of mathematical information where considerable translation or interpretation is required; draw inferences; develop or work with mathematical arguments or models; and justify, evaluate and critically reflect upon solutions or choices.

Note: The proportion of adults scoring at different levels of proficiency adds up to 100% when the 1.2% of numeracy-related non-respondents across countries are taken into account. Adults in the missing category were not able to provide enough background information to impute proficiency scores because of language difficulties, or learning or mental disabilities.

1.1.3 Problem solving in technology-rich environments (TRE)

Problem solving in technology-rich environments is defined as the ability to use digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks. The assessment focuses on the abilities to solve problems for personal work and civic purposes by setting up appropriate goals and plans, and on accessing and making use of information through computers and computer networks (OECD, 2013, p. 59). The proficiency levels in problem solving in TRE is described in Table 4 (taken from OECD, 2013, p. 88).

Table 4. *Description of proficiency levels in problem solving in technology-rich environments.*

Level	Score range	Percentage of adults able to perform tasks at each level (average)	The types of tasks completed successfully at each level of proficiency
No computer experience	Not appli-cable	9.3%	Adults in this category reported having no prior computer experience; therefore, they did not take part in the computer-based assessment but took the paper-based version of the assessment, which did not include the problem solving in technology-rich environment domain.

Failed ICT core	Not appli-cable	4.9%	Adults in this category had prior computer experience but failed the ICT core test, which assesses the basic ICT skills, such as the capacity to use a mouse or scroll through a web page, needed to take the computer-based assessment. Therefore, they did not take part in the computer-based assessment, but took the paper-based version of the assessment, which did not include the problem solving in technology-rich environment domain.
"Opted out" of taking computer-based assessment	Not appli-cable	10.2%	Adults in this category opted to take the paper-based assessment without first taking the ICT core assessment, even if they reported some prior experience with computers. They also did not take part in the computer-based assessment, but took the paper-based version of the assessment, which did not include the problem solving in technology- rich environment domain.
Below level 1	Below 241 points	12.3%	Tasks are based on well-defined problems involv-ing the use of only one function within a generic interface to meet one explicit criterion without any categorical or inferential reasoning, or trans-forming of information. Few steps are required and no sub-goal has to be generated.
1	241 to less than 291 points	29.4%	At this level, tasks typically require the use of widely available and familiar technology applica-tions, such as e-mail software or a web browser. There is little or no navigation required to access the information or commands required to solve the problem. The problem may be solved regard-less of the respondent's awareness and use of specific tools and functions (e.g. a sort function). The tasks involve few steps and a minimal number of operators. At the cognitive level, the respondent can readily infer the goal from the task statement; problem resolution requires the respondent to apply explicit criteria; and there are few monitoring demands (e.g. the respondent does not have to check whether he or she has used the appropriate procedure or made progress towards the solution). Identifying content and operators can be done through simple match. Only simple forms of reasoning, such as assigning items to categories, are required; there is no need to contrast or integrate information.
2	291 to less than 341 points	28.2%	At this level, tasks typically require the use of both generic and more specific technology applications. For instance, the respondent may have to make use of a novel online form. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g. a sort function) can facilitate the resolution of the problem. The task may involve multiple steps and operators. The goal of the problem may have to be defined by the respondent, though the criteria to be met are explicit. There are higher monitoring demands. Some unexpected outcomes or impasses may appear. The task may require evaluating the relevance of a set of items to discard distractors. Some integration and inferential reasoning may be needed.

3	Equal to or higher than 341 points	5.8%	At this level, tasks typically require the use of both generic and more specific technology applications. Some navigation across pages and applications is required to solve the problem. The use of tools (e.g. a sort function) is required to make progress towards the solution. The task may involve multiple steps and operators. The goal of the problem may have to be defined by the respondent, and the criteria to be met may or may not be explicit. There are typically high monitoring demands. Unexpected outcomes and impasses are likely to occur. The task may require evaluating the relevance and reliability of information in order to discard distractors. Integration and inferential reasoning may be needed to a large extent.

1.2 Basic cognitive skills, cognitive foundation skills, intelligence – a cluster of related concepts

A distinction can be made between basic cognitive skills on the one hand and cognitive foundation skills on the other hand (Desjardins & Warnke, 2012). The former category of skills refer to concepts and measures that have been developed in basic research on individual differences in cognitive abilities and which aim to account for general structures and processes related to cognitive skills. Salthouse (2004) is an example of a study focusing on age differences in skills which uses a hierarchical approach to describing and analyzing cognitive skills.

Cognitive foundation skills refer to skills which rather are defined in terms of tasks practical relevance in daily life, such as literacy, numeracy and problem solving skills. Such tasks often require integration of basic cognitive skills to perform the tasks. However, both basic cognitive skills and cognitive foundation skills can range from simple to complex.

These two approaches to conceptualizing and measuring skills are described in greater detail below.

1.2.1 Basic cognitive skills

Research on individual differences in cognitive abilities using systematic empirical approaches and taking advantage of statistical techniques goes back more than

100 years. In the early decades of the 19th century Binet and Simon developed the first tests of general intelligence, using comparisons of levels of performance on different test items between children in different age groups to construct scales for use, among other things, in diagnosing mental retardation. At about the same time, Spearman (1904) administered a wide variety of tasks measuring performance on both school related tasks and task used in psychological research, and observed positive correlations of varying magnitude among performance on all the tasks. He proposed a theory which posited general ability (the *g* factor) as an unobservable factor influencing performance on all the different tasks. Some tasks were expected to be more highly related to the *g* factor while other tasks were expected to have a lower relation to *g*. Spearman also developed a mathematical/statistical model which predicted the amount of correlation among the different performance measures as a function of their relations with *g*, and from which model procedures for estimating the tasks' *g*-relations were developed.

Spearman (1904) found empirical support for the *g*-factor, and so have others. However, through work by Thurstone (1934), among others, it became obvious that the unidimensional model proposed by Spearman could not fully account for the structure of cognitive abilities and the Spearman model was either rejected in favor of models with multiple, correlated, ability dimensions, or was extended to include factors in addition to *g*.

An alternative model that has gained wide recognition is the Horn-Cattell model (Cattell, 1963; Horn & Cattell, 1966), which distinguishes two main dimensions of ability. One is Fluid intelligence (*Gf*), which is involved in abstract reasoning and problem solving, and particularly so with new content, and the other is Crystallized intelligence (*Gc*), which reflects conceptual and verbal knowledge primarily acquired through education and other systematic learning opportunities. The Gf-Gc distinction is supported by investigations of the structure of cognitive abilities with factor analytic approaches, but the distinction is also supported by other sources of evidence. One important finding is that during the life-span, *Gf* and *Gc* display differential patterns of change. The level of *Gf* increases up to about 25 years of age, and declines slowly thereafter, while *Gc* grows, or keeps stable, during most of the life-time (Horn & Cattell, 1967).

Much work in the field of cognitive abilities has during the last couple of decades focused on integration of competing models. Carroll (1993) reanalyzed almost all data sets ever collected and pieced the results together in the so called

Three-Stratum model. The model has *g* at the highest level (third stratum), some eight broad factors at the second stratum, among others *Gf* and *Gc*, and a large number of narrow factors at the first stratum. This model was later merged with the Horn-Cattell model to form what is referred to as the CHC (Cattell-Horn-Carroll) model (see, e.g., McGrew, 2009). This model keeps the *g*-factor at the apex, and *Gf* and *Gc* are still located at the second stratum. The CHC consensus model provides a taxonomy which summarizes much of what is known about the structure of human cognitive abilities, and it has had impact both on development and use of tests, and on research.

Nevertheless, the model leaves some fundamental theoretical issues unresolved. While Cattell (1987) saw *Gf* and *Gc* as two general factors, they are in the CHC model regarded as two broad factors among a larger set. The Horn-Cattell model did not include a third order *g* factor, but Cattell (1987) hypothesized that such a factor would be closely related to *Gf*.

In support of this hypothesis, Gustafsson (1984) demonstrated empirically that a third-order *g* factor and *Gf* have a relation of unity. One consequence of this finding is that *Gf* should be lifted from the second stratum and instead take the place of the third stratum *g*-factor.

The finding of a perfect relation between *g* and *Gf* has been replicated many times, but not in each and every study. Valentin Kvist and Gustafsson (2008) found an explanation for the disagreements by demonstrating that the perfect relation between *g* and *Gf* could only be found when the persons in the sample had had equal opportunities to learn the material that was tested. An explanation for this follows from Cattell's (1987) Investment theory, which is the dynamic version of the structural Gf-Gc theory. According to the Investment theory, knowledge and skills are developed as a function of investment of *Gf* in learning activities. The learning outcomes are partly determined by *Gf*, but also by the amount of time and effort invested. *Gf* thus influences development of knowledge and skills in each and every domain, which explains why it becomes the general factor. However, if subsets of persons have had different opportunities to learn the material the generality of the *Gf* influence will not apply. Thus, the perfect relationship between *Gf* and *g* can only be expected to appear in groups which are homogeneous with respect to age, education and experience. This homogeneity requirement is easy to satisfy in investigations of school-aged children, but it typically is not satisfied in investigations based on samples of adults with different educational and occupational backgrounds.

This does of course not imply that measures of *Gf* and *Gc* are not interpretable in samples of adults, but the perfect relationship between *Gf* and *g* cannot be expected to hold up in such groups. It should also be noted that the interpretation of the meaning of measures of *Gc* may be quite different, as a function of differences in opportunity to acquire the particular selection of knowledge and skills tested.

While it is often implicitly or explicitly assumed that *Gf* is a fixed and immutable ability, and that *Gc* is heavily influenced by education and environment, the results from research point in other directions. One interesting finding is the substantial increase in the population mean in cognitive abilities that has been documented for many Western countries during the 50-year period from the 1930s to the 1980s, which is referred to as the Flynn (1987) effect. Interestingly enough the increase is more pronounced for *Gf*, where it amounts to around 1 standard deviation, than it is for *Gc*. While this may partly be due to fact that the vocabulary tests used to measure *Gc* have become more difficult over time, thereby underestimating the actual change for *Gc*, the results nevertheless show that *Gf* is not immutable. While there is no generally agreed upon explanation for the Flynn effect, it seems that the increasing length and quality of education provides at least a partial explanation. Thus, a study conducted on effects of lengthening compulsory education in the 1960s in Norway (Brinch & Galloway, 2011) demonstrated that this had effects on cognitive ability which could account for a substantial part of the Flynn effect in Norway.

Other studies too have estimated effects on cognitive abilities of education with methods that allow credible causal inference. Cliffordson and Gustafsson (2008) investigated effects on different cognitive abilities of participating in different high school programs in Sweden. It was found that all programs had an effect ($d = 0.30$) on a *Gf* test. The highest effect on *Gc* (vocabulary) was observed for the Social Science program ($d = 0.45$), while weaker effects were observed for the Natural Science and Technology programs ($d = 0.24$). For the latter two programs there also were effects on a Technical Comprehension test ($d = 0.20$), while no other program had an effect on this program.

1.2.2 Cognitive foundation skills

A basic point of departure in PIAAC is that the cognitive outcome measures should reflect abilities amenable to policy initiatives, either in the educational system, the labor market or in other fields of human development. PIAAC measures three such cognitive skill domains, namely literacy, numeracy and "problem solving in technology rich environments". The definition of the three domains given by OECD stresses the links between cognitive skills and functioning in society. Literacy is specified as "The ability to understand, evaluate, use, and engage with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential" (OECD, 2013). Participants as well as test items in each skill domain are located on a scale from the least proficient/demanding to the most proficient/demanding, based on certain item characteristics. Is the required response a literal transfer from the text in the test item? If not, does the response require low or high inference? This might be (at the low end) a change from a distance given in kilometers in the text to a required response in meters, or (at the high end) several iterations of information from the information given in the test item to the required response.

A second aspect of item difficulty is the volume of information that is required to locate the necessary pieces of information needed for a correct response. Is there irrelevant information in the text that might be mistaken for relevant by the test taker? Is there sufficient information in the text leading directly to the response, or is the test taker required to provide background knowledge him-/herself? Are there cohesive links between passages in the text which clearly model the line of thought? If not, the test taker has to create and elaborate upon a hypertext to provide the correct response. At the test/test taker interface a number of processes are involved (OECD, 2013, p. 59); Access and identify, Integrate and interpret (relating parts of text to one another), Evaluate and reflect, Locate or access, Act upon and use (order, count, estimate, compute, measure, model), Analyze, Monitor progress etc.

The three cognitive skill domains are psychometrically closely related to each other. Correlations between them range from .75 to .85 (ibid.), which indicate that they tap the same basic cognitive resources. Reading is of course a common denominator. The processes specified above could very well be part of a description of processes involved in reading comprehension. A number of the processes involved could also be descriptions of verbal intelligence. Cunningham and Stanovich (2001) have convincingly argued that "reading makes you smarter". Vocabulary, inferential skills and familiarity with "story scripts" develop alongside daily reading, most evident with challenging texts. These skills are dependent on nature as well as nurture factors. Differences in reading experience between individuals have been shown to relate closely to cognitive differences. Volume of reading is functionally related to vocabulary development. From early school years onwards it predicts vocabulary among young adults (Stanovich 1986). Ramsden et al. (2013) have shown that verbal IQ improvement during the early teens was predicted by initial reading ability.

The first rounds of IALS/SIALS, the predecessors of PIAAC, demonstrated substantial differences in skill level, not only between individuals, but also between participant countries, indicating social and cultural impact (educational achievement, reading and writing habits, work force participation, etc.). This might be due to a number of factors beside information processing capability. While the direct assessment via test items in PIAAC is limited to the cognitive skills a number of non-cognitive factors have to be accounted for. In the acquisition of work skills, cognitive skills are by no means the sole players. There are most likely effects of psychological factors like motivation, conscientiousness, self-perception and social cognition (Lepine, Colquitt & Erez, 2006). PIAAC handles a number of these additional domains in a so called "Job Requirement Analysis" section of the background questionnaire. There seems to be a consensus among researchers, however, that cognitive abilities contribute more to work performance than personality traits (Neubert, 2004).

Furthermore, a number of "key skills", some of them specific to certain professions, some of them common to most professional fields, is operating. While cognitive skills is a major factor in job situations at large, interpersonal traits and skills contribute a lot to performance in a diversity of social situations including the workplace. Research on skill acquisition offers a model where cognitive skills like literacy and numeracy is linked to such skills and traits. Ackerman (1991) is a much quoted paper in this vein, and which may be regarded as an elaboration of the Cattell (1987) Investment theory. After an initial emphasis on the cognitive domain in skill acquisition, an emphasis on perceptual and psychomotor skills follows. Each time a worker is confronted with a new challenging task the three phases are iterated. The cognitive phase can be seen as an essential sine qua non threshold to coping with new demands.

To sum up, there is no clear divide between traits on the one hand and skills on the other. Instead, research supports the conclusion that there is a reciprocal and dynamic relation between the two. Over the life span, education and informal training goes along with genetically endowed traits to differentiate developmental trajectories between individuals. A rich environmental support could well compensate for less of resources given by nature and vice versa.

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2

Distributions of skills in the Nordic countries – a comparison

Abstract: Finland outperforms the other Nordic countries on both the literacy and the numeracy scale in PIAAC, while Sweden has a slightly higher rate of respondents on the two highest levels in problem solving compared to their Nordic neighbours. Only small gender differences are found in literacy, while men outperform women in numeracy in all countries. Also there are more men than women performing on the highest level in problem solving. As might be expected, the youngest part of the respondents performs best on problem solving in technology-rich environments. Moreover, adults between 25 and 44 years of age have the best literacy and numeracy skills, while the oldest group, 55–65, perform significantly lower than the younger age groups in all countries. We observed a large and significant difference in all skills measured between respondents who were born in the country compared to adults born outside the country in the Nordic countries. As reported in previous surveys, a high educational level is strongly related to a high level of skills. Also, adults permanently outside the labour market or unemployed have significantly lower skills in literacy, numeracy and problem solving than those employed or categorized as students.

In this chapter, we will study the distribution of the three skill-domains measured in PIAAC in the Nordic countries. We start with literacy, continue with numeracy before we finish the presentation with the problem solving results. For each skill domain, we will be referring to chapter 1 for the definition and in depth explanations of the different levels being used in the presentation.

2.1 Literacy

2.1.1 Main results

Three of the Nordic countries have an average literacy score above the OECD average (273 points) (see Table 1). In the international ranking of 23 countries participating in PIAAC 2012, Finland (288) is number 2, behind Japan (OECD, 2013). Sweden (279) and Norway (278) are ranked as numbers 5 and 6. Denmark (271) is slightly below the OECD average (273) and is ranked as number 14 (OECD, 2013).

Table 1. *Literacy skills in the Nordic countries by means*

	n	mean	s.e. mean	SD
Denmark	7 286	270.8	0.6	47.7
Finland	5 464	287.6	0.7	50.7
Norway	4 947	278.4	0.6	47.0
Sweden	4 469	279.2	0.7	50.6
OECD		272.8	0.2	50.1

Table 2 displays how adults in the Nordic countries aged between 16 and 65 are grouped on the six levels chosen for presenting the distribution of literacy in the PIAAC.

Table 2. *Percentage of adults at each proficiency level in literacy*

	below level 1	level 1	level 2	level 3	level 4	level 5	missing
Denmark	3.8	11.9	34.0	39.9	9.6	0.4	0.4
Finland	2.7	8.0	26.5	40.7	20.0	2.2	0.0
Norway	3.0	9.3	30.2	41.6	13.1	0.6	2.2
Sweden	3.7	9.6	29.1	41.6	14.9	1.2	0.0

Finland has the highest percentage of adults scoring at level 3 and above (62.9%), followed by Sweden (57.7%) and Norway (55.3%). In Denmark scores almost fifty percent at level 3 and above (49.9%).

At the other end of the literacy distribution, we find that between 2.7% (Finland) and 3.8% (Denmark) of adults in the Nordic countries score below level 1. Previous international surveys of adult literacy (IALS and ALL) have not reported at this level.

Adults at level 1 obviously also have insufficient literacy skills, and Table 2 indicates that between 8% (Finland) and 12% (Denmark) are included in this group. The percentages for Norway and Sweden are close to 9.5%.

2.1.2 Literacy skills in different age groups

Adults between 25 and 44 years of age have the best literacy skills in all the Nordic countries, while the oldest group, 55–65, performs significantly lower than the other age groups in all countries. When we compare the mean scores for the two youngest age cohorts, we find that Finland is outdoing its Nordic neighbors. For the age group 16–24, the Finnish mean score is more than 20 points higher than for Denmark and Norway. The difference in score between Sweden and Finland is also significant in favor of Finland, but Swedish youth perform some better than Danish and Norwegian youths in literacy. Table 3 confirms the same pattern in literacy skills for adults between 25 and 34 years of age, but here there is no significant difference between Norway and Sweden. Norway is one out of three countries (together with Cyprus and Great Britain) in PIAAC 2012 where its youngest cohorts have a lower score than their countries' total means score.

Although the gap between Finland and the other countries is narrowing, it is still significant when we look at the mean scores for adults between 35 and 44. For this age group there are no significant differences between Denmark, Norway and Sweden.

The mean scores for the two oldest age groups show a downward tendency for all the Nordic countries, as in earlier studies of adult literacy. Denmark has a significant lower score compared to the other countries in the age group 46–54. In addition there is a significant difference between Sweden and Finland. In the oldest age

Table 3. *Literacy skills in different age groups*

	age	n	percent	mean	s.e. mean	SD
Denmark	16–24	1 064	17.3	276.1	1.3	41.7
	25–34	1 028	17.7	282.1	1.8	51.7
	35–44	1 354	21.6	281.1	1.7	46.6
	45–54	1 446	21.7	265.5	1.4	47.3
	55–65	2 394	21.7	252.4	1.1	43.9
Finland	16–24	895	17.0	296.7	1.9	43.2
	25–34	1 044	19.3	308.9	1.7	46.9
	35–44	971	18.2	298.8	2.1	49.5
	45–54	1 123	20.8	283.6	1.8	50.9
	55–65	1 431	24.8	259.7	1.5	46.0
Norway	16–24	964	18.4	275.0	1.4	43.4
	25–34	920	19.7	288.5	1.9	50.8
	35–44	1 072	21.6	288.2	1.6	48.2
	45–54	1 056	20.7	277.5	1.5	44.0
	55–65	935	19.7	261.9	1.5	42.8
Sweden	16–24	842	18.5	282.8	1.7	45.7
	25–34	803	18.7	290.0	1.9	54.7
	35–44	866	20.5	287.4	1.9	52.8
	45–54	926	20.5	276.0	1.7	49.4
	55–65	1 032	21.8	262.4	1.3	44.7

cohort (55–65), Denmark is also significantly lower than the other three countries, while there are only small differences in the mean score among them.

2.1.3 Literacy and gender

Table 4 shows only small differences in the mean scores on the literacy scales when comparing men and women. In Denmark and Finland women score higher than men, but only the Finnish difference is significant. This is opposite to Norway and Sweden, where men gained a significantly higher literacy mean score compared to women.

Table 4. *Mean literacy skills by gender*

		n	mean	s.e. mean	SD	m-f
Denmark	Male	3 590	270.6	1.0	49.7	-0.4
	Female	3 696	271.0	0.8	45.6	
Finland	Male	2 757	286.0	1.2	52.0	-3.2
	Female	2 707	289.2	1.0	49.3	
Norway	Male	2 557	280.3	1.0	47.8	3.9
	Female	2 390	276.4	0.9	46.1	
Sweden	Male	2 253	280.9	1.1	50.0	3.3
	Female	2 216	277.5	1.1	51.1	

2.1.4 Literacy and educational status

Level of education has been the most important single factor for explaining adult skills in the previous surveys of competencies among 16- to 65-year-olds (IALS and ALL). Table 5 confirms the importance of educational status for literacy skills in the Nordic countries. We use four levels of education in this presentation:

- Low: lower than upper secondary school
- Medium vocational: upper secondary school – vocational orientation
- Medium general: upper secondary school – general orientation
- High: at least a bachelor degree

With two exceptions we find significant differences in the literacy mean scores between adults from the different levels of education in all four countries. The exceptions are in Denmark and Finland where there are no such differences in the mean scores between informants from Medium level general and Higher education (see Table 5).

At the *low educational level,* we find a significant difference in the mean scores between Finland (260) and Norway (256) on the one hand, and Sweden (248) and Denmark (246) on the other. It is worth noticing that Finland has the lowest proportion of its adult population from this educational level (less than 20%).

Looking at adults categorized with *Medium vocational* as their educational level, we find Sweden with the highest mean score (276), slightly ahead of Finland (273).

Table 5. *Mean literacy skills by educational status*

		n	pct	mean	s.e. mean	SD
Denmark	Information missing	330	4.7	260.9	3.2	46.0
	Low	1 697	26.3	246.1	1.5	49.7
	Medium vocational	1 694	24.4	260.6	1.3	39.8
	Medium general	701	10.5	291.0	1.8	42.0
	High	2 864	34.1	292.2	1.0	40.8
Finland	Information missing	0				
	Low	978	19.6	260.4	1.9	53.3
	Medium vocational	1 750	33.0	272.5	1.3	44.5
	Medium general	573	11.0	310.6	2.4	445
	High	2 163	36.4	308.8	1.1	43.7
Norway	Information missing	1	0.02	322.0	17.0	0.0
	Low	1 226	27.4	255.8	1.3	46.5
	Medium vocational	1 143	24.1	266.6	1.5	41.5
	Medium general	674	13.8	286.9	1.9	40.4
	High	1 903	34.7	301.1	0.9	42.1
Sweden	Information missing	505	12.5	273.5	2.3	49.1
	Low	931	23.7	247.6	1.6	50.7
	Medium vocational	765	18.3	276.4	1.7	38.4
	Medium general	757	17.4	286.9	1.6	43.8
	High	1 511	28.1	305.6	1.2	45.9

Finland has the highest proportion of adults at this level (33%), while Sweden is at the bottom of the Nordic ranking with only 21%. Both these countries have a significantly higher score compared to Norway (267) and Denmark (261). The difference in scores between Norway and Denmark is also significant.

Finland (311) is outdoing the other Nordic countries when we compare the results for adults with *Medium general education*. The differences in mean scores are 19 points (Denmark) and 24 points to Norway and Sweden.

Adults with education at *high level* are the largest group in all the Nordic countries (includes around one-third of the adult population between 16 and 65). Finland (309) is also ranked first for this category, with a minor, but significant difference from Sweden (306). The mean scores in both Finland and Sweden are significantly higher than those in Norway (301) and Denmark (292). The Norwegian score is also significantly higher than the Danish one for this educational level.

2.1.5 Literacy and immigrant status

In all countries participating in PIAAC 2012 there was a significant difference in literacy scores between respondents who were born in the country compared to adults born outside the country. Table 6 shows that the difference in average scores in the Nordic countries is highest in Sweden (54 points). The score difference in Finland is close to this (51 points), while it is less than 40 points in both Denmark and Norway.

Table 6. *Mean literacy skills by immigrant status*

	Born in country of interview	n	percent	mean	s.e. mean	SD
Denmark	Yes	5 774	88.2	275.2	0.7	43.5
	No	1 511	11.8	237.6	2.0	62.5
Finland	Yes	5 228	94.3	290.6	0.7	47.2
	No	231	5.7	239.5	4.1	73.1
Norway	Yes	4 310	86.6	283.6	0.6	42.0
	No	635	13.4	245.4	2.6	61.8
Sweden	Yes	3 727	82.5	288.7	0.8	41.6
	No	740	17.5	235.0	1.9	63.8

Finland has the smallest proportion of immigrants (less than 6%), while about one out of six respondents (17.5%) in Sweden were foreign born. The comparable percentages were 11.8% in Denmark and 13.5% in Norway. All four countries have a higher percentage of immigrants compared to the IALS survey conducted during the 1990s.

It is necessary to underline that all the respondents in the PIAAC were introduced to texts and tasks written in the main language of each country (except Finland).

2.1.6 Literacy and labor force status

Labor force status in Table 7 is divided into the following four categories:

- Working (employed or self-employed)
- Unemployed, looking for work
- Student (including work programmes)
- Other (not working, including different types of retirement and unpaid housework)

Norway has the highest proportion of adults included in the *employed* category (70%), followed by Sweden (68%). The percentages for Denmark and Finland are around 62% for this category.

Finland (294) is far ahead of the other countries when we compare the mean scores for adults who have status as *employed*. Also, Norwegian (284) and Swedish (286) adults who are working have better literacy skills than Danish (277). The difference between Sweden and Norway is slightly significant.

Looking at the *Student* category (which includes participants on work programmes), we find that students on average score significantly higher compared to adults in the category Working in Denmark and Finland. The opposite tendency is valid for Sweden and Norway.

We can observe the same pattern when comparing the mean scores for adults who are *Unemployed* (but looking for work). Finland achieved the highest mean score (271), and for this category the differences are significant to all the other countries. We observe only minor differences between Denmark (256), Norway (260) and Sweden (259).

The proportion of adults who are categorized as being outside the workforce (named *Other* in the table) differs between the four countries. One out of six adults aged 16–65 in Finland are included in this category, while the number in Sweden is less than one out of eight. Informants in this category have the lowest average score in all the Nordic countries. Finland (262) gained a significantly higher mean score also for this group than the other three countries. Denmark (242) also scores significantly lower than Sweden (247) and Norway (250).

Table 7. *Mean literacy skills by labor force status*

	Labor force status	n	percent	mean	s.e. mean	SD
Denmark	employed	4 656	62.4	276.9	0.8	44.7
	unemployed	447	6.7	256.2	3.1	48.4
	student	975	16.0	280.0	1.6	43.5
	other	1 207	14.9	241.8	1.6	51.4
Finland	employed	3 462	62.3	293.5	0.9	46.4
	unemployed	321	6.4	270.7	3.8	56.4
	student	761	14.6	298.9	2.3	49.0
	other	919	16.7	261.8	1.8	54.9
Norway	employed	3 512	70.4	284.1	0.8	45.0
	unemployed	129	3.0	259.9	4.9	50.6
	student	762	14.2	279.3	1.7	43.5
	other	543	12.5	249.7	2.4	49.6
Sweden	employed	3 112	68.4	286.2	0.8	46.1
	unemployed	236	6.1	259.1	3.6	55.7
	student	653	13.7	281.5	2.1	53.6
	other	466	11.9	246.7	2.5	53.5

Finally, when comparing the mean scores for the categories *Unemployed* and *Other* we find a significant difference in all countries. We find the biggest gap in Denmark (14 score points).

2.2 Numeracy

In the following part of the chapter, we will study the distribution of numeracy skills in the Nordic countries.

2.2.1 Main results

All the Nordic countries have an average numeracy score above the OECD average (269 points) (see Table 8). In the international ranking of the 23 countries participating in the PIAAC, Finland (282) is number 2, behind Japan. Sweden (279), Norway (278) and Denmark (278) are ranked very close to each other as number 4 and number 5. The Finnish mean score is significantly higher than the mean scores in the other Nordic countries, while there are no statistical differences between Denmark, Norway and Sweden.

Table 8. *Numeracy skills in the Nordic countries by means*

	n	mean	s.e. mean	SD
Denmark	7 286	278.3	0.7	51.2
Finland	5 464	282.2	0.7	52.2
Norway	4 947	278.3	0.8	54.2
Sweden	4 469	279.1	0.8	54.9
OECD		268.7	0.2	54.2

Table 9 displays the distribution of adults aged between 16 and 65 at the six levels used for the numeracy scale. Finland has the highest percentage of adults scoring at level 3 and above (57.9%), followed by Sweden (56.6%) and Norway (56.0%). The percentage in Denmark is 54.9%, underlining the fact that the Nordic countries have close results on this scale.

Table 9. *Percentage of adults at each proficiency level in numeracy*

	below level 1	level 1	level 2	level 3	level 4	level 5	missing
Denmark	3.4	10.8	30.7	38.0	14.9	1.7	0.4
Finland	3.1	9.7	29.3	38.4	17.2	2.2	0.0
Norway	4.3	10.2	28.4	37.4	15.7	1.7	2.2
Sweden	4.4	10.3	28.7	38.0	16.7	1.9	0.0

We also find small differences at the other end of the distribution: between 3.1% and 4.4% of adults in the Nordic countries have a score below level 1. The previous international survey of adult numeracy (ALL) has not reported at this level.

Adults at level 1 obviously also have insufficient numeracy skills, and Table 9 indicates that between 9.7% (Finland) and 10.8% (Denmark) are included in this group. The percentages for Norway and Sweden are 10.2% and 10.3%.

2.2.2 Numeracy skills in different age groups

When comparing the mean scores on the numeracy scale for five different age cohorts in the Nordic countries, we find quite different rankings (see Table 10).

Table 10. *Numeracy skills in different age groups*

	age	n	pct	mean	s.e. mean	SD
Denmark	16–24	1 064	17.3	273.1	1.5	45.9
	25–34	1 028	17.7	286.7	1.9	55.9
	35–44	1 354	21.6	290.0	1.6	50.7
	45–54	1 446	21.7	276.8	1.6	51.5
	55–65	2 394	21.7	265.4	1.2	47.6
Finland	16–24	895	17.0	284.8	1.8	47.3
	25–34	1 044	19.3	302.5	2.1	48.8
	35–44	971	18.2	292.0	2.2	51.7
	45–54	1 123	20.8	279.3	2.0	54.7
	55–65	1 431	24.8	260.1	1.3	47.4
Norway	16–24	964	18.4	270.9	1.7	50.2
	25–34	920	19.7	284.9	2.0	58.6
	35–44	1 072	21.6	289.0	1.9	56.8
	45–54	1 056	20.7	280.3	1.7	50.9
	55–65	935	19.7	264.7	1.7	49.7
Sweden	16–24	842	18.5	278.2	1.7	49.9
	25–34	803	18.7	287.7	2.0	59.0
	35–44	866	20.5	286.1	2.0	57.2
	45–54	926	20.5	276.3	2.3	55.8
	55–65	1 032	21.8	268.3	1.7	49.8

Finland is ranked ahead of Sweden, Denmark and Norway for both the age groups 16–24 and 25–34. The scores show that they have a significantly better result in all comparisons. The differences are between 15 and 18 score points for the age group 25–34, corresponding to about a third of a standard deviation. It is worth noting that the mean scores for Norway, Denmark and Sweden for the youngest age group are below the average scores for their countries (16–65).

Sweden has the lowest mean score in the age group 35–44, significantly different from Denmark and Finland. The differences between Denmark, Finland and Norway are not significant.

For the age group 45–54 Norway is ranked at the top, slightly ahead of Finland, but with a significantly higher mean score compared to Denmark and Sweden.

The oldest age group (55–65) has a significantly lower mean score compared to the younger age groups in all four countries. For this group Sweden has the best ranking, and scores significantly better than Denmark, Norway and Finland. The Finnish score is also significantly lower than the Norwegian and Danish ones.

2.2.3 Numeracy and gender

Table 11 confirms the results from previous surveys: men are superior to women when it comes to numeracy skills. In all four countries men have a significantly higher mean score compared to women. The score difference is greatest in Norway (15 points), followed by Sweden (13 points), while both Denmark and Finland have a difference of 10 score points.

Table 11. *Mean numeracy skills by gender*

	Gender	n	mean	s.e. mean	SD	m-f
Denmark	Male	3 590	283.4	1.2	53.1	10.3
	Female	3 696	273.1	1.0	48.8	
Finland	Male	2 757	287.3	1.2	53.7	10.2
	Female	2 707	277.1	1.0	50.2	
Norway	Male	2 557	285.6	1.2	54.6	14.9
	Female	2 390	270.7	1.1	52.7	
Sweden	Male	2 253	285.7	1.3	54.3	13.5
	Female	2 216	272.2	1.0	54.6	

2.2.4 Numeracy and educational status

Table 12 confirms the importance of educational level for numeracy skills in the Nordic countries. In this presentation we are using the same four levels of education as those used for the literacy domain.

Table 12. *Mean numeracy skills by educational status*

		n	pct	mean	s.e. mean	SD
Denmark	Information missing	330	4.7	271.0	3.7	48.5
	Low	1 697	26.3	248.2	1.7	49.4
	Medium vocational	1 694	24.4	272.9	1.4	43.2
	Medium general	701	10.5	292.9	2.1	47.1
	High	2 864	34.1	301.8	1.1	46.0
Finland	Information missing	0				
	Low	978	19.6	254.8	1.9	53.0
	Medium vocational	1 750	33.0	266.4	1.2	45.7
	Medium general	573	11.0	302.9	2.4	48.1
	High	2 163	36.4	305.1	1.2	45.8
Norway	Information missing	1	0.02	324.6	9.3	0.0
	Low	1 226	27.4	249.6	1.7	53.6
	Medium vocational	1 143	24.1	269.3	1.6	47.3
	Medium general	674	13.8	285.1	2.1	47.4
	High	1 903	34.7	304.5	1.2	48.4
Sweden	Information missing	505	12.5	272.5	2.7	52.6
	Low	931	23.7	244.5	1.8	54.2
	Medium vocational	765	18.3	276.4	1.8	43.6
	Medium general	757	17.4	287.9	2.0	48.4
	High	1 511	28.1	307.4	1.3	49.4

With one exception, we find significant differences in the numeracy mean scores between adults from the four levels of education in all four countries. The exception is Finland where there are no such differences in the mean scores between people with Medium general education and High education.

At the *Low educational level,* the ranking of the countries is Finland (255), Norway (250), Denmark (248) and Sweden (245). The differences are significant between Sweden and the three other countries, and between Finland compared to Denmark and Norway.

For adults categorized with *Medium vocational* as their highest education level, Sweden has the highest mean score (276), slightly ahead of Denmark (273). Both are significantly higher than Norway (269) and Finland (266).

Finland (303) is in the lead with a significantly higher mean score than the other Nordic countries when we compare the results for adults with *Medium general education.* The differences in mean scores are 10 points (Denmark), 15 points (Sweden) and 18 points (Norway). The Danish result is also significantly higher than those of Sweden and Norway.

Adults with education at *High level* are the largest group in all the Nordic countries. Sweden (307) is ranked at the top for this category, with a slightly higher score than Finland (305). The Swedish score is barely significantly higher than Norway (305) and Denmark (302). The mean score in Finland and Norway is significantly above the Danish one.

One has to note that information about educational level is missing for 12.5% of the respondents in Sweden and for 4.7% in Denmark

2.2.5 Numeracy and immigrant status

As regards the comparison of literacy scores, we find a large and significant gap in numeracy scores between native- and foreign-born respondents in all the four countries. The gap is close to a standard deviation. Table 13 shows that the difference in mean score is biggest in Sweden (56 points). The score difference in Finland is close to this (52 points), while it is 46 points in Norway. We find the smallest gap between these two categories (37 points) in Denmark. The dispersion in numeracy skills is far larger among foreign-born citizens than native-born.

Table 13. *Mean numeracy skills by immigrant status*

	Born in country of interview	n	percent	mean	s.e. mean	SD
Denmark	Yes	5 774	88.2	282.7	0.8	47.44
	No	1 511	11.8	245.4	2.2	64.75
Finland	Yes	5 228	94.3	285.3	0.7	48.82
	No	231	5.7	233.6	4.0	74.81
Norway	Yes	4 310	86.6	284.6	0.8	47.70
	No	635	13.4	238.1	3.1	72.99
Sweden	Yes	3 727	82.5	289.0	0.9	45.77
	No	740	17.5	232.7	1.9	68.60

2.2.6 Numeracy and labor force status

In Table 14 we use the same four categories for labor force status as those used in the presentation of literacy. When comparing mean numeracy scores for the largest category, adults included under the label *employed*, there are quite small differences between the Nordic countries. The mean score is highest in Finland (289.2), barely significantly ahead of Denmark (287.3), Sweden (286.9) and Norway (286.4).

Looking at the *student* category (which still includes participants in work programmes), we observe that they have a significant lower mean score compared to the *employed* group in Denmark, Norway and Sweden (more than 10 points). There is no such difference in Finland.

However, adults belonging to the two categories *employed* and *student* (which account for between 77% and 85% of the Nordic informants) perform significantly better than people included in the categories *unemployed* and *other*.

Finland has the highest mean score in the group labelled *other* (261), significantly higher compared to Denmark (250), Sweden (248) and Norway (244). The difference between Denmark and Norway is also significant. As mentioned in the presentation of the literacy results, close to 17% of the target population in Finland belongs to this group compared to 12% in Sweden and Norway.

The *unemployed* group shows very small differences in the Nordic countries, with mean scores between 254 (Norway) and 258 (Denmark). In Denmark, Sweden and Norway this group scores significantly higher compared to the mean scores for

Table 14. *Mean numeracy skills by labor force status*

	Labor force status	n	percent	mean	s.e. mean	SD
Denmark	employed	4 656	62.4	287.3	0.9	48.7
	unemployed	447	6.7	258.5	3.0	50.4
	student	975	16.0	277.3	1.8	48.7
	other	1 207	14.9	250.4	1.8	52.1
Finland	employed	3 462	62.3	289.2	0.9	48.2
	unemployed	321	6.4	256.9	4.0	57.4
	student	761	14.6	288.5	2.2	53.0
	other	919	16.7	260.6	2.0	55.0
Norway	employed	3 512	70.4	286.4	1.0	51.2
	unemployed	129	3.0	253.5	5.6	59.1
	student	762	14.2	274.0	2.2	51.3
	other	543	12.5	243.6	2.6	56.6
Sweden	employed	3 112	68.4	286.9	1.1	50.5
	unemployed	236	6.1	257.9	3.7	58.3
	student	653	13.7	276.1	2.3	57.0
	other	466	11.9	248.0	2.9	60.5

the other group. The difference in Finland is very small and goes in the opposite direction.

2.3 Problem solving in technology-rich environments (TRE)

2.3.1 Main results

The problem solving scale was included in the survey in 20 out of the 23 countries that participated in the PIAAC. On average 74.1% of adults in these countries participated. The percentages were higher in the Nordic countries: between 81.5% (Finland) and 87.9% (Sweden) (OECD, 2013). Only adults who performed the PIAAC on the digital platform were tested with the problem solving scale. For this reason it is of limited interest to compare countries by their mean score.

Table 15 presents the main results for the Nordic countries on the problem solving TRE scale. Five categories are included in the presentation: *Not classified -Below level 1 – Level 1 – Level 2 – Level 3*. Sweden has the highest rate of respondents (44.0%) on the two highest levels, levels 2 and 3, followed closely by Finland (41.6%) and Norway (41.0%). In Denmark 38.7% were on these levels.

Table15. *Percentage of adults at each proficiency level in problem solving in technology-rich environments*

	not classified	below level 1	level 1	level 2	level 3
Denmark	14.52	13.92	32.89	32.34	6.33
Finland	18.56	11.03	28.85	33.21	8.35
Norway	15.75	11.45	31.82	34.91	6.07
Sweden	12.11	13.14	30.77	35.21	8.77

In Table 16 the mean scores for adults who did the PS TRE test are also included, confirming that the Danish mean score is significantly lower compared to the other Nordic countries. We also observe a slightly significant difference between Finland vs. Sweden and Norway and between Sweden and Norway.

Table 16. *Problem solving skills in TRE in the Nordic countries by means*

	n	mean	s.e. mean	SD	s.e. SD
Denmark	6 098	283.08	0.68	42.39	0.58
Finland	4 503	289.37	0.83	42.41	0.58
Norway	4 342	286.49	0.57	40.25	0.64
Sweden	3 963	287.77	0.65	43.96	0.73

2.3.2 Problem-solving in technology-rich environments in different age groups

We find nearly identical patterns in the Nordic countries when comparing the problem solving results for different age groups.

We observe in Table 17 that the three youngest age-cohorts have the lowest percentage of informants not participating in the problem solving test; less than 12% for all groups. In the oldest age cohort (55–65), between 23% (Sweden) and 43% (Finland) were not classified.

Table 17 also displays that the age group 25–34 has the highest percentage of respondents at levels 2 and 3, with one exception. In Sweden the youngest age group has a slightly higher percentage at these levels (62 vs. 60). The age group 16–24 is ranked number two in the other three countries when we compare the percentages of respondents at levels 2 and 3 combined, followed by the age group 35–44. Finland is ranked top for all three cohorts.

We find significantly lower percentages at levels 2 and 3 in the two oldest age cohorts. For informants between 45 and 54 they are between 30 (Denmark and Finland) and 35 (Sweden), while in the oldest cohort the percentages range between 9% (Finland) and 17% (Sweden).

Table 17. *Percentage of adults at each proficiency level in problem solving in technology-rich environments, by age*

	age group	not classified	below level 1	level 1	level 2	level 3
Denmark	16–24	7.77	7.23	34.59	42.40	8.01
	25–34	11.79	6.70	23.83	43.78	13.89
	35–44	10.51	10.35	31.24	39.83	8.07
	45–54	16.15	15.97	37.88	27.07	2.93
	55–65	24.50	26.67	35.58	12.77	0.47
Finland	16–24	4.86	3.59	29.70	50.37	11.49
	25–34	5.10	4.08	23.33	47.74	19.76
	35–44	10.80	7.68	28.86	43.10	9.56
	45–54	20.37	14.06	35.45	26.58	3.55
	55–65	42.60	21.46	27.02	8.43	0.48

Norway	16–24	6.29	6.97	31.90	46.72	8.13
	25–34	13.03	5.88	24.76	44.60	11.73
	35–44	12.71	8.73	30.19	41.20	7.16
	45–54	16.07	13.66	38.57	29.01	2.69
	55–65	30.34	21.91	33.52	13.43	0.79
Sweden	16–24	4.78	5.24	28.28	49.95	11.74
	25–34	8.57	6.07	24.90	44.41	16.04
	35–44	9.33	11.06	29.06	39.41	11.13
	45–54	13.48	15.78	36.07	29.75	4.93
	55–65	22.68	25.36	34.56	15.99	1.42

2.3.3 Problem-solving in technology-rich environments and gender

Men perform better than women in all the Nordic countries on the problem solving scale. Between 37% (Denmark) and 42% (Sweden) of women have a score on levels 2 or 3. The percentages for men are between 40% (Denmark) and 46% (Sweden).

In Table 18 the significant gender differences within countries are marked in colored cells.

Table 18. *Percentage of adults at each proficiency level in problem solving in technology-rich environments, by gender*

	gender	not classified	below level 1	level 1	level 2	level 3
Denmark	male	16.38	13.06	30.51	32.76	7.28
	female	12.63	14.79	35.30	31.92	5.36
Finland	male	19.31	10.96	27.04	33.47	9.22
	female	17.80	11.10	30.69	32.94	7.47
Norway	male	15.40	10.39	30.19	36.89	7.13
	female	16.13	12.56	33.52	32.83	4.96
Sweden	male	11.95	12.77	29.37	35.86	10.05
	female	12.27	13.51	32.22	34.54	7.46

2.3.4 Problem-solving in technology-rich environments and educational level

Table 19 displays different patterns in the Nordic countries when we compare the number of respondents at levels 2 and 3 belonging to different educational cohorts. In Denmark and Finland adults with *Medium general education* perform better than those with education at *High level*. In Denmark the percentages are 59% and 55% for the groups mentioned. The gap is much wider in Finland (70% and 56%). We can also note that adults from the *Low level (max.* secondary school) perform slightly better in Finland and Denmark compared to those from the category *Medium vocational* (higher percentages on level 2 and 3 combined).

Table 19. *Percentage of adults at each proficiency level in problem solving in technology-rich environments, by educational status*

	Educational status	not classified	below level 1	level 1	level 2	level 3
Denmark	Information missing	20.95	17.07	34.26	24.73	2.98
	Low	26.70	18.95	30.80	21.35	2.20
	Medium vocational	14.77	20.79	38.68	23.90	1.86
	Medium general	6.23	5.76	28.55	45.33	14.13
	High	6.53	7.17	31.50	43.99	10.81
Finland	Information missing	0				
	Low	34.56	13.13	25.96	23.15	3.19
	Medium vocational	25.50	16.40	33.08	22.22	2.80
	Medium general	7.74	3.40	19.28	51.45	18.13
	High	6.90	7.34	29.48	43.07	13.21
Norway	Information missing	*				
	Low	23.99	17.18	33.49	23.40	1.94
	Medium vocational	15.01	16.39	38.54	27.79	2.28
	Medium general	9.19	8.47	31.52	42.37	8.45
	High	6.95	5.41	28.00	48.21	11.42

Sweden	Information missing	9.84	11.56	32.70	35.43	10.47
	Low	24.68	23.46	29.47	20.33	2.06
	Medium vocational	9.23	13.85	39.03	33.88	4.02
	Medium general	10.28	9.82	30.73	40.54	8.62
	High	5.53	6.70	25.67	45.23	16.87

*Only 1 observation missing information

In Norway and Sweden we find another pattern: adults at the *Low level* of education also have the lowest percentages at levels 2 and 3, followed by the cohort with *Medium vocational*. Adults with *Medium general education* are ranked number two in these countries, with approximately 10% lower numbers of respondents at levels 2 and 3 compared to adults at *High educational level*.

We observe the highest rate of adults not participating on the problemsolving test among those from the *Low educational level* in all the countries (between 23% in Norway and 35% in Finland). Except for Denmark, informants with *High level of education* have the lowest rate not classified on this test.

2.3.5 Problem-solving in technology-rich environments and immigrant status

As was observed for the literacy and numeracy scales, immigrants are found more seldom at the highest levels of performance than native born also on the problem solving TRE scale. Table 20 compares the percentages of adults born in and outside the Nordic countries. When combining the percentages for levels 2 and 3, we find the highest difference between these two groups of respondents in Sweden (49% vs. 21%) and the lowest in Finland (43% vs. 24%). The corresponding percentages in Denmark were 41% vs. 21% and in Norway 45% vs. 24%.

The table also includes the percentages that were excluded from the problem solving tasks in each country. 40% of the respondents who were foreign born belong to this group in Finland compared to 17% of native born. The percentages in Denmark were 36% (foreign) and 11% (native), in Norway 30% (foreign) and 11% (native) and in Sweden 30% (foreign) and 8% (native).

Table 20. *Percentage of adults at each proficiency level in problem solving in technology-rich environments, by immigrant status*

	foreign born	not classified	below level 1	level 1	level 2	level 3
Denmark	no	11.30	13.57	33.94	34.43	6.77
	yes	35.79	16.97	26.14	17.83	3.27
Finland	no	17.16	10.86	29.33	34.04	8.61
	yes	39.94	14.10	21.52	20.12	4.32
Norway	no	11.30	10.54	33.42	38.19	6.55
	yes	29.77	19.31	27.02	19.83	4.06
Sweden	no	8.18	10.75	32.05	38.92	10.10
	yes	30.30	24.41	24.86	17.86	2.58

2.3.6 Problem-solving in technology-rich environments and labor force status

Table 21 presents the percentages of respondents from each of the four categories of labor force scoring on each level of the problem solving TRE scale.

Table 21. *Percentage of adults at each proficiency level in problem solving in technology-rich environments, by labor force status*

	Labor force status	not classified	below level 1	level 1	level 2	level 3
Denmark	employed	10.61	13.04	34.80	34.98	6.57
	unemployed	23.75	13.91	28.87	29.07	4.39
	student	6.79	6.97	32.41	42.88	10.95
	other	32.99	25.46	27.99	12.16	1.39
Finland	employed	14.02	11.04	31.97	34.62	8.35
	unemployed	30.57	13.77	28.62	23.16	3.89
	student	6.07	3.38	24.63	50.39	15.54
	other	41.85	16.62	20.96	16.80	3.78

Norway	employed	10.73	10.86	33.95	37.84	6.62
	unemployed	18.55	14.73	33.04	29.86	3.82
	student	6.62	6.19	30.67	47.28	9.24
	other	38.42	22.03	26.63	11.88	1.04
Sweden	employed	8.97	12.60	32.34	36.91	9.18
	unemployed	19.41	13.65	31.44	29.69	5.81
	student	7.02	6.78	25.66	46.85	13.69
	other	32.46	23.01	27.40	14.84	2.29

Adults belonging to the *student* category (which also includes people participating in work programmes) have the highest rate of respondents on levels 2 and 3 combined. Finland is at the top with 66% of students performing on these levels, followed by Sweden (61%), Norway (57%) and Denmark (54%). Students also have the lowest percentages of respondents not classified on the PS-TRE in all countries (between 6% and 7%).

In the *employed* group between 42% (Denmark) and 46% (Sweden) perform on levels 2 and 3. The corresponding percentages in the *unemployed* group are 27% (Finland), 33% (Denmark), 34% (Norway) and 36% (Sweden).

Adults outside the workforce (named *Other*) have the highest rate of non-performers on the problem solving scale in all four countries (between 32% in Sweden and 42% in Finland). This labor force category also has the lowest rate of respondents at levels 2 and 3. The percentages differ from 13% (Norway) to 21% (Finland).

2.4 Summary

Finland outperforms the other Nordic countries on both the literacy and the numeracy scale in PIAAC, while Sweden has a slightly higher rate of respondents on the two highest levels in problem solving compared to the other countries. Finland has the highest share of informants not participating on the problem solving test.

Only small gender differences are found in literacy, while men outperform women in numeracy in all countries. Also there are more men than women performing on the highest level in problem solving.

As might be expected, the youngest part of the respondents performs best on problem solving in technology-rich environments. Moreover, adults between 25 and 44 years of age have the best literacy and numeracy skills in all the Nordic countries, while the oldest group, 55–65, performs significantly lower than the younger age groups in all countries.

In all the Nordic countries participating in PIAAC, there was a large and significant difference in literacy, numeracy and problem solving skills between respondents who were born in the country compared to adults born outside the country.

As reported in previous surveys, a high educational level is strongly related to a high level of skills. Also, adults permanently outside the labor market or unemployed have significantly lower skills in literacy, numeracy and problem solving than those employed or categorized as students.

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3

Use of skills at work, cognitive foundation skills, and age

Abstract: We look at development over age of both measured CFS (literacy, numeracy, and problem solving) and the use of CFS at work in two categories of occupations: a group "ISCO 0–4" that contains major occupations (0) armed forces occupations, (1) managers, (2) professionals, (3) technicians and associate professionals, (4) clerical support workers, and a group "ISCO 5–9" that contains major occupation (5) service and sales workers, (6) skilled agricultural, forestry and fishery workers, (7) craft and related trades workers, (8) plant and machine operators and assemblers, and (9) elementary occupations.

The amount of measured CFS declines with age from age category 35–44 to age category 55–64 in both group ISCO 0–4 and in group ISCO 5–9, and the amount of decline appears to be of the same magnitude. However, the decrease in human capital over age as measured by CFS is not reflected in decreases in the use of these skills over age. The results of the paper does thus not support the 'use it or lose it' hypothesis, that a lack of use of human capital entails a depreciation of the amount of human capital (or productive skills).

3.1 Introduction

The topic of this paper is use of skills at work, Cognitive Foundation Skills (CFS) and age. Measured skills vary over age, as does the use of skills. This paper gives an overview of variation over age of skills and the use of skills at work in the Nordic countries. Furthermore we show how both skills and the use of skills vary according to occupations.

Skills and use of skills in relation to choice of occupation is an important topic. A classical line of thought in the economics literature is the so-called Roy model according to which workers chose occupation according to their relative abilities to perform the tasks of the occupation in question. In this paper we analyze both measured skills and the use of skills at work. Another classical line of thought in the economics literature is the human capital model according to which productive skills are formed by investment in both formal education and during training on the job. Productive skills developed during formal education at a young age might depreciate if these skills are not maintained during the work life. One conjecture in relation to the development of CFS over age might be that the deterioration of skills over age is more pronounced in occupation with a limited use of CFS relative to occupations with more intensive use of these skills. In this paper we will test this hypothesis by analyzing both measured skills and the use of these skills over age categories in major occupations of the workforce.

We use a graphical analysis to display the variation in CFS and skill use over ages and occupations. In addition to a display of the averages we also display the uncertainty affiliated with the averages in the form of 95% confidence intervals. The combination of both averages and confidence intervals enables us (and the reader) to assess to what extent there are significant differences between CFS and skill use across ages, occupations, and countries. The aim of the paper is to provide a readily accessible overview of the development in CFS and skill use at work over age and occupational categories in the four Nordic countries.

The hypothesis that a lack of use of human capital entails a depreciation of the amount of human capital (or productive skills) is treated in the economics literature in relation to absence from work. An early contribution is Mincer and Ofek (1982), who look at the consequences of interrupted work careers for subsequent wages. The relation between ageing and the level and use of cognitive skills is a topic in the psychological literature; see e.g. the review by Salthouse (2006) for a treatment of evidence for the 'use it or lose it' hypothesis or the 'mental-exercise'. Salthouse (2006, 70) states that 'The view that keeping mentally active will maintain one's level of cognitive functioning, and possibly even prevent cognitive decline and the onset of dementia, is so pervasive in contemporary culture that it is frequently expressed in the 'use it or lose it' adage. Salthouse (2006) does not find much evidence for the hypothesis, but this result can be discussed, see the exchange in Schooler (2007) and Salthouse (2007). Desjardins and Warnke (2012) is a broad review of the literature on ageing and skills.

The paper is organized as follows. Section 2 describes the data and the methodology. Section 3 deals with CFS in main occupations and age. Section 4 describes how the use of skills varies over main occupations and age. Section 5 concludes.

3.2 Data and methodology

The data for the paper stem from the PIACC data base. The information used in this paper is the scores for the three measures of CFS (literacy, numeracy, and problem solving) and the four measures of skill use at work (literacy, writing, numeracy, and problem solving). In addition we use the background information about the age of the worker and the occupation of the worker.

A main contribution of the paper is to investigate how both CFS and the use of skills vary between occupations. The PIACC database contains variables indicating the occupations of the respondents according to the International Standard Classification of Occupations (ISCO) categories. The occupational categories are numbered in such a way that the first digit indicates the major occupational category that each occupation belongs to. The ten major occupational categories are as follows: (0) armed forces occupations, (1) managers, (2) professionals, (3) technicians and associate professionals, (4) clerical support workers, (5) service and sales workers, (6) skilled agricultural, forestry and fishery workers, (7) craft and related trades workers, (8) plant and machine operators and assemblers, and (9) elementary occupations.

There is considerable variation in measured CFS between these major occupations. The general pattern is that the higher the occupation number, the lower is measured CFS. This paper shows how CFS and skill use varies over age in occupations. However, the number of observations in each of the major occupations is too small to trace a statistical significant development over age in each of the major occupations. We have thus lumped together the major occupations in two aggregate categories: (a) "ISCO 0–4" that contains major occupations from "0 army" to "4 clerical support workers" and (b) "ISCO 5–9" that contains major occupations from "5 service and sales workers" to "9 elementary occupations". The first group "ISCO 0–4" thus contains the first five major occupations, while the second group "ISCO 5–9" contains the last five major occupations. In all the countries the group "ISCO 0–4" contains slightly more than half of the observations, while the group "ISCO 5–9" contains slightly less than half. The average skill level and the average use of skills at work for these two groups of occupations are displayed for age categories in the graphs in the paper.

The occupational categories applied in this paper are the categories of the current job. That is, one condition to be included in the assessments of this paper is that the respondents are employed (non-employed respondents are included in the ISCO assessment at the one digit level in the PIACC data as "Out of work for 5 years" and "Valid skip" but these categories are not used in the present paper).

The graphs in the paper contain not only average measures of CFS and skill use, but also the confidence intervals for the averages. The confidence intervals measure the uncertainty affiliated with the averages. The confidence intervals are the 95 per content confidence intervals. These confidence intervals are constructed from the standard error of the estimate of the averages. The estimation of standard errors of the averages presented in the paper takes into account both stratification in the sample survey (some groups are oversampled in the survey designs) and the different response rates of different groups (strata). Furthermore, estimation of the standard errors of means of measured skills takes the test design into account as the respondents do not answer all questions in the questionnaire (the measurement of CFS in PIACC is performed by the technique "multiple imputation").

As background material for the graphs we include tables with descriptive statistics in the appendix. Table A1 contains information about the mean scores for the three measures of CFS for group "ISCO 0–4" and group "ISCO 5–9" in each of the Nordic countries. In addition to the average scores, we also report the standard error of the mean score, the standard deviation of the scores, the standard error of the standard deviation and the number of observations. Table A2 contains analogous information about the four measures of the use of skills at the workplace.

3.3 CFS in major occupations and age brackets

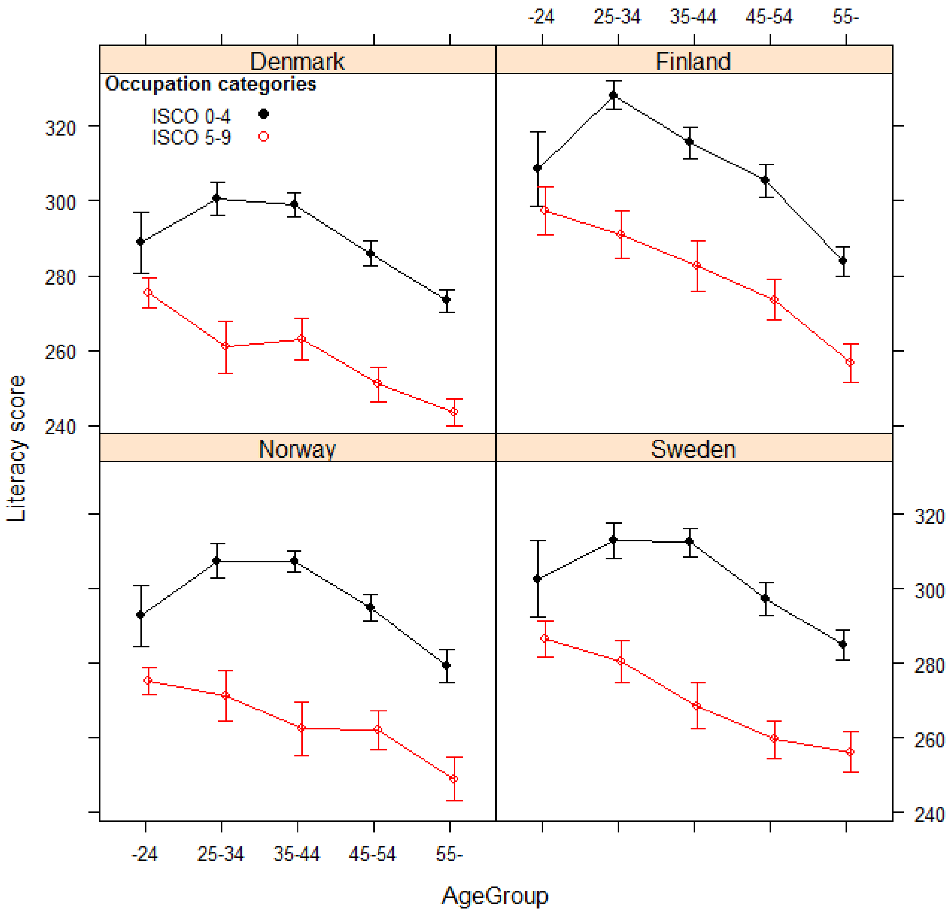
This section displays results for CFS and age in major occupational categories in each of the Nordic countries. The results for the three measures of CFS, literacy, numeracy, and problem solving, are displayed in separate graphs.

Figure 1 show how the literacy score varies over ages and occupations. The upper box to the left contains the literacy scores for Denmark. For the occupations in the occupational categories ISCO 0–4, the literacy score in age category 16–24 is about 290, and this score increases to about 300 in age category 25–34. The score in age category 35–44 is nearly the same as in age category 25–34. However, the score decreases to a level of about 285 in age category 45–54 and furthermore to a level of about 275 in age category 55–64. For the occupations in the occupational categories ISCO 5–9 the literacy score in age category 16–24 is about 275. The score decreases to about 260 in age category 25–34, followed by decreases to a low level of about 245 in age category 55–64.

The vertical bars in the diagram illustrate the 95% confidence intervals of the means. We see for example that the upper limit of the confidence interval for age category 55–64 in occupational categories ISCO 0–4 is below the lower limit of the confidence interval for age category 45–54 in occupational categories ISCO 0–4. This implies that the decrease in literacy score from age category 45–54 to age category 55–64 in occupational categories ISCO 0–4 is statistically significant. The same is the case for the decrease in the score from age category 35–44 to age category 45–54 in occupational categories ISCO 0–4, while the decrease in the score from age category 25–34 to age category 35–44 in occupational categories ISCO 0–4 is not statistically significant. For occupational categories ISCO 5–9 we also see a significant decrease in the literacy score from age category 35–44 over age category 45–54 to age category 55–64.

There is a considerable difference between the curves for the literacy score in occupational categories ISCO 0–4 and the score in occupational categories ISCO 5–9. For age classes 25–34, 35–44, and 45–54 the difference is 35–40 points on the scale of the literacy score. This difference is comparable in magnitude to the standard deviation of the literacy score in both occupational category ISCO 0–4 and ISCO 5–9, which is 39.1 and 45.2, respectively; see Table A1 in the appendix. The measured literacy ability is thus considerably higher in occupational categories ISCO 0–4 compared to the measured literacy ability in occupational categories

Figure 1. *Literacy scores in main occupations and ages*



ISCO 5–9. This observation underscores the importance of including occupational categories in the analysis of CFS of employed workers.

The upper box to the right in Figure 1 displays an analogous assessment for Finland. The development in age brackets for occupational categories is similar to the development for Denmark. First the literacy score in occupational categories ISCO 0–4 increases from age category 15–24 to age category 25–34, after which the score decreases up to age category 55–64. The literacy score in occupational categories ISCO 5–9 exhibits a steady decrease from age category 15–24 to age category 55–64.

A major difference between the Denmark and Finland with respect to literacy score is the level of the curves. The literacy score is higher in Finland than in Denmark for all age classes in both occupational categories ISCO 0–4 and in occupational categories ISCO 5–9. Furthermore, the bars indicating the confidence intervals show that all the differences in literacy score between the two countries are statistically significant. This visual impression is confirmed by the figures in Table A1 in the appendix, where the mean score for group ISCO 0–4 is significantly higher for Finland than for Denmark, and the same holds true for mean score for group ISCO 5–9.

The lower box to the left displays Norway. The two curves in the box are very similar to the curves for Denmark both with respect to the development of the curves over age categories and the height of the curves.

The lower box to the right displays Sweden. The development of the curves over age categories is similar to the development in both Denmark and Norway. However, the height of the curves for Sweden is slightly higher than for both Denmark and Norway. The difference in the levels of the curves for Denmark and Norway and the levels of the curves for Sweden appears to be bordering on statistical significance.

All four countries exhibit similar developments in the curves at the end of the age distribution and at the beginning of the age distribution. At the end of the age distribution there is a tendency towards a slight decrease in the difference in the literacy score between occupational categories ISCO 0–4 and occupational categories ISCO 5–9 from age category 45–54 to age category 55–64. Retirement from the labor force begins in the last age category and the slight decrease in the difference in the score between the two occupational groups might thus be due to changes in the composition of the respondents from age category 45–54 to age category 55–64 (e.g. the narrowing of the difference might reflect that persons in category ISCO 5–9 with low levels of CFS are more likely to retire than other groups).

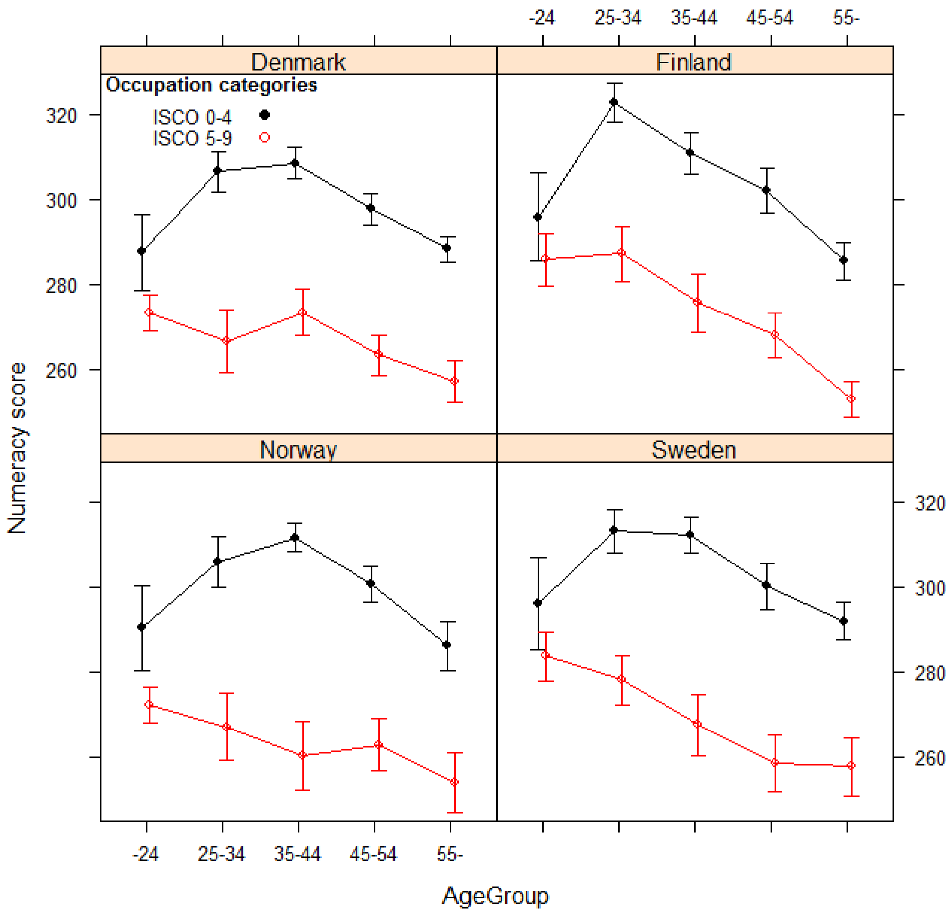
At the beginning of the age distribution all four countries exhibit an increase in the literacy score from age category 15–24 to age category 25–34 in occupational categories ISCO 0–4. These increases are either statistically significant or close to significant. In contrast, for all other age classes the literacy score is either at the same level or lower compared to the level at the previous and younger age class, in many cases statistically significantly lower.

The likely reason for the increases in the literacy score from age category 15–24 to age category 25–34 in occupational categories ISCO 0–4 is a composition effect.

The persons in occupational categories ISCO 0–4 in age category 25–34 are different from the persons in category 15–24. For example, many employees in occupational categories ISCO 2, professionals, have a higher education and often leave the higher educational institutions after the age of 25. This group that scores high on literacy ability is thus typically included in age category 25–34, but not in age category 15–24. The number of persons belonging to category ISCO 0–4 at age 15–24 is limited, which is reflected in the comparatively large confidence intervals for this group.

We next look at the numeracy score, which is displayed in Figure 2. In most aspects, Figure 2 appears to be similar to Figure 1.

Figure 2. *Numeracy scores in main occupations and ages*



There is a significant decline in CFS in occupational categories ISCO 0–4 from age 35–44 in Denmark, Norway, and Sweden and from age 25–34 in Finland. Occupational categories ISCO 5–9 exhibit a decline from age 15–24 in all the Nordic countries. This decline is significant in Finland and Sweden and on the borderline of significance in Denmark and Norway. In the older age classes there are no major differences between the levels of the numeracy between the four countries. In the younger age classes the most noticeable difference is that Finland has a significantly higher score in age bracket 25–34 than the rest of the Nordic countries.

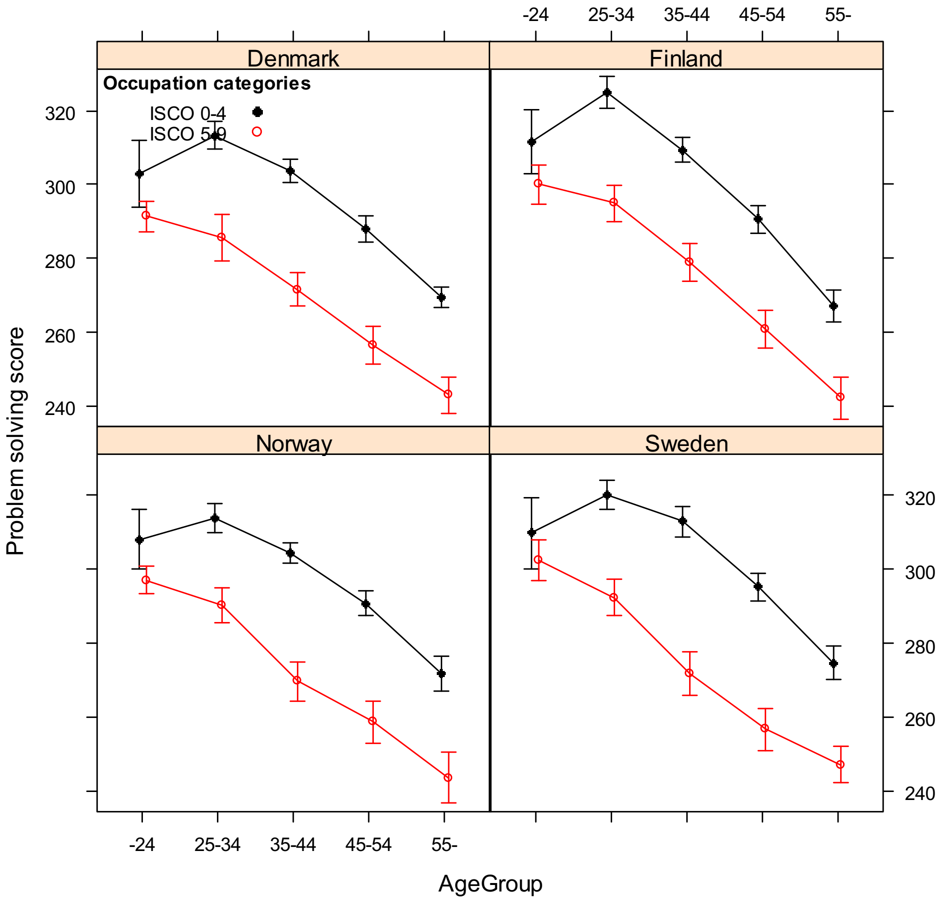
We next look at the problem solving score which is displayed in Figure 3. In general, the Figure 3 appears similar to the two previous figures, Figure 1 and Figure 2.

A major difference is that the problem solving scores declines much faster with age than the scores for literacy and numeracy for both occupational categories ISCO 0–4 and occupational categories ISCO 5–9. The problem solving scores in several age classes appear to be lower in Denmark and Norway than in Finland (and to some extent Sweden), but the differences are on the borderline of statistical significance.

All three graphs in this section show a significant decline in CFS from the middle of the working life in all the Nordic countries. This decline is present in both of the two occupational categories applied in the paper, the upper level occupations on the scale of major occupations, and the lower level of the occupational scale. For occupation groups ISCO 0–4 the decline in Denmark, Norway, and Sweden begins from age category 35–44 while the decline in Finland begins from age category 25–34. For occupation groups ISCO 5–9 the decline begins at age category 15–24 in all four countries. However, in most cases the decline in CFS for occupation groups ISCO 5–9 is not statistically significant from one age group to the next.

This section has shown how CFS declines with age in major occupational groups. To what extent is this decline in CFS associated with a decline in the use of skills at work in major occupational groups? This question is answered in the next section.

Figur 3. *Problem solving scores in main occupations and ages*



3.4 Skill use at work in major occupations and ages

This section displays results for skill use at work and age in major occupational categories in each of the Nordic countries. The results for the four measures of skill use, literacy, writing, numeracy, and problem solving, are displayed in separate graphs.

We first look at the use of reading or literacy at work. There are eight questions in the questionnaire about this topic. The participants were asked to state the intensity of the following activities at the workplace: (a) read directions or instructions, (b) read letters, memos, or mails, (c) read newspapers or magazines, (d) read professional journals or publications, (e) read books, (f) read manuals or reference materials, (g) read financial statements, and (h) read diagrams, maps, or schematics.

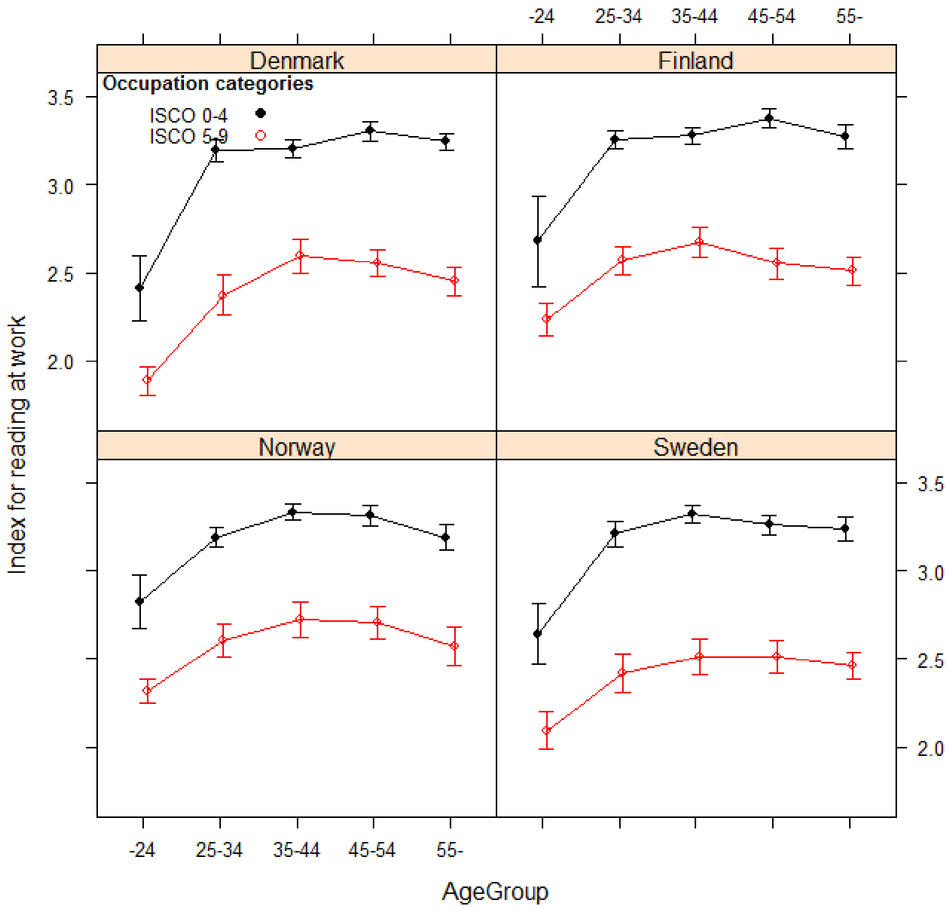
The answer categories for each of the questions are "never" (value 1), "less than once a month" (value 2), "less than once a week but at least once a month" (value 3), "at least once a week but not every day" (value 4), and "every day" (value 5). In addition, participants who did not answer the question were placed in the following categories: "valid skip", "don't know", "refused", and "not stated or inferred". For the participants who answered the questions we calculated the mean value of the score for the eight questions concerning reading at work (the value for the literacy score for each participant is thus between one and five). These score for literacy use at work for each participant form the basis for calculating the average use of literacy for age groups and occupation groups in the following.

The indices for writing, numeracy, and problem solving at work in the following are constructed analogously. We apply these indices in the place of the indices for reading, writing, numeracy and problem solving at work constructed by OECD that are included in the PIACC data base. However, we have made graphs with the indices constructed by OECD and compared them with the graphs presented in this paper. The conclusions that can be drawn from the two sets of graphs are identical. A main reason for applying our own indices instead of the indices in the PIACC data base is that the levels of the indices in the PIACC data base do not have a natural interpretation.

Figure 4 show the use of reading at work. For occupational groups ISCO 0–4, all four countries exhibit a steep and significant increase in the use of reading at work from age category 15–24 to age category 25–34. However, afterwards the curves are essentially flat – there are no significant differences in the use of reading at work between age category 25–34, age category 35–44, age category 45–54, and age category 55–64. Occupational groups ISCO 5–9 show the same picture, a significant increase in the use of reading at work from age category 15–24 to age category 25–34 (although not so steep as the increase for occupational groups ISCO 0–4) followed by constancy.

The levels of the curves are about the same for occupational groups ISCO 0–4 in all four countries. The use of reading at work is substantial and significantly higher in occupational groups ISCO 0–4 than in occupational groups ISCO 5–9 in all four countries. For occupational groups ISCO 5–9 the use of reading at work appears to be significantly higher in Norway than in Denmark, Finland, and Sweden, and the

Figure 4. *Read at work in main occupations and ages*



difference between the two curves in Norway is thus smaller than the difference in the other Nordic countries.

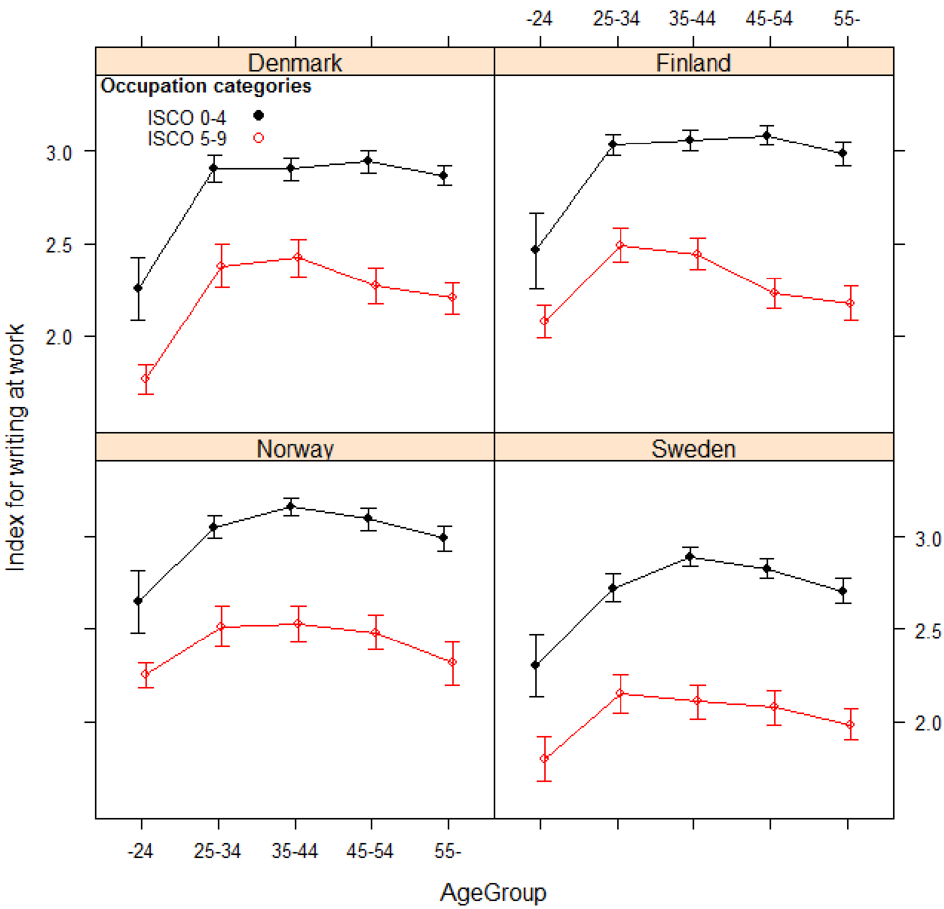
We next look at the use of writing at work. This activity is measured by the following four questions: (a) write letters, memos, or mails, (b) write articles, (c) write reports, and (d) fill in forms. The answer categories for the intensity of these activities are the same as the answer categories for the questions about the use of reading at work. We attach values one to five to the answer categories, and for each respondent we calculate the mean value of the score for the four questions about the intensity of use of writing at work.

Figure 5 shows the use of writing at work. The general impression is that Figure 5 appears very similar to Figure 4.

For both occupational categories ISCO 0–4 and occupational categories ISCO 5–9 the use of writing at work increase from age category 15–24 to age category 25–34. Afterwards, there are no significant differences between the age categories with exemption of Finland who exhibit a significant decrease in the use of writing at work from age category 45–54 to age category 55–64.

There are large and significant differences in the use of writing at work between occupational categories ISCO 0–4 and occupational categories ISCO 5–9 in all four

Figure 5. *Write at work in main occupations and ages*



countries. The level of the use of writing in occupational categories ISCO 0–4 and categories ISCO 5–9 is about the same in Denmark, Finland, and Sweden while the use of writing in both occupational categories is significantly higher in Norway than in the other Nordic countries.

Next we look at the use of numeracy at work. The intensity of this activity is assessed from the answers on the following six questions: (a) calculating costs or budgets, (b) use or calculate fractions of percentages, (c) use a calculator, (d) prepare charts, graphs, or tables, (e) use simple algebra or formulas, and (f) use advanced math or statistics. From the answers of these questions we calculate the mean score for use of numeracy at work in the same way that we calculated the mean scores for reading at work and writing at work.

Figure 6 show the use of numeracy at work. The development of the use of numeracy at work exhibit some differences compared to the development in the use of reading at work displayed in Figure 4 and the use of writing at work displayed Figure 5.

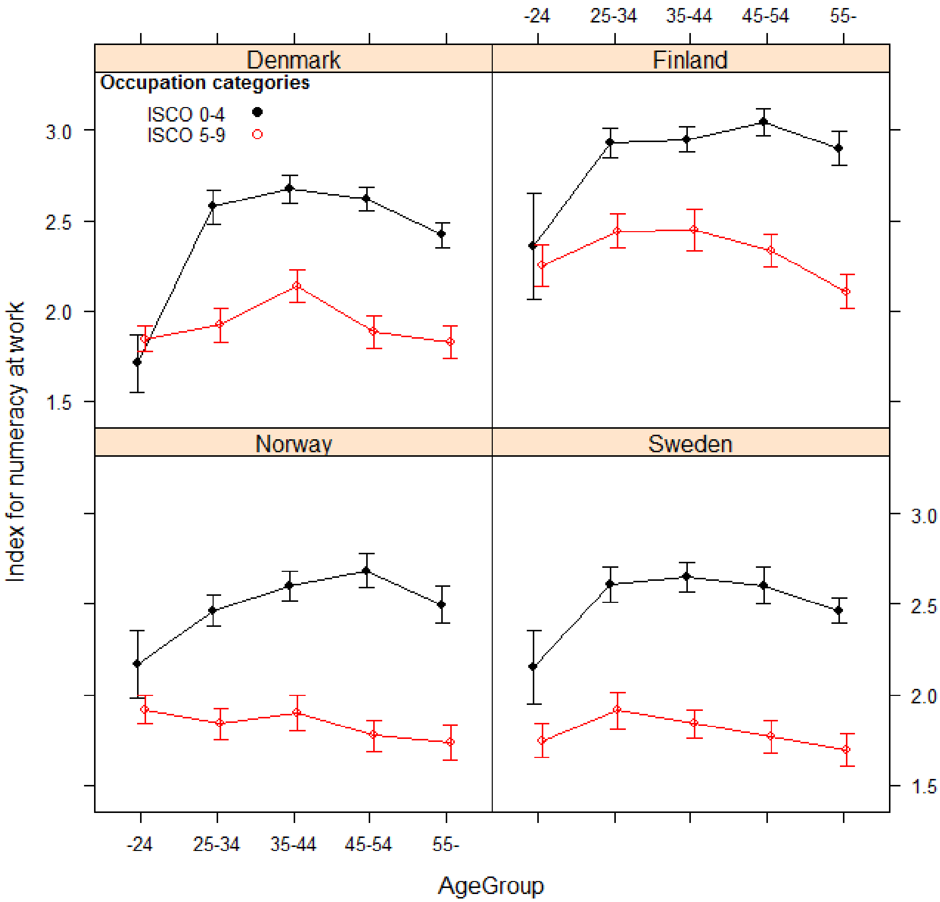
The development the use of numeracy at work in occupational categories ISCO 0–4 is comparable to the use of reading and writing: first an increase from age category 15–24 to age category 25–34 and then constancy for the rest of the working life. In contrast, the use of numeracy in occupational categories ISCO 5–9 is essentially constant through age brackets (there are no significant differences between the use of numeracy at work within the four countries with the exception of age 35–44 in Denmark and age 55–64 in Finland). With respect to the level of the use of numeracy at work, Finland has a more intense use of numeracy at work than Denmark, Norway, and Sweden in both occupational groups.

Finally we look at the intensity of problem solving or ICT at work. The amount of problem solving is assessed from the answers to the following seven questions about how often ICT is used at work: (a) for mail, (b) work related info, (c) conduct transactions, (d) spreadsheets, (e) word, (f) programming language, and (g) real-time discussions. For each respondent the index of problem solving at work is calculated the same way as the mean scores for reading, writing, and numeracy at work.

Figure 7 show the use of problem solving at work. The use of ICT at work appears very similar to the use of reading at work displayed in Figure 4.

The use of ICT in both occupational categories ISCO 0–4 and categories ISCO 5–9 increases significantly from age category 15–24 to age category 25–34. For the

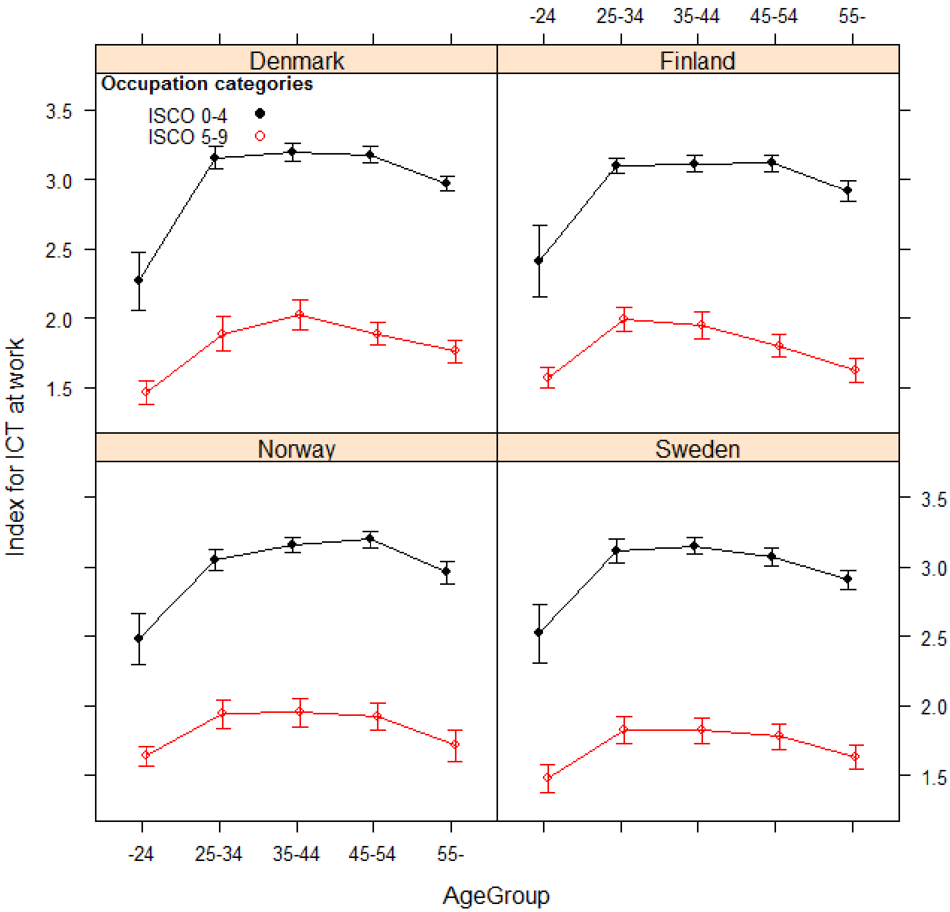
Figure 6. *Numeracy at work in main occupations and ages*



older age classes from age category 25–34 to age category 55–64 there are no significant differences in the use of problem solving at work.

The level of the use of ICT in occupational categories ISCO 0–4 is about the same in all the Nordic countries and the same is the case for the use of ICT in categories ISCO 5–9. However, there appears to be a large difference between the level of the use of ICT in occupational categories ISCO 0–4 compared to occupational categories ISCO 5–9: in all the four countries the difference between the curves for the use of ICT at work appears to be significantly larger than the differences in the

Figure 7. *ICT at work in main occupations and ages*



curves for the use of reading, writing, and numeracy at work. The figures in Table A2 in the appendix confirm that the difference in the use of ICT between the two occupational groups is indeed larger than the difference in use of reading, writing, and numeracy: the differences in the mean use of ICT between categories ISCO 0–4 and ISCO 5–9 are larger than the standard deviations for all four countries, while the differences in mean use of reading, writing, and numeracy between the two occupational groups are less than the standard deviations in all the countries.

This section has shown that the use of CFS at work in the Nordic countries is approximately constant from age category 25–34 to age category 55–64 within occupation groups ISCO 0–4 and ISCO 5–9. However, the use of CFS at work increases from age category 15–24 to age category 25–34 within the two occupational groups.

3.5 Conclusions

This paper has analyzed the amount of measured CFS and the use of CFS at work in the Nordic countries. We have looked at development over age of both measured CFS and the use of CFS at work in two aggregate categories of occupations: a group "ISCO 0–4" that contains major occupations from 0 to 4 and a group "ISCO 5–9" that contains major occupation from 5 to 9. The analysis shows the following.

The amount of measured CFS declines with age from age category 25–34 or age category 35–44 to age category 55–64. The decline is present in both the group ISCO 0–4 and in group ISCO 5–9 and the amount of the decline appears, on the basis of the graphical analysis, to be of about the same magnitude. However, the decrease in human capital over age as measured by CFS is not reflected in decreases in the use of these skills over age.

The use of CFS at work is approximately constant from age category 25–34 to age category 55–64. This constancy is present in both the group ISCO 0–4 and in group ISCO 5–9.

There are substantial differences between the amount and the use of CFS between group "ISCO 0–4" and group "ISCO 5–9". From age category 25–34 both the amount and the use of CFS is substantially higher in group "ISCO 0–4" than in group "ISCO 5–9". Workers with high levels of CFS in the Nordic countries thus appear to sort into occupations with relative intensive use of these skills.

In the introduction we stated that one conjecture in relation to the development of CFS through age brackets might be that the deterioration of skills over age is more pronounced in occupations with a limited use of CFS relative to occupations with more intensive use of these skills. The analysis in this paper shows that this hypothesis is rejected by the present data for the Nordic countries. The decline in measured CFS appears to be of about the same magnitude in both group "ISCO 0–4" and in group "ISCO 5–9". The 'use it or lose it' hypothesis is not supported by the evidence in the present paper.

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Appendix

Table A1. *Scores for literacy, numeracy and problem solving in major occupational groups in the Nordic countries*

	Occupation group	Number	Mean	Standard error	Standard deviation	Standard error
Literacy						
Denmark	ISCO 0-4	3103	290.5	0.9	39.1	0.7
	ISCO 5-9	2193	259.8	1.1	45.2	1.0
Finland	ISCO 0-4	2064	309.1	1.0	41.6	1.0
	ISCO 5-9	1805	279.5	1.3	46.7	1.2
Norway	ISCO 0-4	1982	298.4	0.9	38.3	0.8
	ISCO 5-9	1507	265.8	1.3	46.0	1.2
Sweden	ISCO 0-4	1895	302.2	1.1	40.5	0.9
	ISCO 5-9	1417	269.7	1.2	45.7	1.1
Numeracy						
Denmark	ISCO 0-4	3103	300.3	1.0	44.2	0.8
	ISCO 5-9	2193	267.4	1.2	47.6	1.1
Finland	ISCO 0-4	2064	305.5	1.2	44.2	1.1
	ISCO 5-9	1805	273.3	1.2	47.1	1.2
Norway	ISCO 0-4	1982	301.8	1.2	44.2	1.0
	ISCO 5-9	1507	264.5	1.4	52.0	1.5
Sweden	ISCO 0-4	1895	304.1	1.1	44.1	1.0
	ISCO 5-9	1417	268.5	1.6	50.4	1.1
Problem solving						
Denmark	ISCO 0-4	2928	295.2	0.9	38.4	0.7
	ISCO 5-9	1723	272.2	1.2	41.4	1.0
Finland	ISCO 0-4	1955	300.3	1.1	39.4	0.9
	ISCO 5-9	1419	278.7	1.3	40.8	0.9
Norway	ISCO 0-4	1888	297.6	0.9	36.0	0.9
	ISCO 5-9	1275	277.8	1.3	40.0	1.1
Sweden	ISCO 0-4	1825	301.6	1.1	39.3	0.9
	ISCO 5-9	1203	275.0	1.4	42.7	1.1

Notes: ISCO 0-4 is major occupational group 0-4 and ISCO 5-9 is major occupational group 5-9 in the International Standard Classification of Occupations.

Table A2. *Reading, writing, calculating and problem solving at work in major occupational* groups in the Nordic countries

	Occupation group	Number	Mean	Standard error	Standard deviation	Standard error
Reading						
Denmark	ISCO 0-4	3,100	3.19	0.01	0.73	0.01
	ISCO 5-9	2,192	2.36	0.02	0.90	0.01
Finland	ISCO 0-4	2,063	3.27	0.02	0.66	0.01
	ISCO 5-9	1,800	2.52	0.02	0.81	0.01
Norway	ISCO 0-4	1,981	3.24	0.02	0.64	0.01
	ISCO 5-9	1,506	2.56	0.02	0.81	0.01
Sweden	ISCO 0-4	1,894	3.23	0.01	0.66	0.01
	ISCO 5-9	1,415	2.41	0.02	0.82	0.01
Writing						
Denmark	ISCO 0-4	3,100	2.87	0.02	0.71	0.01
	ISCO 5-9	2,192	2.20	0.02	0.93	0.01
Finland	ISCO 0-4	2,063	3.02	0.01	0.65	0.01
	ISCO 5-9	1,800	2.29	0.02	0.87	0.01
Norway	ISCO 0-4	1,981	3.06	0.02	0.63	0.01
	ISCO 5-9	1,506	2.41	0.02	0.90	0.01
Sweden	ISCO 0-4	1,894	2.77	0.01	0.66	0.01
	ISCO 5-9	1,414	2.03	0.02	0.81	0.01
Calculating						
Denmark	ISCO 0-4	3,100	2.54	0.02	1.04	0.01
	ISCO 5-9	2,192	1.93	0.02	0.88	0.01
Finland	ISCO 0-4	2,063	2.94	0.02	0.95	0.01
	ISCO 5-9	1,800	2.32	0.02	0.95	0.01
Norway	ISCO 0-4	1,981	2.55	0.02	0.96	0.01
	ISCO 5-9	1,506	1.84	0.02	0.80	0.01
Sweden	ISCO 0-4	1,894	2.57	0.02	0.95	0.01
	ISCO 5-9	1,415	1.79	0.02	0.77	0.01
Problem solving						
Denmark	ISCO 0-4	3,101	3.09	0.02	0.86	0.01
	ISCO 5-9	2,192	1.80	0.02	0.94	0.01
Finland	ISCO 0-4	2,063	3.04	0.02	0.74	0.01
	ISCO 5-9	1,802	1.79	0.02	0.84	0.01
Norway	ISCO 0-4	1,982	3.08	0.02	0.76	0.01
	ISCO 5-9	1,506	1.83	0.02	0.86	0.02
Sweden	ISCO 0-4	1,894	3.04	0.02	0.72	0.01
	ISCO 5-9	1,416	1.72	0.02	0.78	0.01

Notes: ISCO 0-4 is major occupational group 0-4 and ISCO 5-9 is major occupational group 5-9 in the International Standard Classification of Occupations.

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4

Adult education and training in the Nordic countries

Abstract: Adult education and training (AET) is an essential part of life-long learning as it may help adults to halt the decline in their key competencies and develop them further. Based on PIAAC 2012 data, this article focuses on describing participation in formal and non-formal AET in the Nordic countries by age, educational level, occupation, and gender. Furthermore, the association between the key information processing skills and participation in adult education is studied. In this analysis, the educational attainment, age, occupation, and gender of the respondents are controlled. The results show that overall participation in adult education in the four Nordic countries studied is equally high, and in all the Nordic countries non-formal adult education is clearly more common than formal education. Participation in AET varies by age, education and occupation in every Nordic country studied and there are many similarities, but also some differences, between the Nordic countries in their success in drawing different groups of adults to education. The analysis shows that participation in adult education is associated with adults' information processing skills but the adjusted score point differences show very small differences between those who had participated in AET in the 12 months preceding the survey and those who had not. These findings and the limitations of the cross-sectional study are discussed.

4.1 Introduction

The role of life-long learning in competitiveness and employability, social inclusion, and active citizenship has been acknowledged for some time, and adult education is seen as an essential part of its framework. In fact, adult education and training (AET) is often considered to be the main type of life-long learning, which in its many forms may help adults to halt the decline in their key competencies and develop them further (OECD, 2013a, p. 208). In addition, the European Union's (EU) expert group on literacy emphasized the need for high-quality AET in a recent report (HLG, 2012, p. 52). Consequently, the EU has established a benchmark for adult participation in life-long learning: the objective is for 15% of European adults (age 25–64) to be participating in life-long learning activities by 2020. Within the EU, only five countries (Denmark, the Netherlands, Finland, Sweden, and the United Kingdom) have exceeded the benchmark so far, and only Denmark, Finland, and Sweden have achieved participation levels well above 20% (European Commission, 2013, pp. 57–58).

A particular concern in the EU is reducing the number of adults with low-level skills, and increasing participation in adult education is one way to address this issue. Indeed, based on the PIAAC (Programme for the International Assessment of Adult Competencies) results, in all the participating countries there were adults with low levels of key competences (OECD, 2013a), including in the countries where overall performance was relatively high. In some countries, the overall performance has been worryingly low. This intensifies the focus on life-long learning, and adult education in particular, since in our rapidly changing world all adults, irrespective of their level of educational attainment, occupation, and age, frequently face situations in which they need to adapt to new demands that require updating their key competencies. In countries that offer a wide range of opportunities for life-long learning, adults are well equipped for changes to work, in their personal life, and in society at large. The PIAAC results confirm that the Nordic countries of Denmark, Finland, Norway, and Sweden qualify as such countries, as they were among the five countries in which the participation rates in adult education exceeded 60%, together with the Netherlands. In these countries, adults of all (literacy) proficiency levels are eager to use opportunities for adult education. However, as with all countries participating in PIAAC, adults with higher proficiency levels are more active participants in adult education than those with lower levels of proficiency (OECD, 2013a, pp. 208–209).

This article focuses in detail on AET in the four Nordic countries of Denmark, Finland, Norway, and Sweden. The population studied is 16–65-year-olds, excluding 16–24-year-olds still in their initial cycle of studies. Consequently, 64% of participants in this age group are excluded, which equates to 11% of all participants in the Nordic countries. The data used will be PIAAC-based, which includes information about both formal and non-formal adult education. Formal refers to education resulting in formal qualifications, whereas non-formal refers to various forms of more or less organized training that does not result in formal qualifications, such as a degree (e.g. workshops, seminars, private lessons, instruction given by colleagues or supervisors). Formal education and training comprises education that is institutionalized, intentional, and planned through public organizations and recognized private bodies. Non-formal education is institutionalized, intentional, and planned by an education provider, and generally leads to qualifications not recognized as formal qualifications by the relevant national educational authorities, or to no qualifications at all (OECD, 2013b, p. 46). Additionally, the data includes detailed information about job-related and non-job-related training, including duration and usefulness (OECD, 2013b, p. 39).

First, the article describes participation in formal and non-formal adult education in the Nordic countries, and by different groups of adults by age (10-year intervals), educational level (low, medium vocational, medium general, high), occupation (skilled, semi-skilled white-collar, semi-skilled blue-collar, elementary occupations), and gender. This gives an overview of the participation rate of AET, and enables comparisons between countries. In addition, the reasons for participating in adult education are studied (job-related or not, main reason for participating).

Second, the article examines the association between the key information processing skills, i.e. literacy, numeracy, and problem solving in technology-rich environments, and participation in adult education. In this analysis, it is necessary to control the educational attainment, age, occupation, gender, and native language of the respondents. It must be noted, however, that conclusions about the effectiveness of the adult education cannot be made based on PIAAC data. This type of study would, at the very least, require information about the participants' proficiency level prior to beginning adult education.

4.2 Participation in adult education and training in the Nordic countries

In this and the following chapter, Nordic adults' participation rate in adult education is examined in detail. Table 1 shows that the overall participation rate in adult education varies very little among the Nordic countries, since in each country nearly two-thirds of adults participated either in formal or non-formal adult education. However, this means that a third of adults did not participate in any kind of adult education in the 12 months preceding the survey. This includes both formal education resulting in formal qualifications and non-formal events such as on-the-job instruction by colleagues and workshops. These adults may have participated in adult education earlier, of course, but have not done so recently.

Table 1. *Percentage of adults participating in formal and/or non-formal AET by country*

	Denmark	Finland	Norway	Sweden	Average
Formal or non-formal AET:					
Overall participation rate	66.8	66.0	64.8	65.4	65.8
Reason for participation:					
Job-related	77.9	72.7	76.3	72.0	74.7
Non-job-related	11.9	16.0	11.7	19.6	14.8
Unknown	10.1	11.3	12.1	8.3	10.4
Formal AET:					
Overall participation rate	17.9	16.5	18.0	14.2	16.7
Reason for participation:					
Job-related	80.2	79.0	72.6	70.0	75.5
Non-job-related	9.0	19.2	15.5	28.1	18.0
Unknown	10.8	1.8	11.8	1.9	6.6
Non-formal AET:					
Overall participation rate	59.9	60.4	58.8	60.2	59.8
Reason for participation:					
Job-related	76.2	70.3	76.7	72.3	73.9
Non-job-related	13.7	16.0	11.2	17.8	14.7
Unknown	10.0	13.7	12.1	9.9	11.4

In each Nordic country, non-formal adult education is more common than education resulting in formal qualifications (Table 1). Approximately 60% of adults in each country participated in non-formal instruction in the year preceding the survey, while the percentage of adults participating in formal education was far smaller, varying between 14% and 18% in the Nordic countries. This is hardly surprising because non-formal education usually takes place over a shorter period than formal education, which requires a longer commitment. Overall, there seems to be more unity than diversity among the Nordic countries, given that the participation profiles in adult education are rather similar.

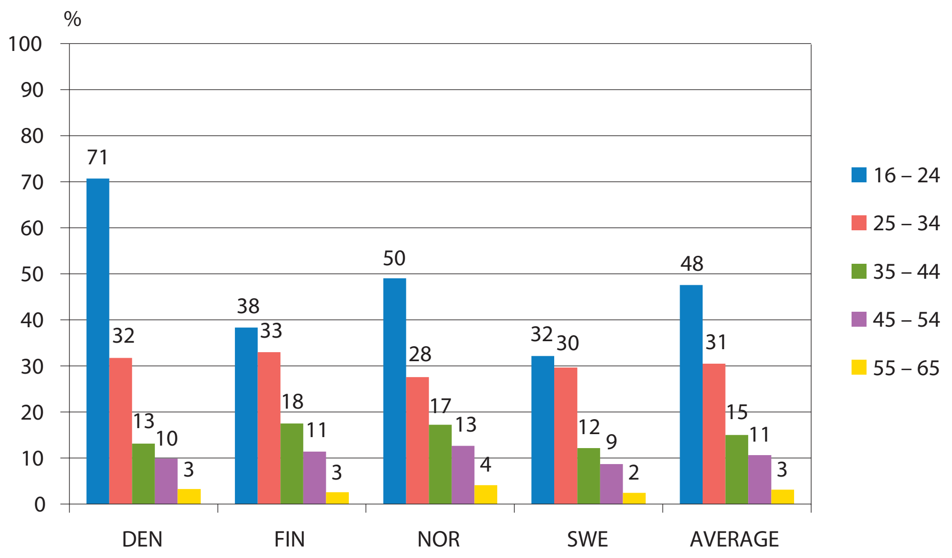
In all Nordic countries, and for both formal and non-formal education, adults usually participated in adult education for job-related reasons (Table 1). The job-related reasons for participating in adult education also dominated when adults were asked to describe their *latest training* in more detail (whereas Table 1 describes the overall participation in the 12 months preceding the survey): 82% of Norwegian adults participating in adult education reported that the reason for the latest activity was job-related, as did 78% and 74% of adults in Denmark and Sweden, respectively. In Finland, the percentage was slightly smaller, standing at 67%. The most common reason for participating in the latest educational activity in all Nordic countries was the desire to do their job better or to improve their career prospects (this varied from 35% in Norway to 52% in Sweden). However, many of the adults were obliged to participate in the activity (this varied from 10% in Sweden to 24% in Finland). On the other hand, they participated in many of the activities due to having an interest in some knowledge or skills (this varied from 24% in Sweden to 32% in Norway).

4.3 Participation in adult education and training in the Nordic countries by age, gender, educational level, and occupation

The *overall participation rate* in adult education (both formal and non-formal) was the highest in the youngest age groups and lowest in the oldest age group. Among 24-year-olds or younger, the overall participation rate varied from 73% in Sweden to 86% in Denmark, while among the 55-year-olds and older it varied from 41% in Norway to 49% in Sweden. In Denmark and Norway, the participation rate was highest in the youngest age group, but in Finland and Sweden, the participation rate was highest among 25–34-year-olds, albeit this was only slightly higher than in the youngest age group.

The *formal adult education* (which was less common than the non-formal) shows a clear association with age in each Nordic country, as indicated by Figure 1. In Denmark and Norway, there were drastic differences between the youngest and other age groups, as approximately 70% and nearly half of 24-year-olds and younger adults participated in formal education during the year preceding the survey, respectively. The youngest age group also presented the clearest differences between the Nordic countries, as in Finland and Sweden, 38% and 32% of the youngest adults participated in formal education, respectively. The high participation rate among the youngest group in Denmark and Norway can most likely be explained by the features of their educational systems; for example, in Denmark, the parallel competence system gives all adults opportunities for formal education and training. In the other age groups, the differences between countries were much smaller; among the 25–34-year-olds, the participation

Figure 1. *Percentage of adults participating in formal AET by country and by age*

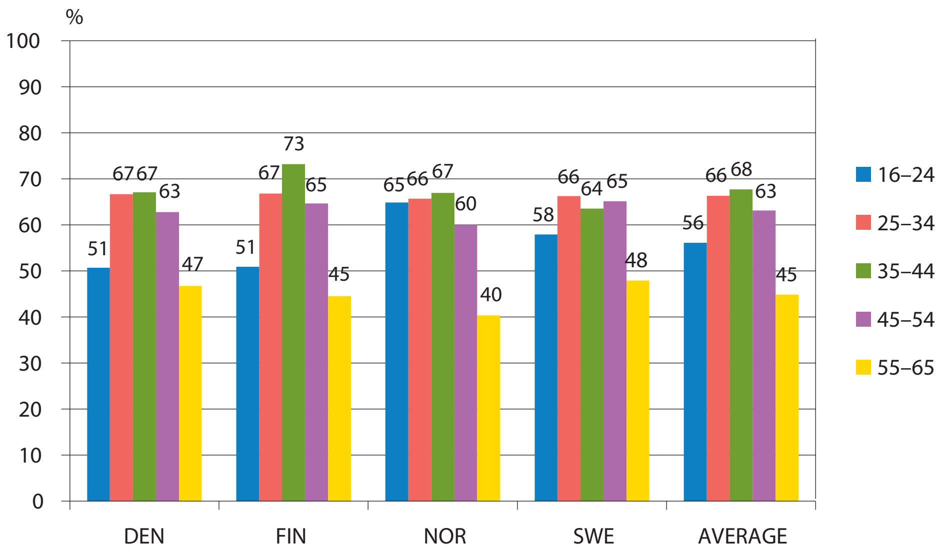


Note: The 16–24 years-old age group excludes 64% of participants still in their initial cycle of studies.

rate varied from 28% in Norway to 33% in Finland. Among 35–44-year-olds and 45–54-year-olds, the rate of participation in formal education was slightly lower in Denmark and Sweden than in Norway and Finland, but in each Nordic country, participation in formal adult education was very rare in the oldest age group (from 2% to 4%).

In *non-formal adult education*, the differences between age groups were less striking. In all four countries the participation rate was highest (at least 60%) in the age groups 25–34, 35–44, and 45–54 (Figure 2). Participation rates among these three age groups were relatively even, varying within four percentage points in Denmark and Sweden and seven percentage points in Norway. The Finnish 35–44-year-olds were an exception, as they were the most active age group in non-formal adult education, with 73% of adults having participated during the year preceding the survey. Additionally, in Norway, adults in the youngest age group were as active as adults in the next two age groups. In each Nordic country, the oldest adults in the survey were least active in non-formal education. However, between 40% and 48% of adults in this age group participated.

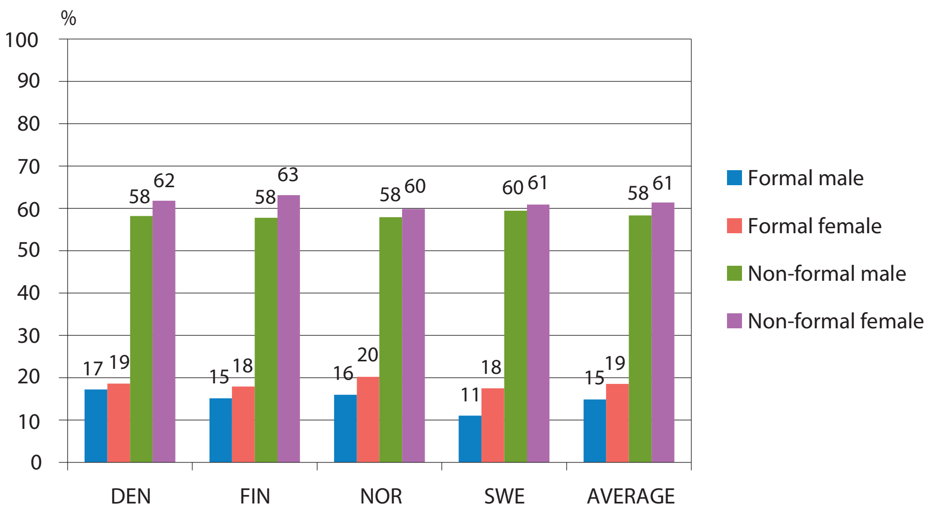
Figure 2. *Percentage of adults participating in non-formal AET by country and by age*



Note: The 16–24 years-old age group excludes 64% of participants still in their initial cycle of studies.

With regard to gender, there are consistent differences that show females were more active than men in all adult education, although the differences were relatively minor. The *overall participation rate* for men was 63–65%, and for women 66–69%. The most active men in this respect came from Denmark, and the most active women from Finland. The gender differences in the overall participation rate varied from two percentage points in Norway to six percentage points in Finland. In addition, in *formal education* (Figure 3), gender differences in the participation rate were relatively small, between two and four percentage points, except in Sweden, where the gender difference was seven percentage points. Swedish men were the least active participants in formal education, as 11% of Swedish men, compared to between 15% and 17% of men in other Nordic countries, participated in formal education in the year preceding the survey. For women, the participation rate varied from 18% in Sweden to 20% in Norway. In *non-formal education* (Figure 3), the gender difference varied from one percentage point in Sweden to five percentage points in Finland. The participation rate for men was 60% in Sweden and 58% in other Nordic countries, and for women was between 60% and 63%, with Finnish women being the most active group. The pattern for gender differences for women is broken by job-related non-formal education, as in Finland and Sweden, men were slightly more active than women (albeit only by one percentage point) or equally active,

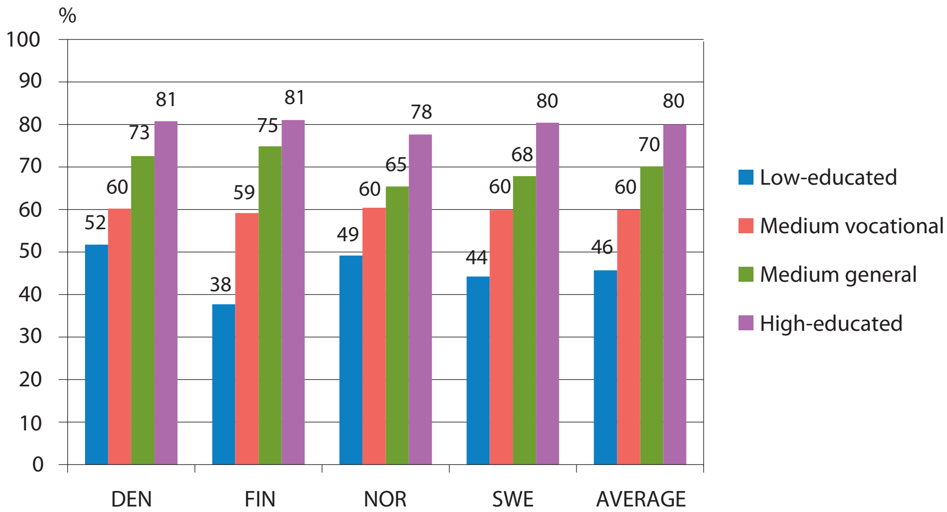
Figure 3. *Percentage of adults participating in formal and non-formal AET by country and by gender*



as in Denmark and Norway. In job-related formal education, women were more active, with between one and five percentage points of difference. Non-job-related non-formal activities were most clearly more common among females than males, particularly in Finland, where 7% of men and 14% of females participated in this kind of activity in the year preceding the survey.

In addition to age and to some extent gender, the *overall participation* in adult education is also associated with educational level. As shown in Figure 4, increases in adult participation rates corresponded to increases in educational level. This holds for all Nordic countries. Among adults with a lower education level (less than an upper secondary degree – ISCED 1, 2, 3C shorter than two years, or less), Finnish adults had the lowest participation rate of 38%. However, in Denmark and Norway, approximately every second adult in this group reported participating in some kind of educational activity in the year prior to the survey. Among adults with a medium-level education (upper secondary – ISCED 3A–B, C, two years or more) and post-secondary non-tertiary (ISCED 4) qualifications, there was a clear difference between those with vocational education and training and those with a general education in all Nordic countries. In each country studied, the overall participation rate in adult education among adults with medium-level vocational training was

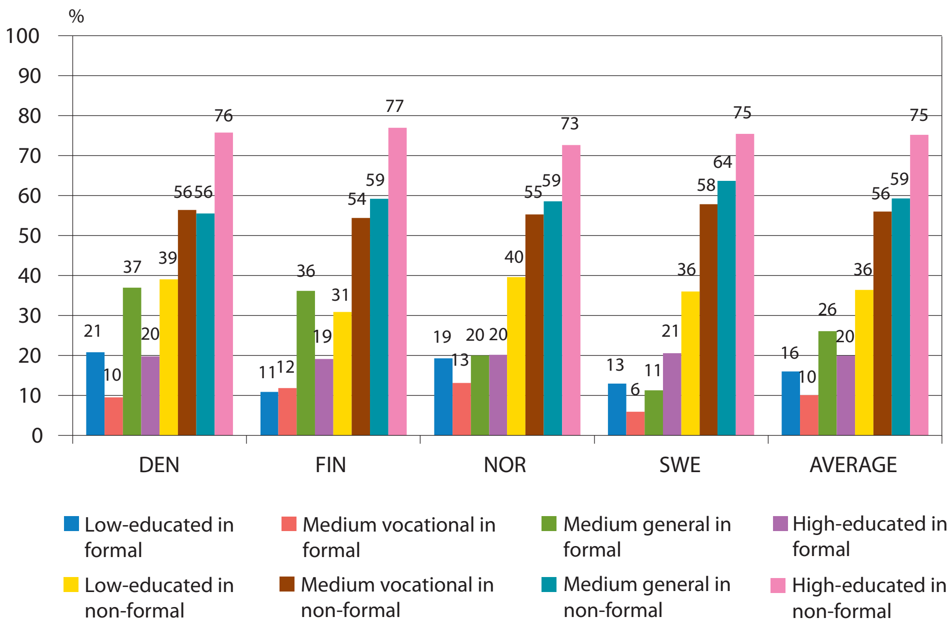
Figure 4. *Percentage of adults participating in either formal or non-formal AET by country and by educational level*



approximately 60%. Among adults with a general medium-level education, there was greater variation among the Nordic countries, as the overall participation rate varied from 65% in Norway to 75% in Finland. Among adults with a high-level education (higher than an upper secondary degree – ISCED 5B, 5A, 6), the overall participation rate varied between 78% and 81%.

There are similarities between *non-formal education* and overall participation when considering the association between participating in adult education activities and educational level, as the participation rate is greater when the adults' educational level is higher (Figure 5). Among adults with a low educational level, the participation rate varied from 31% in Finland to approximately 40% in Denmark and Norway. Among those with medium-level qualifications, the participation rate was higher for those with a general education, as opposed to those with vocational training, in every country except Denmark, where there was practically no difference. There was little difference in the other Nordic countries, varying from four to six percentage points. Among the highly educated adults, the participation rate was

Figure 5. *Percentage of adults participating in formal and non-formal AET by country and by educational level*

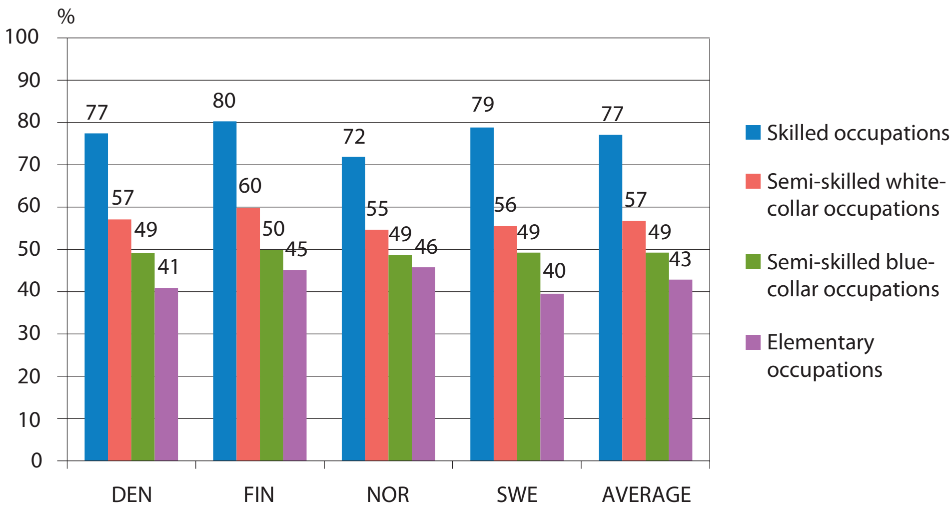


highest, and varied between 73% and 77%. In Finland, the difference in participation rates between those with a low and high educational level was the greatest, as the former group was less active than in the other three countries.

In *formal adult education*, the relationship between participation in adult education and educational level is less straightforward than in overall participation or non-formal education, as shown in Figure 5. In Denmark, Norway, and Sweden, the participation rate in formal education was lowest among adults with medium-level vocational qualifications. In Finland, however, adults with a low-level education and medium-level vocational qualifications had nearly equally low participation rates in formal education. Thus, the other Nordic countries have succeeded in getting low-educated adults into formal adult education more successfully than Finland. This is particularly true in Denmark and Norway, where approximately every fifth low-educated adult reported participating in formal adult education in the year prior to the survey. In the Nordic context, adults participating most in formal AET are Danish and Finnish adults with medium-level general qualifications. In Norway, and particularly in Sweden, the participation rate among this education-level group was clearly lower. Meanwhile, in every Nordic country, every fifth adult with high-level qualifications participated in formal adult education in the year before the survey took place.

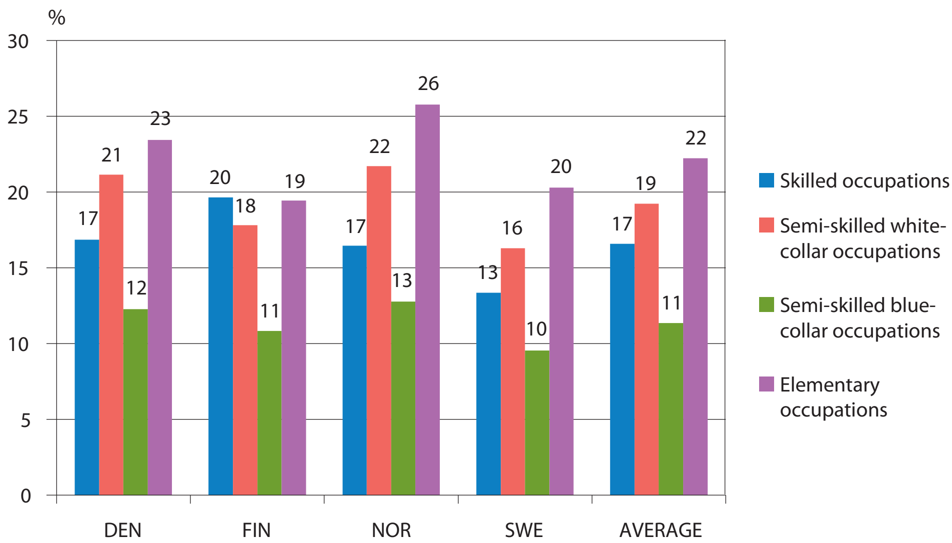
The type of occupation – skilled, semi-skilled white-collar, semi-skilled blue-collar, or elementary – is also associated with participation in adult education, and the relationship is straightforward with regard to overall participation rate or non-formal education. In each Nordic country, adults in skilled occupations (legislators, senior officials and managers, professionals, and technicians) had the highest participation rate; semi-skilled white-collar workers (clerks, service, and sales workers) the second highest rate; and semi-skilled blue-collar workers (skilled agricultural and fishery workers, craft and trades workers, plant and machine operators, and assemblers) and workers in elementary occupations the next highest participation rates, with the two latter groups being approximately equally active in adult education overall. In *overall participation*, Finnish adults in skilled occupations showed the highest participation rate among those in skilled occupations (84%), and also among all occupational groups. Among adults with elementary occupations, Swedish adults showed the lowest overall participation rate, 52%, which was also the lowest among all groups by occupation and by country. Norwegian adults in elementary occupations were the most active in that occupational group across the Nordic countries (58%). The participation rate among adults with semi-skilled white-collar occupations varied from 62% in Sweden to 67% in Finland, and it was 54% and 55% among semi-skilled blue-collar workers. In *non-formal adult education*, the relationship between occupational status and adult education is even clearer, as Figure 6 shows. Among adults in skilled occupations, the participation rate varied from 72% in Norway to 80% in Finland; among those with semi-skilled white-collar occupations it varied from 55% in Norway to 60% in Finland; among semi-skilled blue-collar workers it was between 49% and 50% across the Nordic countries; and among elementary workers the participation rate in non-formal education varied from 40% in Sweden to 46% in Norway.

Figure 6. *Percentage of adults participating in non-formal AET by country and by occupation*



Again, with *formal adult education* the relationship with occupation is not as straightforward as with overall participation rate or non-formal education. In each Nordic country, with the exception of Finland, adults in elementary occupations participate most actively of all occupational groups in formal adult education, the participation rate varying from 20% in Sweden to 26% in Norway (Figure 7). In addition, adults in elementary occupations in Finland had a 19% participation rate, which was almost as high as that of skilled workers (20%), these two groups of adults being the two most active by occupation in Finland. Semi-skilled white-collar workers in each country reported relatively active participation in formal education in the year preceding the survey, with the participation rate varying from 16% in Sweden to 22% in Norway. In all countries except Finland, this was the second most active group of adults by occupation. Overall, in each country, the occupational group with the lowest participation rate in formal adult education was semi-skilled blue-collar workers.

Figure 7. *Percentage of adults participating in formal AET by country and by occupation*



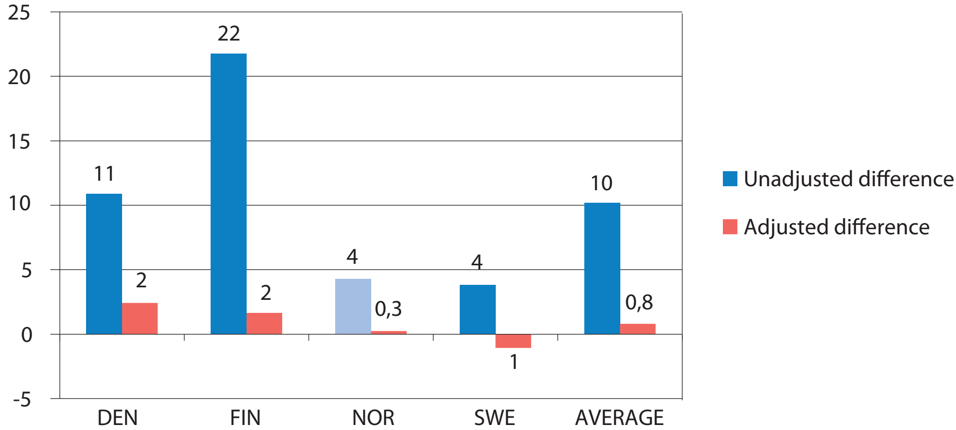
4.4 Participation in adult education and key information processing skills

In this chapter, we study the association between participation in adult education and adults' key information processing skills, literacy, numeracy, and problem solving. Both unadjusted and adjusted score point differences between adults who had and had not participated in formal and non-formal adult education were calculated. For adjusted differences, respondents' age, education, gender, occupation, and native language, i.e. if it was the same as the test language, have been controlled.

Participation in formal adult education is associated with adults' information processing skills. This holds for all Nordic countries in problem solving in technology-rich environments, for Denmark, Norway, and Finland in literacy (the difference in Sweden was not statistically significant, p=.215), and for Denmark and Finland in numeracy (the differences in Norway and Sweden were not statistically significant), as shown in Figures 8a–8c. Thus, adults who participated in formal adult education had – on average – better skills than non-participants. The unadjusted score point difference in literacy between those who had participated in formal education in the 12 months preceding the survey and those who had not was four score points in Norway and eleven score points in Denmark (Figure 8a). In Finland, however, the figure was much higher, standing at 22 score points. The corresponding score point difference in numeracy was non-existent and not statistically significant in Norway and Sweden, five score points in Denmark, and again clearly more in Finland, at 20 score points (Figure 8b). In problem solving, the score point difference between those who had participated in formal education and those who had not was bigger than in other skill areas in each Nordic country, being as much as 23 score points in Finland and between 12 and 16 score points in the other countries (Figure 8c). It must be noted, however, that in each country there were adults who did not participate in the problem solving assessment due to a lack of basic computer skills or confidence in computer use (12%–19%). These adults were not equally distributed among all groups, but most likely were older people with less education (e.g. Malin, Sulkunen, & Laine, 2013). These groups were less likely to participate in adult education, which most likely is reflected in the score point differences in problem solving.

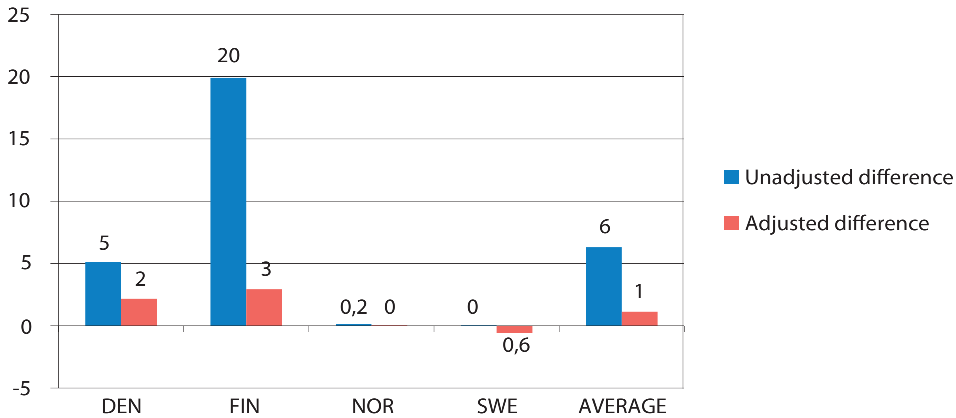
The unadjusted score point differences were biggest in Finland, which possibly reflects the results described earlier in this article: Finnish adults in skilled professions are more active adult education participants than their peers with similar characteristics in other Nordic countries. Thus, it is likely that the skills of Finnish adults participating in formal adult education are of a relatively high level in comparison with Finnish adults who do not participate, which in part explains the large score point differences.

Figure 8a. *Unadjusted and adjusted score point differences in literacy by participation in formal AET and by country*



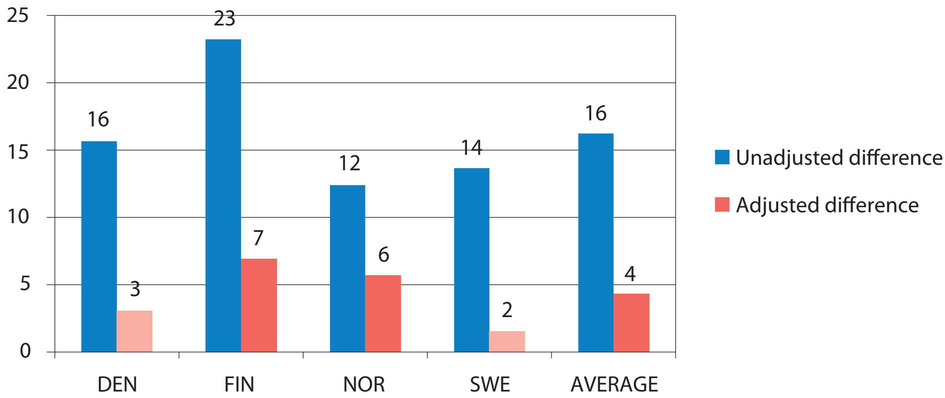
Adjusted for age, education, gender, occupation, and native language.
Statistically significant differences are marked in a darker tone.

Figure 8b. *Unadjusted and adjusted score point differences in numeracy by participation in formal AET and by country*



Adjusted for age, education, gender, occupation, and native language.
Statistically significant differences are marked in a darker tone.

Figure 8c. *Unadjusted and adjusted score point differences in problem solving in technology-rich environments by participation in formal AET and by country*

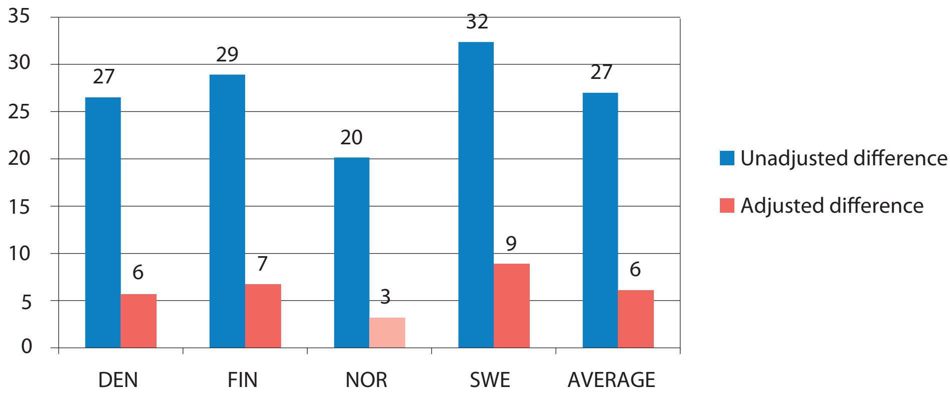


Adjusted for age, education, gender, occupation, and native language.
Statistically significant differences are marked in a darker tone.

In contrast to the unadjusted score point differences, the adjusted score point differences show very small differences between those who had participated in formal education in the 12 months preceding the survey and those who had not (Figures 8a–8c). In literacy, the score point differences narrowed down to a maximum of two score points, and in numeracy to three score points or less, and the differences were not statistically significant. In problem solving, the differences were between two and seven score points, and they were statistically significant only in Finland and Norway. In Sweden, the adjusted difference in literacy and numeracy was actually negative, although not statistically significant, which means that those who had not participated in formal adult education may have a slightly higher score than those who had participated. In all, this means that there were differences in information processing skills between adults participating in formal education activities and those not participating, but the differences are mostly explained by age, education, occupation, gender, and respondents' familiarity with the test language, and not by adult education activities. This holds for all Nordic countries.

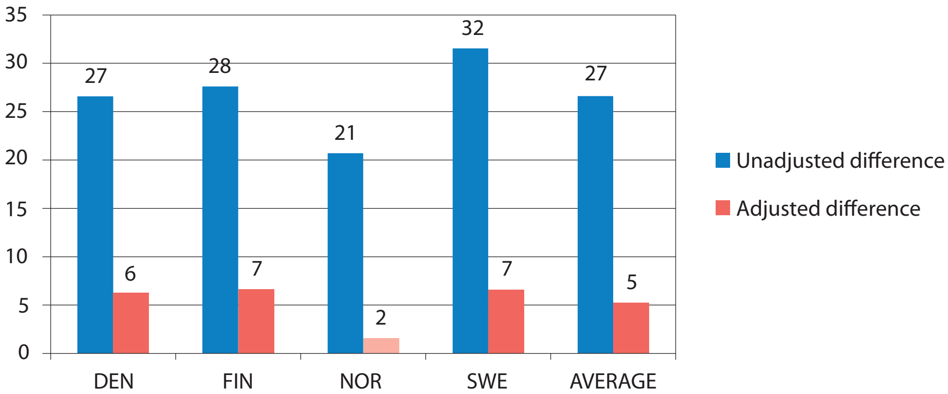
In *non-formal education*, the association between participation in adult education and information processing skills is stronger than in formal education in each Nordic country, although in Finland the difference is noticeably smaller than in other Nordic countries. This again means that those who participated had better skills – on average – than those who had not. The unadjusted score point difference in literacy between those who had participated in non-formal adult education in the 12 months preceding the survey and those who had not was as much as 20 score points in Norway, 27 in Denmark, 29 in Finland, and 32 in Sweden (Figure 9a). In numeracy (Figure 9b), the unadjusted score point differences were almost the same, varying from 21 score points in Norway to 32 in Sweden. In addition, in problem solving in technology-rich environments, those who had participated in non-formal adult education had higher scores and thus better skills than those who had not participated. The score point difference was the smallest in Finland, at 16 score points, and the largest in Sweden, at 26 score points (Figure 9c). Thus, in Finland, the association between problem solving skills and participation in non-formal adult education is weaker than in formal adult education. This is the opposite of what is found in the other Nordic countries.

Figure 9a. *Unadjusted and adjusted score point differences in literacy by participation in non-formal AET and by country*



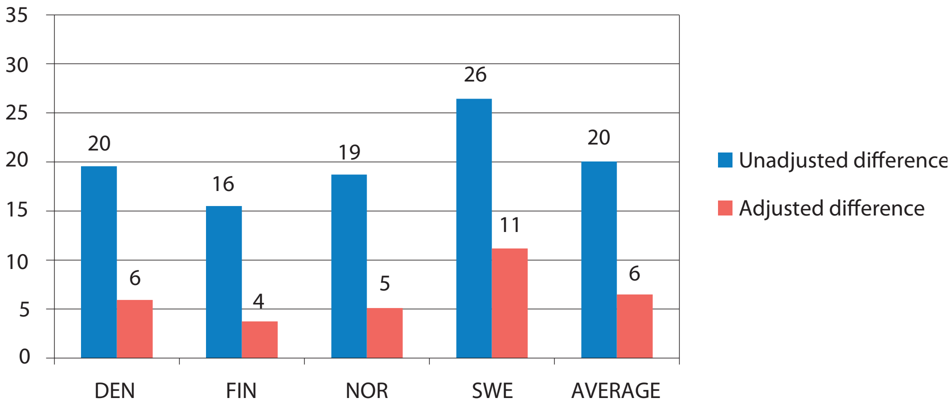
Adjusted for age, education, gender, occupation, and native language.
Statistically significant differences are marked in a darker tone.

Figure 9b. *Unadjusted and adjusted score point differences in numeracy by participation in non-formal AET and by country*



Adjusted for age, education, gender, occupation, and native language.
Statistically significant differences are marked in a darker tone.

Figure 9c. *Unadjusted and adjusted score point differences in problem solving in technology-rich environments by participation in non-formal AET and by country*



Adjusted for age, education, gender, occupation, and native language.
Statistically significant differences are marked in a darker tone.

Similar to formal adult education, in non-formal education the adjusted score point differences are clearly smaller than the unadjusted ones (Figures 9a–9c). In literacy, the score point differences narrow down to between three and nine score points, in numeracy to between two and seven score points, and in problem solving to between four and eleven score points. The smallest differences in literacy and numeracy were found in Norway, and these were not statistically significant. Once again, most of the differences in key skills between those who participated in non-formal adult education and those who did not were explained by respondents' age, gender, education, occupation, and familiarity with the test language.

4.5 Conclusions

The results of the study show that overall participation in adult education in the four Nordic countries studied is equally high, and very high in terms of an international comparison (OECD, 2013a, pp. 208–209). In all the Nordic countries, non-formal adult education, which typically includes diverse short-term training events, was clearly more common than formal education that requires a longer commitment. The overall differences between the Nordic countries were minor, but the Swedish participation rate in formal adult education was slightly lower than in the other three countries. Generally, the Nordic countries are a highly homogeneous entity in terms of participation in adult education.

Particularly in relation to long-term formal adult education, the challenge lies in getting those who need the programs most – those with the poorest skills or lowest qualifications – to participate. The results described above show that some groups' participation in adult education is lower than other comparable groups. Additionally, there are many similarities, but also some differences, between the Nordic countries in their success in drawing different groups to adult education. In formal adult education, every Nordic country succeeded in getting the youngest adults, aged 24 or below, to adult education. Norway and Denmark were particularly successful in this, since the Norwegian and Danish young adults participated more actively in formal adult education than their peers in Finland and Sweden. This is most likely explained by the fact that their educational systems offer parallel competence provisions. Likewise, in every country, participation in formal education among the oldest groups of adults, those 55 years old or older, was clearly less common than in the younger groups. However, adults in this older age group have many active years left, and would benefit from training their basic competences given that their average performance in each Nordic country was lowest in all PIAAC-measured skills (OECD, 2013a, pp. 106–108). However, one can question whether adult education resulting in new professional degrees is the best type of training in basic competencies for this age group. Indeed, an average of 45% of adults aged 55–65 participated in non-formal adult education in the Nordic countries. Content-wise, non-formal training can include a diverse range of topics, and not all of the training is targeted at basic competencies.

The educational groups that the Nordic countries have succeeded in best drawing to formal education include adults with a general medium-level education in Denmark and Finland, high-educated adults in Sweden, and both of these groups in Norway. Denmark and Norway have succeeded in getting the low-educated into formal adult education to a greater extent than Finland and Sweden. The most neglected educational group in every country was that of adults with vocational medium-level qualifications, and in Finland also the low-educated adults, and these are the two educational groups with the lowest average performance in the key competencies measured in PIAAC (OECD, 2013a, p. 119; Malin et al., 2013, pp. 38–39). Occupational groups most active in formal adult education within each country were adults with elementary occupations, except in Finland where adults in skilled occupations were equally as active. Indeed, among the Nordic countries, Finland has had most success in drawing adults in skilled occupations into formal education, but the least success in getting adults in elementary occupations to formal training. The most passive participants by occupation came from the group of semi-skilled blue-collar occupations in every Nordic country.

In non-formal education, in which participation rates clearly exceeded those for formal education in every Nordic country, adults aged 25–54 were the most active participants, and adults aged 55 or older were the most passive. Nevertheless, among the oldest age group nearly half of adults participated in some type of non-formal adult education or training, but despite this, this age group has the greatest needs in developing key competences further, as discussed above. Clearly, more could be done better engage this group with adult education in each Nordic country.

In non-formal adult education, each Nordic country has managed to get more high-educated adults to participate in adult education than adults with medium-level qualifications, who in turn participated more than low-educated adults. This was also the case – to some degree – with formal education, which suggests that a solid initial education provides adults with easy access to adult education, as these adults are likely to have positive experiences of learning and good studying skills. In every country but Denmark, however, there was again a divide involving the group of adults with medium-level qualifications, albeit not as grave as that found in formal education; adults with vocational medium-level qualifications participated less actively in non-formal adult education than those with a general medium-level education. Finland failed to match the achievements of the other countries in getting the low-educated adults into non-formal education and training. The occupational group that participated most actively in non-formal adult education in every Nordic country was that of adults in skilled occupations, whereas adults in elementary occupations were the least active participants. In Finland, all occupational groups except the elementary one were slightly more active in non-formal adult education than in other Nordic countries, while Norway best reached the adults in elementary occupations.

What are the measures to take to draw into education the groups of adults who need it most? Furthermore, to what extent have the measures taken so far been effective? For example, the Finnish NOSTE program, implemented in 2003–2009 as a result of IALS (International Adult Literacy Survey), focused on a clearly defined target group of adults with low educational levels and an incomplete secondary education, if any, and developed numerous outreach activities for this purpose (MEC, 2010, pp. 11–16). The aim was to meet the adults in their everyday environment (e.g. at work) and to disseminate information about the opportunities the program offered through different media and local authorities, campaigns, and roadshows to gain maximum visibility. According to a recent European report (European Commission, 2013), Finland and Sweden have developed flexible study opportunities for adults, and Finland utilizes career guidance to increase participation in adult education. Finland has also developed web-based guidance and implemented awareness campaigns for adult learners. In both Finland and Sweden, new modes of learning and individualized approaches have been introduced, as well as outreach activities and exemption from training fees for low-skilled adults in Finland. Indeed, the PIAAC results confirm the need for all these activities, as, for instance, the well-educated and those working in skilled occupations are still the most active in Finnish adult education, and the most neglected groups are those with the lowest basic competencies. The same phenomenon is evident in the other Nordic countries, but it is most pronounced in Finland.

Overall, the current results raise interesting questions, more so than providing clear answers. Why in every country, and particularly in Finland, are the best-educated and skilled adults also the most active participants in adult education? Are these adults inherently more motivated to participate in adult education than their low-educated peers in less-skilled occupations? Are there enough reach-out activities and information about adult education freely and easily available? Do the reach-out activities target the adults whose basic competences are the weakest? If so, are they actually effective? Is there an adequate amount of adult education available in relation to adults' needs? Does the content of the education match the adults' needs? Have all adult groups been considered in devising adult education opportunities? What kinds of changes in work life generate a need for adult education? Clearly, this could involve technological changes; however, the personal and public lives of adults have also created the need for ICT education, and are there other demands? If yes, do different groups of adults have different needs? Are the highly educated in skilled occupations those who have the need to develop their competences continuously, while others do not have such needs? Are the answers to these questions the same across the Nordic countries, or are there differences that could give other countries sound ideas for developing their own adult education activities further? To answer any of the questions properly requires more information.

Getting the adults into education is one challenge. Another is to get the adults engaged in learning by offering them relevant and meaningful learning experiences so that they will complete the training program once they start it. As many adults with, for instance, low levels of education have negative experiences of school, school-like instruction is not likely to motivate them. Instead, programs that meet adults' individual needs and offer problem-based rather than subject-specific instruction in small homogeneous groups are more likely to succeed. A critical element of any adult education is linking the content to their everyday life, which requires highly qualified teachers aware of the needs of this special target group (Brooks, 2001; HLG, 2012, pp. 52–53.) All this translates into high-quality adult education. To heighten its quality further, Finland and Sweden have improved quality assurance programs for vocational education, and Denmark has focused on the validation of non-formal and informal learning (European Commission, 2013).

We know that PIAAC, like IALS and ALL before it, offers a huge dataset with many possibilities for detailed studies on adults' key competencies and learning opportunities. However, PIAAC (like its predecessors) is a cross-sectional, not longitudinal, study, and as such cannot be used to examine the effectiveness of adult education programs. Although participation in adult education has a positive association with proficiency levels in literacy, numeracy, and problem solving in technology-rich environments, as shown above, it is impossible to draw any conclusions about the causal relationship behind the association and thus about adult education programs' impact on proficiency in these competencies (see also Carpentieri, 2013). In fact, there is evidence that adults improve their skills even without participating in such programs at or outside of work (New Zealand Department of Labour, 2010; Reder, 2009; see also Carpentieri, 2013). Carpentieri (2013, p. 4) suggests that this would be expected because most adult education programs with a limited duration match only very short periods of compulsory education. In this study, differences in key competencies between those who participate in adult education and those who do not decreased to only a few score points after adjusting for respondents' age, education, gender, occupation, and familiarity with the test language; this suggests that the impact of adult education may be limited, at least on key information processing skills.

This is not to say, however, that adult education is meaningless. Rather, this emphasizes the above-mentioned limitations of the PIAAC data and many other measures used to evaluate gains associated with adult education programs. Research on the impact of adult education is required, but it needs to acknowledge the diverse objectives of programs and learners and the long-term developments initiated by the programs. These include improvement in key competencies, but also, for instance, in confidence, social interaction, and mental health (Carpentieri, 2013, pp. 57). In addition, changes in literacy practices that over a longer period lead to a skills gain should be taken into account (Reder, 2009), and this inevitably necessitates longitudinal studies (HLG, 2012, p. 81).

In order to achieve any significant gains, adult education programs need to be long and intensive enough. Key competences take years to develop in compulsory and secondary education, and it would be unrealistic to think that a few hours per week for a few months would have the same impact (Brooks, 2011; Carpentieri, 2013). According to the PIAAC results, the average difference associated with an additional year of completed education or training is approximately seven score points, on average, on both the literacy and numeracy scales (OECD, 2013a, p. 61). From this perspective, non-formal education – including workshops, seminars, private lessons, courses, instruction given by colleagues or supervisors, and open or distance learning – is less likely to offer long-term opportunities to develop key competences unless they offer long-term training.

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Appendix

A1. The following derived PIAAC variables were used to study participation in AET:

Variable	Description
	Formal AET:
FAET12	Participated in formal AET in 12 months preceding survey
FAET12JR	Participated in formal AET for job-related reasons in 12 months preceding survey
FAET12NJR	Participated in formal AET for non-job-related reasons in 12 months preceding survey
	Non-formal education:
NFE12	Participated in non-formal education in 12 months preceding survey
NFE12JR	Participated in non-formal education for job-related reasons in 12 months preceding survey
NFE12NJR	Participated in non-formal education for non-job-related reasons in 12 months preceding survey
	Formal or non-formal AET:
FNFAET12	Participated in formal or non-formal AET in 12 months preceding survey
FNFAET12JR	Participated in formal or non-formal AET for job-related reasons in 12 months preceding survey
FNFAET12NJR	Participated in formal or non-formal AET for non-job-related reasons in 12 months preceding survey

Patrik Lind

5

Educational mismatch, skills, and age *

Abstract: Data from the OECD *Programme for the International Assessment of Adult Competencies* (PIAAC) makes it possible to contrast three commonly used measures of educational mismatch. Of these, two are self-assessment (SA) measures, SA-hiring and SA-doing. The third is a job analysis (JA) measure, based on the *International Standard Classification of Occupations* (ISCO 08). In this study, educational mismatch in the Nordic countries Denmark, Finland, Norway, and Sweden is described and analyzed using each of these three measures. There are large differences in incidence of over- and under-education depending on the measure used and the characteristics of the mismatch-groups vary depending on measure, as well. Skill differences between well-matched and mismatched are similar across measures where over-educated perform worse and under-educated better, on average, than well-matched. Moreover, conditional on age and tenure the three measures show similar patterns with respect to both incidence and skill differences. This suggests that any of the measures, if available in panel-data, should be adequate to study the individual persistence of mismatch. However, regarding estimates of the cross-sectional incidence of educational mismatch in a country, the results in this study urges caution as the incidence of educational mismatch seems to be highly measure-dependent.

* Helpful comments and succestions from Erik Mellander are gratefully acknowledged.

5.1 Educational mismatch

Educational mismatch – the notion that individuals in the labor market have either a lower or a higher level of education than their jobs require – creates inefficiencies both at the individual level and for society as a whole. At the individual level, over-education is perhaps more relevant than under-education, as previous studies have found that under-educated individuals earn more on average than their equally educated peers who have well-matched (lower-level) jobs (see Leuven & Oosterbeek, 2011), and thus, there are no (economic) inefficiencies at the individual level due to under-education. At the societal level, under-education might induce inefficiencies if it occurs to some extent as a result of firms not finding the competencies that they need.

For over-educated individuals, inefficiency arises due to the opportunity cost of not having a job with educational requirements that match their education. This can either (or both) be a better-paid job or a job that increases those individuals' well being (e.g., providing better job satisfaction). For the society, the inefficiency stems from a less-than-optimal production level. The lower production level can be explained by two factors: 1) there are individuals in the labor market with the potential to produce more (in terms of either quality, quantity, or both), 2) there are individuals who have spent time in the educational system without managing to gain the skills that they should have gained. For the latter group, it would have been more efficient to use those extra years of studies (that did not provide the necessary skills) working in the labor market.

These inefficiencies will, of course, only arise if a true incidence of educational mismatch exists. There is a fairly large body of literature on educational mismatch in which different measures of mismatch have been used, and they all give different incidences (see Leuven & Oosterbeek, 2011, for a recent literature review). To date, there is no consensus on which measure should be preferred. Because many previous studies have only had one measure of educational mismatch available, this report will focus on how the choice of measure affects the incidence and in turn the conclusions regarding educational mismatch in the Nordic countries.[1]

[1] That is the Nordic countries that participated in the OECD Programme for the International Assessment of Adult Competencies (PIAAC): Denmark, Finland, Norway, and Sweden.

Skills and age are two important factors to take into account when analyzing potential inefficiencies due to educational mismatch, and if the inference by these two factors on educational mismatch would differ depending on the measure of mismatch being used, the choice of measure in studies on educational mismatch would be even more important.

5.1.1 Labor market theories of educational mismatch

Leuven and Oosterbeek (2011) discuss labor market theories that could explain educational mismatch: the theories of human capital, career mobility, job competition, signaling, preferences, and search and frictions.

According to these authors, the human capital model (see e.g., Mincer, 1974) is consistent with previous findings that over-education is more common among the young, as schooling is only one part of an individual´s total amount of human capital. The lack of job-specific training or experience could thus be substituted with more formal education. In other words, young individuals with a given amount of schooling might have to settle for a job that requires a lower amount of education until they have gained the necessary experience (in excess of their education) to get a well-matched job in terms of their educational level. This theory can also explain under-education if the (formally) undereducated possess some ability that increases their total human capital to the level that will get them hired for a job that normally requires a higher level of education.

The theory of career mobility (see Sicherman & Galore, 1990; Sicherman, 1991) states that it can be rational for some individuals to initially accept a job that requires less education than what they have acquired if the probability of promotion is higher compared to a well-matched job. This strategic decision would then increase their lifetime earnings.

The theory of job competition (see Thurow, 1975) explains over-education with a model in which jobs are ranked based on the wages they offer (which is only determined by the requirements of the job) and individuals are ranked on their ability to be further trained ("trainability"), which is based on attained education. The highest-ranked individual will then be matched with the highest-ranked job, and when the highest-ranked jobs are filled, the remaining highly educated individuals will have to settle for a lower-ranked job even though they have an education that exceeds the requirements for that job (i.e., they will be over-educated). This theory cannot explain under-education.

Signaling theory (see Spence, 1973) states that investment in education is rational from the individual's perspective, but it does not change his or her productivity. The level of education will instead act as a signal for the level of productivity that they have. This theory would explain over-education in a similar way as job competition. To get the most attractive jobs, individuals will acquire as much education as they can to signal a high level of ability. If the number of highly educated individuals increases faster than the development of job requirements, the high-educated individuals with the weakest ability signal will have to settle for jobs for which they are over-educated. Under-education could be explained by this theory if the ability signal consists of more than just formal education, i.e., if applicants for a job can signal their ability by means other than just their education.

The preferences both regarding education and the mix of job and leisure could explain over-education. If some individuals have preferences towards learning and also value leisure over work, they might overinvest in education and later voluntarily choose jobs that require less schooling if this means more leisure time. Gottschalk and Hansen (2003) have modeled this and find that some college workers choose to work in the non-college sector and thus become over-educated. This does not consequently represent a misallocation of resources. Under-education could be explained by individuals having preferences to start at the bottom and work their way up rather than first acquiring a formal education and starting their career higher up in the hierarchy.

Search and frictions (see Gautier, 2002) could explain over-education, as the search for a suitable job match is not frictionless. Given these frictions, an individual with a given level of education could be willing to accept a job only requiring a lower level of education than s/he possesses to avoid unemployment. This choice of a lower-level job over unemployment would be a valid and rational choice as long as there is the opportunity for on-the-job-search for better-matched jobs. The over-education state of an individual would then represent an ongoing matching process rather than a constant misallocation.

This theory could also explain under-education, as frictions in the labor market would not only affect the matching from the individuals' point of view but also from the employers' side because they might not find a well-suited candidate when they need one and instead settle for someone with a lower level of education. This presupposes that undereducated do not possess the same skills as a (education-wise) well-matched individual. If they do possess the same skills, the signaling theory would better explain under-education with ability signals not stemming only from education qualifications.

If the data should give any support for any of these theories at first glance, what would we expect to see? If we should see that over-education is more common among the young who recently finished their highest education, this would give support for the human capital, career mobility, and search and frictions theories. Evidence in favor of the human capital theory should also show that (in)experience in the job and/or industry should matter for educational mismatch as well as other parts of human capital, such as skills measured in PIAAC. If under-educated are *equally* skilled as the well-matched individuals, it would suggest that formal education is only one part of the total amount of human capital.

In a descriptive analysis, it will be difficult if not impossible to find strong evidence in favor of the theories of job competition, signaling, preferences, and search and frictions. However, if under-educated are *equally* skilled as their well-matched peers, this would rule out the search and frictions explanation of under-education but favor the signaling explanation, given that we consider the ability signal to contain more than formal education. It would also give support to the human capital theory and suggest that the apparently under-educated are instead well-matched when considering the total amount of human capital, not just formal education.

If the over-educated are *less* skilled than the well-matched, this would *not* give strong support to the explanation given by the preference theory, at least not if this is found among the young and prime-aged. For the older, the (potential) preferences for being over-educated might have affected their skills negatively. If the over-educated are *equally* skilled as their well-matched peers it would give support for the signaling, job-competition, career-mobility, and search and frictions theories.

Table 1 summarizes which potential findings would support which theories.

Table 1. *Summary of the labor market theories of educational mismatch and expected findings*

Theory	We expect:
Huma n capital (Mincer, 1974): Formal education together with, e.g., experience and skills makes up the total amount of human capital. The parts, e.g., skills and formal education, are interchangeable.	(1) Younger and those who recently finished their highest level of education to be over-educated to a higher extent than the older because the younger have less experience in general. (2) The incidence of over-education to diminish with a person's tenure at the current employer or in the industry, indicating that formal education alone is not enough to get a well-matched job. (3) Over-educated to be less skilled (which is compensated with more formal education) and under-educated to be more skilled (which compensates for a lack of formal education) than their well-matched peers of an equal educational level.
Career mobility (Sicherman & Galore, 1990): Over-education is a rational choice in the beginning of a career, given that the probability of promotion is higher than in a well-matched job.	(1) (2) (4) Young and newly graduated over-educated individuals to be equally skilled as the well-matched, or more skilled than well-matched individuals, while the older over-educated individuals are not. The apparently over-educated will remain over-educated, as they lack skills, while the truly over-educated will move to well-matched jobs over their careers.
Search and frictions (Gautier, 2002): The labor market is not frictionless. It takes time to find a well-matched job and possibly more time for new graduates.	(1) – as new graduates have had less time to find a well-matching job. (2) – as this indicates more time in the matching process. (4)
Signaling (Spence, 1973): Investment in education is rational for individuals, but it does not change their productivity, it just signals it (or signals their ability). If the ability signal contains more than just formal education, we expect:	(3) – Those with lower skills to signal a lower ability than equally educated individuals and those with high skills to signal a higher ability than their level of formal education would signal by itself. (5) Over-educated could also be equally skilled as well-matched individuals if there is an over-supply of highly skilled candidates (compared to high-skilled jobs). This would increase the number of individuals who pursue higher education to signal their ability. If there are not well-matched jobs for all, some will be over-educated despite being equally skilled.
Job-competition (Thurow, 1975): Jobs are ranked based on wages, while workers are ranked based on "trainability".	(5) – It would then be those on the lower end of the trainability distribution that become over-educated despite being equally skilled.
Preferences (Gottschalk & Hansen, 2003): Some might prefer to have a job for which they are over-educated.	(6) over-educated individuals to be equally skilled as well-matched or more skilled, regardless of age (cf. (4)). This would indicate that being over-educated is attributable to individual preferences.

5.1.2 How to measure educational mismatch

Before beginning to describe the incidence of educational mismatch, it is important to remember that how we measure the mismatch will affect the incidence as well as potentially the support for or evidence against the different labor market theories. This is because different measures will have different reference categories. The category *well-matched* will be defined differently and possibly consist of different pools of individuals.

There are three commonly used measures of educational mismatch (cf. Leuven & Oosterbeek, 2011): self-assessment (SA), job analysis (JA), and realized matches (RM). The self-assessment measure of educational mismatch has been operationalized by asking survey respondents one or several questions regarding the levels of education required for their jobs. Two distinct approaches have been to ask respondents (either or both) what level of education would be needed to *get* their jobs today and what level of education would be needed to *do* their jobs well. Direct self-assessment has also been used. With this method, the respondents are asked directly if they consider themselves under- or over-educated for their jobs. The JA approach uses available job classification systems where for each category of jobs, there is an associated educational level that is deemed necessary for a given job. The RM measure is a purely statistical measure of either the mean or mode educational level of those who hold a certain type of job.

All three measures have drawbacks. Whereas the SA measure is based on more information than the other two, it is purely subjective, and respondents' answers will depend on how the question is phrased in combination with the truthfulness of the respondents, their interpretation of the question, and their level of knowledge of the recruitment standards in their occupation. Both the JA and the RM measures are objective, but job classification systems are usually not updated very often and might be outdated. Moreover, the statistical measure (RM) might have to be calculated within categories that are too wide, which ignore the variation of job tasks within job titles. The RM measure, although easily available, is most likely the least desirable of the three, as it will be biased if the educational level needed for the job has increased in recent years while there is simultaneously a large share of older employees with long tenure who needed a lower level of education to get the job when they were hired compared to the time of the measure of mismatch. It is also sample-dependent – the mean or mode educational level estimated will be dependent upon the particular individuals making up the sample analyzed.

As seen in Table 2, where previously found incidences are reported, there is one measure that gives a significantly lower incidence of both under- and over-educated candidates: the measure of realized matches using the mean educational level of the individuals with the same job. The other measure that stands out amongst the others is the direct self-assessment measure with an observed share of over-educated in line with those obtained by the other measures but with a significantly lower share of under-educated. A likely cause of this is that the respondents do not view themselves as under-educated or would not like to admit that they are under-educated due to pride.

Table 2. *Incidences by different measures reported in previous studies*

	Share of under-educated		Share of over-educated	
	Mean	Median	Mean	Median
Direct self-assessment	0.10	0.10	0.33	0.33
Self-assessment	0.32	0.22	0.37	0.33
Job-analysis	0.30	0.32	0.34	0.29
Realized matches (Mean)	0.15	0.15	0.16	0.16
Realized matches (Mode)	0.27	0.27	0.31	0.30

Note: Direct self-assessment refers to asking the respondents directly if they are over- or under-educated for their jobs

Source: Meta-analysis by Leuven & Oosterbeek (2011, p. 297)

In Table 3, the possible measures of educational mismatch using PIAAC data are listed with definitions. The self-assessment measures[2] are available from the PIAAC Background Questionnaire (BQ), and the JA measure can also be constructed using PIAAC data, as jobs in PIAAC are classified according to the ISCO-08 (International Standard Classification of Occupations), which includes the associated educational

[2] There are two questions in PIAAC regarding self-assessed educational mismatch. The first is: “Still talking about your current job: If applying today, what would be the usual qualifications, if any, that someone would need to GET this type of job?” with the second question phrased as: “Thinking about whether this qualification is necessary for doing your job satisfactorily, which of the following statements would be most true? 1. This level is necessary, 2. A lower level would be sufficient, 3. A higher level would be needed.”

Table 3. *Definition of the educational mismatch status for each measure*

	Under-educated	Adequately educated	Over-educated	Source
Self-assessment (hiring)	Less education than what is needed to get the job today	Exactly the education needed to get the job today	More education than what is needed to get the job today	PIAAC BQ: B_Q01a, B_Q01a3, and D_Q12a
Self-assessment (doing)	1. Under-educated according to SA (hiring) and regarding that educational level as necessary to do the job well or that a higher level would be needed 2. Adequately educated [SA (hiring)] but stating that a higher level of education is needed to do the job well	1. Adequately educated [SA (hiring)] and regarding that level of education as neces-sary to do the job well 2. Under-educated [SA (hir-ing)] but stating that a lower level of education would be sufficient to do the job well 3. Over-educated [SA (hiring)] but stating that a higher level of education is needed to do the job well	1. Over-educated [SA (hiring)] and stating that level as necessary to do the job well or that an even lower level would be sufficient 2. Adequately educated [SA (hiring)] but stating that a lower level of education would be sufficient	SA (hiring) and PIAAC BQ: D_Q12b
Job analysis	Less education than usually needed for the ISCO skill level of the respondent's job	Exactly the education usually needed for the ISCO skill level of the respondent's job	More education than usually needed for the ISCO skill level of the respondent's job	PIAAC BQ: B_Q01a, B_Q01a3, and IS-CO08_c

Note: Only respondents that are currently employed (not including self-employed respondents) are classified according to the measures levels usually needed for the respective job types. The RM measure requires population register data for two reasons: 1) PIAAC is a representative sample of the country's population, but that does not necessarily imply that it is representative at the job type level, and the mean educational level of a job found in PIAAC does not need to be the true educational level for that job in the country. Most likely, it is not. 2) The sample in PIAAC is not large enough to allow disaggregation on a detailed job level and the subsequent computation of the mean educational level. In this study, we only have PIAAC data, and thus, this measure will not be considered. It should also be noted that for respondents having completed their highest level of education outside of their country of residence, the self-estimation of their level of education according to the educational system of the country of residence is used as their educational level.

5.1.3 Analyzing PIAAC data

As in every survey, data from PIAAC contains some degree of uncertainty, or error, due to the sampling of individuals from the participating countries' populations. In PIAAC, this uncertainty due to the sampling process is handled by means of replication procedures. Replication procedures use repeated draws of sub-samples from the final sample of respondents using replicate weights, simulating the results that different samples would have yielded. The sub-sample results are then used to calculate standard errors that take the sampling uncertainty into account. In PIAAC, *Jackknife* replication is used and for most countries the number of replicates used in the calculation of standard errors is 80. This means that to compute any statistic using PIAAC data one computation is performed for each replicate sub-sample, 80 for most countries, and one using the full sample and the final weights, to obtain the point estimate.

For statistics involving skill estimates, a further complication is added. The skill estimates in PIAAC, scores in literacy, numeracy, and in problem solving in technology-rich environments (PS-TRE), ranging from zero to 500, have been estimated using *Item Response Theory* (IRT, see e.g., Baker, 2001). In short, this technique is time- and cost efficient as each respondent, at most, takes only two of the tests in literacy, numeracy, and PS-TRE and is only given a sub-set of the full number of items on those two tests. The respondent's own response pattern, combined with the response patterns of similar respondents (similar in terms of background characteristics), is used to estimate (impute) a skill score distribution for each respondent. The fact that the respondent's result is represented by a distribution, rather than by a number, implies that it is associated with uncertainty. In PIAAC, this uncertainty is accounted for by random draws of a set of ten scores, ten *plausible values*, from the respondent's test score distribution. For each one of these ten random draws sampling error has to be accounted for, according to the previous paragraph. The number of computations when skills estimates are involved thus increases to ten times the number of computations needed to adjust for the sampling uncertainty, for most countries this will be equal to 810 computations.

Statistical tools specifically designed to handle these two types of uncertainties in the context of PIAAC have been made available by the OECD[3] and these are used throughout this study to produce correct results.

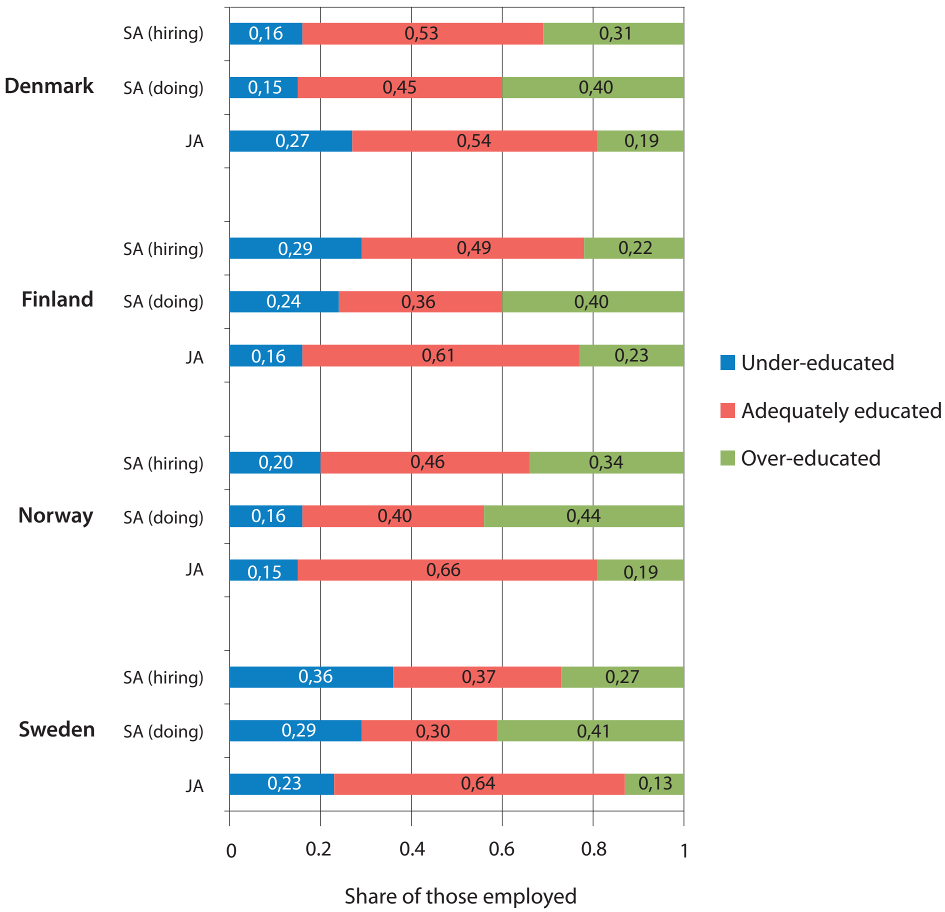
5.1.4 Incidence of educational mismatch in the Nordic countries

As seen in Figure 1, there are quite large differences between the three measures of educational mismatch. The JA measure gives the lowest share of over-educated in all countries except Finland where the shares according to SA (hiring) and JA are almost equal. JA also gives the lowest share of under-educated in Finland, Norway and Sweden. In Denmark, this measure instead gives the highest share of under-educated. The two self-assessment measures look more similar to each other than they are to the JA measure.

The incidence of under- and over-education changes considerably depending on which of the measures is used, and it changes in different directions for each country. The self-assessment measure taking into account the respondents' self-estimates of the level of education needed to *do* their jobs (SA doing) gives the highest share of over-educated in all four countries. Only approximately one-third of the Swedish respondents (and approximately half in the other three countries) who answered that a level of education *lower* than their own would be sufficient to do their job are classified as over-educated according to the JA measure.

3 These tools are available for users of both Stata and SAS and can be found on OECD:s PIAAC website: http://www.oecd.org/site/piaac/publicdataandanalysis.htm

Figure 1. *Incidence of educational mismatch according to the three different measures*



Note: Self-employed respondents are not included. The shares presented are the estimated means (confidence intervals not presented). The numbers for the figure can be found in Table A1 in the appendix.

Comparing the incidence of over-education according to JA and the self-assessment measure considering the level of education needed to *get* the job today (SA hiring), approximately twice as many in Denmark, Norway, and Sweden consider themselves to be over-educated than what is found using JA. The exception is Finland, where the incidence of over-education is roughly the same between these two measures. Finland also shows the largest increase (almost double) in the incidence of over-education if SA (doing) is used instead of SA (hiring). Sweden also shows a large increase of approximately 50% higher incidence of over-education when SA (doing) is used.

In Denmark, fewer respondents consider themselves to be under-educated compared to what is found when their educational level is compared to the level usually required for their jobs according to ISCO. In Finland and Sweden, it is the opposite; more respondents consider themselves to be under-educated compared to what is estimated by JA, while in Norway, the three measures are quite similar in terms of under-education.

If we relate the mean incidences of each measure over all four countries (see Table A1 in appendix) to the incidence found by previous studies (Table 2), the results for both SA measures are lower than the mean of previous findings for under-educated but close to the median incidence previously found. This is also the case for over-educated using SA (hiring), while the mean incidence in the four Nordic countries using SA (doing) is much higher than both the mean and median of the previously found incidence of over-education. For both under- and over-education, the mean incidence in this study using JA is much lower (around ten percentage points) than what previous studies have found on average.

The measure we choose will thus significantly affect the size of the mismatch groups, which can give (at least) two different secondary effects when we want to conduct analyses on educational mismatch: 1) if the group characteristics do not change between measures, the choice of measure should mainly affect the ability to obtain significant estimates due to differences in sample sizes; 2) if the group characteristics *do* change depending on the measure used, the choice of measure can affect both the size and the sign of the estimates. To give an example, in section 4, skill differences (literacy, numeracy, and problem-solving skills as measured in PIAAC) between the group of well-matched and the group of over-educated and between well-matched and under-educated are analyzed, and if the different measures of educational mismatch classify very different groups of individuals as mismatched, this could then possibly give a positive skill difference according to one measure and a negative skill difference according to another.

We can, however, only compare *observable* group characteristics across measures. There might, of course, also be some important unobservable characteristics. With this caveat in mind, the comparison based on observables is conducted in the following section.

5.2 Do the measures correspond to the same phenomenon?

In the previous section, we observed that the sizes of the groups of under- and over-educated (and thus also the reference category, the adequately educated) vary depending on the measure of mismatch and vary differently across countries. It is important to know not only how many but also who will be classified as over- or under-educated depending on the measure we choose.

If the group characteristics are the same across all measures, even though the group sizes differ, the measures are likely to correspond to the same phenomenon but with either stricter or broader classification criteria. If the group characteristics of the mismatch-group differ across measures, we have to conclude that they correspond to different views on mismatch.

The majority of the respondents are categorized differently depending on which measure is being used; only approximately 25% of the respondents in each country have the same status across all three measures. Of those who do change status, only between two and five percent move from being under-educated to over-educated, or vice versa.[4] The majority of those who are categorized differently in different measures move from being either under- or over-educated to being adequately educated for their jobs or from well-matched to mismatched.

5.2.1 Different measures, different groups of mismatched?

Table 4 shows the most noticeable differences between the measures in terms of group characteristics; for Denmark, those where the differences between the groups of under-educated, and in the other countries, it was between the groups of over-educated. In Denmark, there were only notable differences in terms of two background variables compared to four or five variables for the other countries. There are differences in terms of all of the background variables depending on the measure of educational mismatch, but those not presented are not very large.

4 One exception is Sweden, where approximately 7 percent change from over- to under- or from under- to over-educated between the two self-assessment measures.

Table 4. *Differences between group characteristics depending on the measure of mismatch being used*

	JA		SA (doing)		SA (hiring)	
Denmark	***Under-educated***					
	Mode	*Percent*	*Mode*	*Percent*	*Mode*	*Percent*
Education	Professional degree (ISCED 5b)	45.2	Upper secondary	27.7	Upper secondary	27.4
Job skill level	Professionals & managers (ISCO skill level 4)	70.1	Skilled worker (ISCO skill level 2)	39.4	Skilled worker	38.3
Finland	***Over-educated***					
Age	28	3.9	46	3.4	36	3.5
Gender	Female	69.1	Male	50.4	Male	51.3
Education	Bachelor	37.6	Upper secondary	39.2	Upper secondary	34.9
Field	Soc. Sci. / Business / Law	28.7	Engineering / Manufacturing / Construction	29.9	Engineer. / Manuf. / Constr	28.7
Norway	***Over-educated***					
Education	Bachelor	56.0	Upper secondary	17.3	Upper secondary	20.0
Field	Health / Well-fare	25.4	Engineer. / Manuf. / Constr.	24.7	Engineer. / Manuf. / Constr	22.5
Foreign born	No	78.8	No	84.9	No	82.6
Native language = test language	Yes	82.9	Yes	88.6	Yes	86.8
Sweden	***Over-educated***					
Age	27	4.5	39	3.2	43	3.7
Education	Bachelor	31.0	Upper secondary	26.2	Upper secondary	22.7
Field	Soc. Sci. / Business / Law	29.9	Engineer. / Manuf. / Constr.	24.9	Engineer. / Manuf. / Constr.	22.1
Foreign born	No	75.9	No	84.9	No	78.8
Native language = test language	Yes	83.4	Yes	90.6	Yes	86.7

The comparison is made using the mode (the most common) value of the background variables together with the share of individuals in the group having this value. If the share having the mode value on a variable is large, the variation in the group on that variable is small.

In all four countries, it is the Job Analysis (JA) measure that differs most notably from the two self-assessment measures, even though the latter two differ between each other as well. In Denmark, mainly the characteristics in the group of under-educated differ between JA and the two SA measures. Among the Danish under-educated, according to SA (hiring and doing), the most common education is an upper secondary degree, and the most common job type (ISCO skill level) is a skilled worker. Looking at the JA measure, we see that 45% have a professional post-secondary degree (ISCED[5] 5b), and 70% work as professionals and managers. In Denmark, the under-educated according to JA are clearly different from the group of under-educated according to self-assessment, and, as figure 1 shows, the number of under-educated using JA is about twice as many as the under-educated according to SA. In the group of under-educated, according to JA, we see individuals with non-academic post-secondary degrees with high-skilled jobs who do not regard themselves as under-educated for their jobs but are classified as such by JA.

In the other three countries, it is mainly the group of over-educated that differs between the measures. Norway and Sweden show similar patterns, whereas the over-educated according to JA typically have a bachelor's degree in the social sciences or humanities, while the over-educated based on the self-assessment measures have upper secondary degrees in the fields of engineering, manufacturing, or construction. In Sweden, the group of over-educated using JA is also typically younger (mode of 27 vs. approximately 40). Similar to both countries, according to the JA measure, a larger share has a native language other than that of the tests in PIAAC (i.e., other than Norwegian and Swedish, respectively) and a larger share born abroad.

Finland shares the same pattern in the differences in education and fields of study among the over-educated based on JA and SA, as Norway and Sweden, and the differences in age are similar to the corresponding differences in Sweden. A much more notable difference in Finland compared to the other countries is that

5 International Standard Classification of Education. In PIAAC, ISCED 97 is used.

a much larger share (69%) of over-educated according to JA are female, while the mode for the two SA measures is male (although only slightly above 50%).

The group characteristics clearly change between the measures, most notably between the JA compared to the two SA measures. The JA measure seems to classify individuals with a post-secondary degree as over-educated (under-educated in Denmark) to a larger extent than these individuals classify themselves as over- (under-) educated.

This means that we can expect the choice of measure to differ not only in the sample size and the ability to obtain significant estimates but also in the estimates themselves.

5.2.2 Correlation between the measures

Looking at the mode of background characteristics, we observed that different measures seem to categorize different groups of individuals as over- or under-educated. This was informative to get a sense of who is classified as what depending on the measure being used, but it is hard to discriminate between the measures based on this, as there is a great deal of information to take into account.

A more compact analysis would be to see if the correlation between the measures is high. If they are highly correlated, we could conclude that the choice of measure is not of importance, as they would then measure almost the same phenomenon (educational mismatch).

As educational mismatch is not measured on an interval or ratio scale, we cannot use an ordinary correlation measure such as e.g., *Pearson's p*. If we think of the category of being well-matched as our reference category, it is natural to place over-educated above well-matched and under-educated below, i.e., we measure educational mismatch on an ordinal scale. A good measure of correlation between ordinal variables is *Somers' D*, which is an asymmetric measure of association of ordinal variables (Somers, 1962). Somers' *D* is calculated for each pairwise combination of the three measures and for each country separately and is presented in Table 5.

In all four countries, there is a fairly large correlation between the two self-assessment measures, although far from as large as to conclude that they measure educational mismatch in the same way (the correlation is e.g., just above 0.5 in Finland). Comparing the JA to the SA measures, they are not correlated to any

Table 5. *Correlation between the measures of educational mismatch using Somers' D*

		SA (hiring)	SA (doing)	JA
Denmark	SA (hiring)	1		
	SA (doing)	0.68	1	
	JA	0.29	0.22	1
Finland	SA (hiring)	1		
	SA (doing)	0.54	1	
	JA	0.26	0.15	1
Norway	SA (hiring)	1		
	SA (doing)	0.65	1	
	JA	0.24	0.14	1
Sweden	SA (hiring)	1		
	SA (doing)	0.58	1	
	JA	0.34	0.20	1

larger extent, and the correlation between SA (doing) and JA is the lowest in all countries.

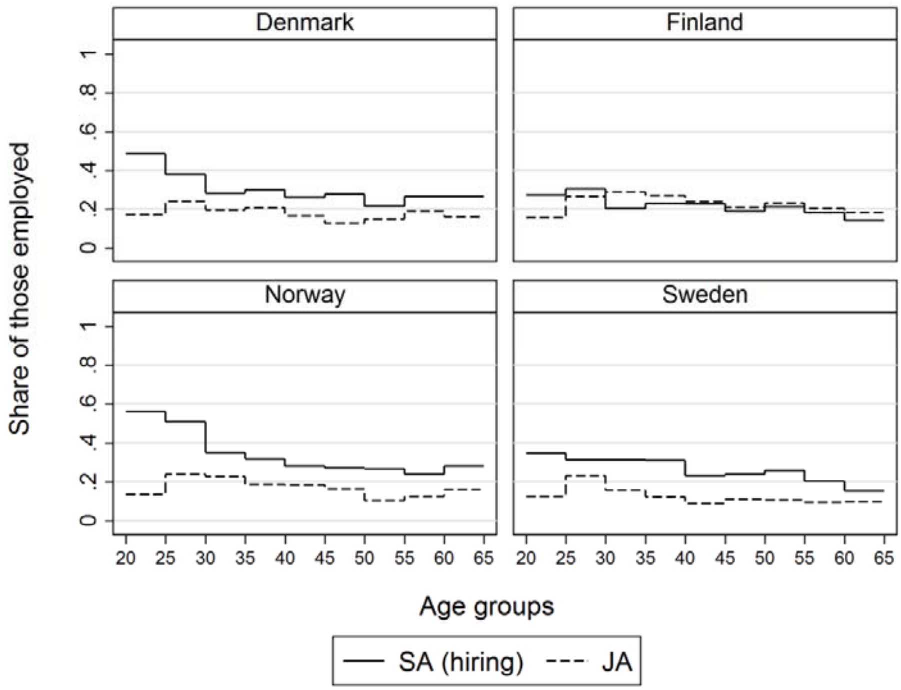
To make the graphs and tables in the following sections easier to read, one of the measures needs to be removed. Given that the two SA measures correlate to a fairly high extent (much more than any other pairwise comparison), one of these will be removed from further analysis. As the JA measure seems to measure educational mismatch in the same way as SA (hiring) a little more than it does compared to SA (doing), the latter together with JA would arguably be the two measures to use, as they show the largest differences in terms of how they measure educational mismatch. However, considering how the SA (doing) measure is constructed, the SA (hiring) measure would instead be a better choice of measure, as it is purely a comparison between the respondents' educational level and their answer to the question in the PIAAC BQ without any adjustments. To construct SA (doing), the classification based on SA (hiring) needs to be used.

If the question of what level of education is needed to *do* the respondents' current jobs would have been asked in the same way as it is for SA (hiring), i.e., asking for the level of education needed to *do* the job as opposed to asking if the level of education to *get* the job is sufficient or inadequate, the choices would have been SA (doing) and JA. On the other hand, if the two questions had been phrased similarly, they might have been correlated to an even higher extent, and the choice would have mattered less in such a case.

5.3 Educational mismatch and age

According to several of the labor market theories that could explain educational mismatch, age is of importance. Figure 2 shows the incidence of over-education by age group for each country.

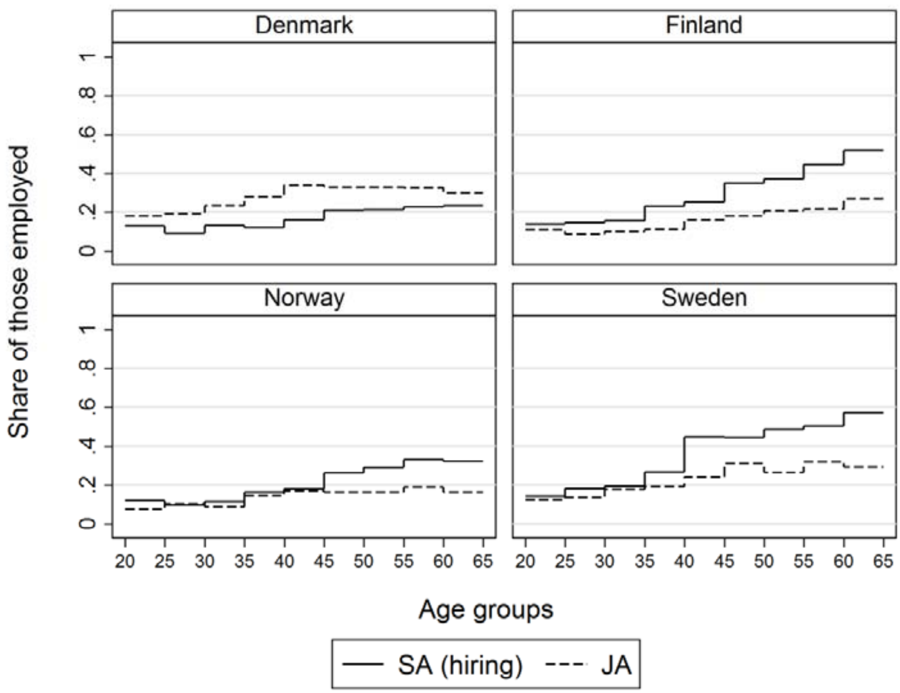
Figure 2. *The estimated shares of over-educated by age group for different measures*



According to both measures, there is a tendency for the incidence of over-education to be higher among younger and lower among the older, and a regression shows a small but significant decrease in the share of over-educated with higher age (see Table A1 in appendix). The difference in shares between measures for the same age group is considerable in all countries and tends to be larger for the youngest and this is most notable in Norway and least in Finland, where there are only minor differences between the measures. In all countries, the difference between the measures is largest for the 20–24 age group, where the difference amounts to between 7% (Finland) and 40% (Norway).

The incidence is the highest over all age groups (with Finland being the exception) when using the self-assessment measure, and for the youngest age group, we find between 27% (Finland) and 56% (Norway) to be over-educated. In this age group, 85% have an upper secondary degree, 38% state that the job they currently have does not require any formal education at all (less than ISCED 1), and as many as 70% say that a lower secondary degree would be sufficient to get their job. Looking at the jobs they have, approximately 75% have jobs, which, according to ISCO, are classified as *skilled workers* and usually require an upper secondary degree. The classification of occupations in ISCO does not seem to correspond well to the views

Figure 3. *The estimated shares of under-educated by age group for different measures*



of the youngest age group regarding the requirements needed to get their jobs. This most likely indicates that ISCO does not acknowledge the heterogeneity of job tasks within job titles and that the youngest in each type of job is likely to perform work duties that belong to the bottom end of the distribution of skill requirements.

The pattern for under-education is the opposite of that of over-education. The incidence is higher among the older and a regression shows that the increase in incidence with age is significant (see Table A2 in appendix). There are large differences in incidence between the measures here as well, and it is larger for the oldest age group. In all countries except Denmark, JA gives lower shares of under-educated, and the difference between the measures for the oldest age group amounts to between 6 (Denmark) and 28% (Sweden). Denmark deviates from the rest in this regard as well and shows the largest difference between measures not for the oldest age groups but rather for the 35–44 age group.

Other than age, tenure in the industry in which an individual works should also be important for the incidence of educational mismatch according to the theories, as more experience comes with longer tenure. Unfortunately, PIAAC does not include information on labor market history other than that of tenure with the current employer. Figures 4 and 5 show the incidence of over- and under-education by respondents' tenure with his/her current employer.

For both over- and under-educated (Figure 5 on the next page), the pattern with respect to tenure with the current employer is very similar to the previous figures showing the incidence with respect to age. Over-education is more common among those with a shorter tenure, and under-education is more common among those with longer tenure. These slopes are also significant (see Table A3 in appendix).

Looking at tenure, Denmark deviates from the other countries in the difference between JA and SA in terms of under-education, where fewer individuals regard themselves as under-educated than the JA measure indicates.

Another proxy for experience (other than age and tenure) is the number of years

Figure 4. *The estimated shares of over-educated by tenure-year groups for different measures*

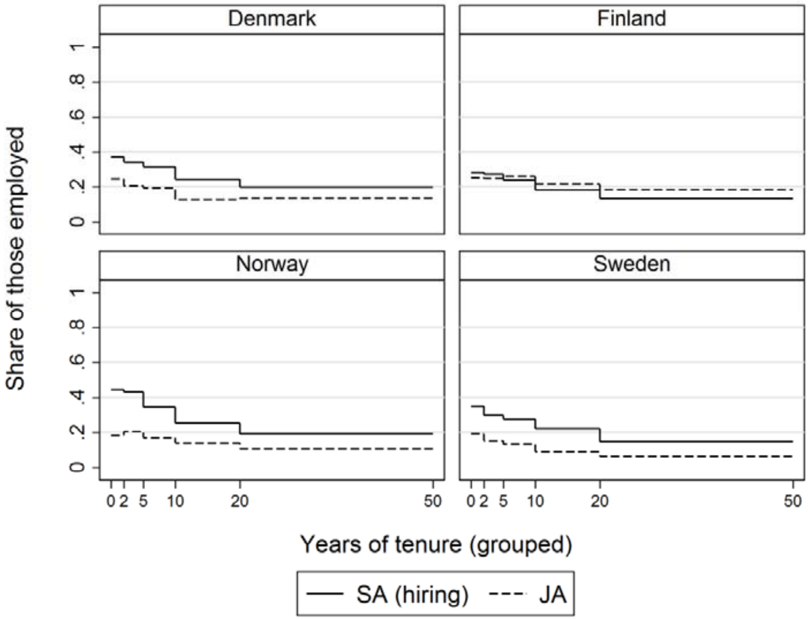
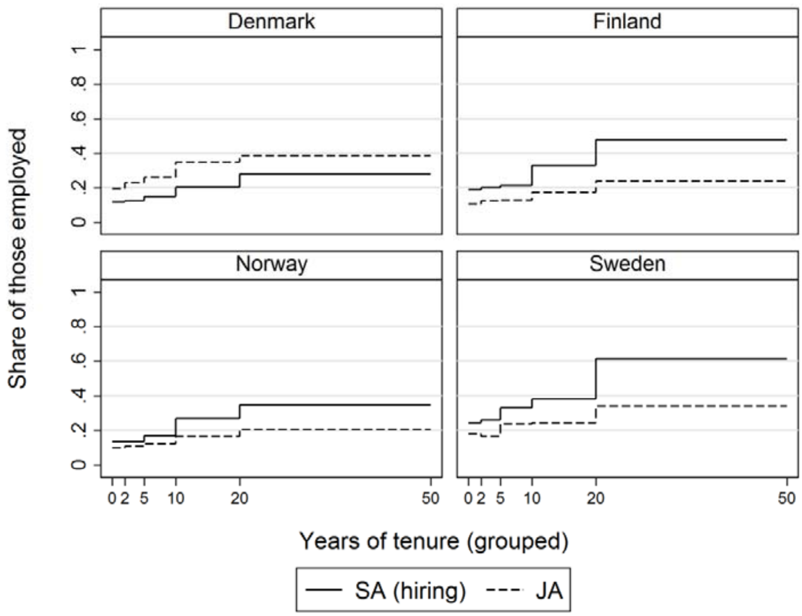


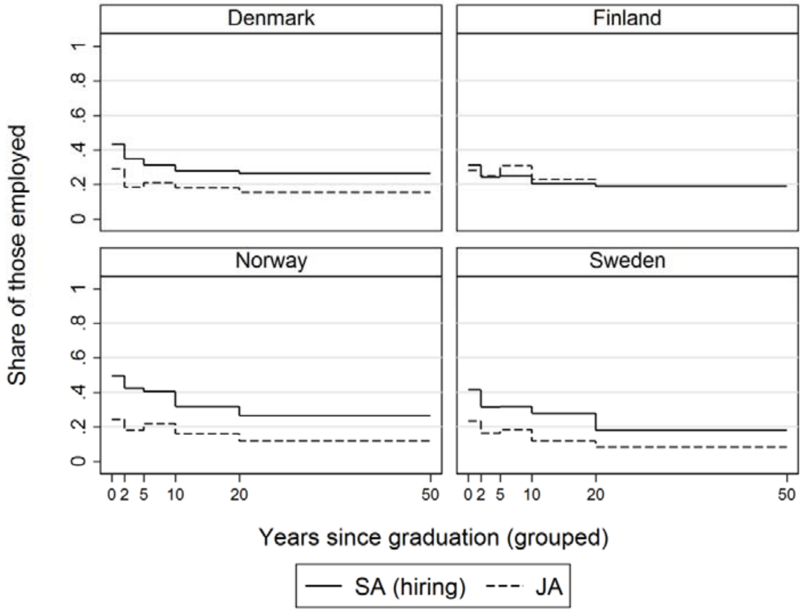
Figure 5. *The estimated shares of under-educated by tenure-year groups for different measures*



since graduating from the highest completed educational level. Some occupations require not only a certain educational level but also previous work experience, and an individual that recently graduated will likely have less (relevant) work experience than someone who graduated a few years earlier. Figures 6 and 7 show the incidence by the number of years since graduation (grouped).

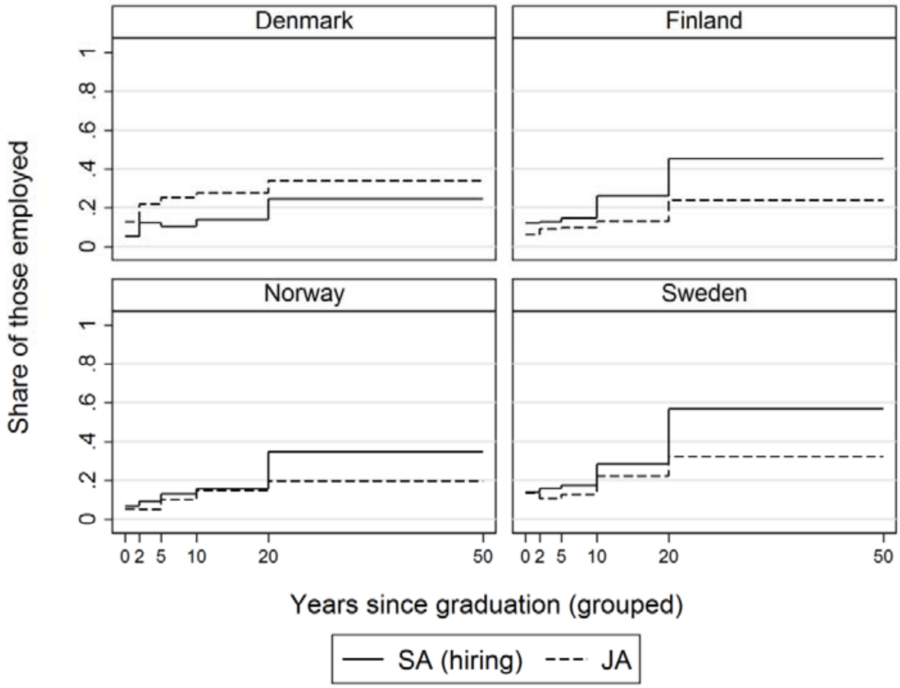
The pattern for over-education remains very similar to the incidence with respect

Figure 6. *The estimated shares of over-educated by number of years since graduating (grouped) for different measures*



to age and tenure, while over-education is more common among those who have recently graduated.

Figure 7. *The estimated shares of under-educated by number of years since graduating (grouped) for different measures*



Again, the same pattern is found when analyzing the incidence of under-education divided by the number of years since graduation, and under-education is less common among those who graduated recently. The estimated slopes seen in Figures 6 and 7 are statistically significant (see Table A4 in appendix), similar to the incidence with respect to age and tenure.

Other than experience (age, tenure, and the number of years since graduation), an individual's ability or skills should, of course, be an important factor when discussing educational mismatch. Skill differences between mismatched and well-matched individuals, by itself, and these skill differences in interaction with age groups are presented in the next section. Because an employee's tenure with his/her current employer and the number of years since he/she graduated show similar patterns as the incidence of educational mismatch with respect to age, they are likely to all be proxies for experience, and as the analysis on age groups allows for more groups (more observations in each cell), only this will be considered in the next section.

5.4 Educational mismatch, skills, and age

In the majority of studies on educational mismatch, the ability, or skill, dimension has been missing. In this section, skills are added to the descriptive analysis, as direct measures on skills in combination with the rich background information are the unique features of the PIAAC survey. Table 6 shows skill differences in numeracy between under-educated and well-matched as well as between over-educated and well-matched individuals. The largest differences are those in numeracy, and these will therefore be presented throughout this section. The differences in literacy and problem-solving skills can be found in Appendix, however. The signs of those differences are the same as in the case of numeracy.

Table 6. *Mean skill score differences in numeracy between mismatched and well-matched individuals for two measures of mismatch*

Country	Measure	Under-educated	Over-educated
Denmark	SA (hiring)	10***	-7***
	JA	9***	-8***
Finland	SA (hiring)	8***	0
	JA	12***	-11***
Norway	SA (hiring)	10***	-6***
	JA	18***	-15***
Sweden	SA (hiring)	6**	-7***
	JA	15***	-9***

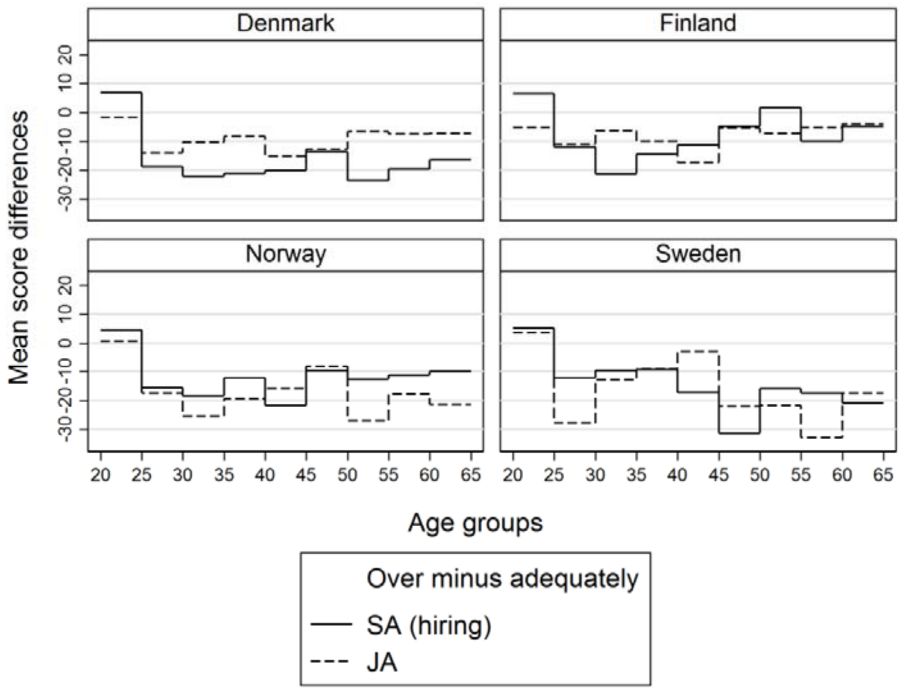
Note: Differences estimated using regressions with controls for age, gender, and education.
*, **, *** denote significance at the 10, 5, and 1 percent levels, respectively

With the exception of Finland (over-educated according to SA hiring), all estimated differences using the SA (hiring) and the JA measures are significant at the 5 percent level (and all but one at the 1 percent level). These significant differences show a consistent pattern where the over-educated, on average, perform worse than their peers who have the same educational level (as well as age and gender) but with a job that matches their education.

Those who have a job that usually requires a higher level of education than they currently have perform, on average, better than similar individuals (in terms of education, age, and gender) who have a lower-level job matched to their educational level. The (absolute) differences between under-educated and well-matched are larger than the differences between over-educated and well-matched.

The expected findings that follow the different labor market theories are related to the skill differences between over-educated and well-matched (see Table 1), and therefore, only this and not the skill difference between well-matched and under-educated will be presented.

Figure 8. *Skill differences in numeracy between over-educated and well-matched by age group for the two measures*



Note: Controlled for educational level and gender

Figure 8 shows that the estimated skill differences between over-educated and adequately educated tend to be negative for all but the youngest age group. The only common pattern is the difference between the youngest age group (20–24) and the rest. The figure shows the point estimates only. If the confidence intervals were added, we would see that all of them would cover zero (not presented in the figure because it would render the figure unreadable), which means that we cannot say that any of the estimated differences are significantly different from zero.

In other words, we cannot say that over-educated perform significantly worse than well-matched in any age group. Here, we see one of the weaknesses when performing these analyses on PIAAC data, which is the restriction due to sample size. In the beginning of this section, we showed that when not estimating separate effects for each age group (merely controlling for age), we found that over-educated perform worse on average than their well-matched peers. The reason for these wide confidence intervals is the small sample sizes that we obtain when dividing the over- and adequately educated into age groups. The analysis has been conducted on ten-year age groups as well, but the confidence intervals are still wide.

5.5 Discussion

The discussion is divided into the two questions that have been present throughout this paper, i.e., how the different measures of educational mismatch compare to each other and if the analyses of mismatch in the Nordic countries give support to any of the labor market theories of educational mismatch.

5.5.1 Does the choice of measure of educational mismatch matter?

There are clear differences between the measures of educational mismatch, and we can see that many more regard themselves as over-educated for their current job than what is found when we compare their educational level to the usual educational requirements in that type of job (JA). There are at least two plausible explanations for this: 1) the respondents are not well informed about the recruitment requirements for their occupation, 2) Job Analysis ignores too much of the heterogeneity of educational requirements (and job tasks) within occupational titles. It is very difficult to determine which of the measures shows the more correct incidence of educational mismatch.

5.5.2 What support can be given to the labor market theories of educational mismatch?

We have found that over-education tends to be more common among the younger that recently finished their highest completed education and those with shorter tenures with their current employers. On average, without estimating separate effects for age groups, the under-educated perform significantly better than their well-matched peers whereas the over-educated perform significantly worse than their well-matched peers. This is irrespective of using SA (hiring) or JA as the measure of educational mismatch. When analyzing separate effects for age groups, we cannot draw any conclusions on these estimated skill differences, as no estimate is significantly different from zero. This is most likely an effect of the smaller number of observations in each mismatch group, which is the result of separate estimates per age group.

Using the results we have (i.e., in terms of the differences in incidence) and comparing these to the expected findings for each of the theories listed in table 1, we find some support for the human capital, career mobility, and search and frictions theories. All of these state that over-education should be less common among older and those with longer tenure. Human capital theory would therefore explain the diminishing incidence of over-education by age/tenure with an increase in experience. According to the theory of career mobility, this would be due to the fact that some of the previously (voluntarily due to strategy) over-educated individuals have gained promotions into well-matched jobs over time. The search and frictions theory would explain these findings by the elapsed time (age, tenure, or the time since graduation) until better matches emerged, either across employers or within employers.

If we had been able to draw conclusions from all of the analyses of skill differences (i.e., if we had more observations), we could have possibly given more support to the search and frictions theory as well as to the theory of career mobility. However, the result that over-educated (without separate estimates per age group) are less skilled than their well-matched peers on average and that under-educated are more skilled on average supports the human capital theory.

We find no support for the job-competition theory or for the theory of preferences for educational mismatch. If individuals are ranked only based on their "trainability," which in turn only is based on their education, and then matched with the highest-ranked jobs, we would not expect the over-educated to be less skilled. A well-matched and an over-educated individual with the same educational level would have the same "trainability," and any difference in skills between individuals with the same educational level would be random, as it would be unobserved by the employer. Instead, we find that the skills of over-educated are systematically lower than those of the well-matched. This theory could, however, still plausibly explain over-education in terms of job competition if the "trainability" would include some information that could rank individuals of the same educational level. This could, for example, be grades.

As the over-educated clearly perform worse on average than their well-matched peers, we do not find evidence that the preference for being over-educated could explain the phenomenon of over-education. It could, however, still be an explanation for over-education if skills diminish with the time an individual has been over-educated. What first was a preference will then over time turn into a skill difference between otherwise similar individuals. We cannot test this using these data, as we would need at least two measures of skills at different points in time and data on how long an individual has been mismatched. A second measure of skills will not be available in the foreseeable future, but we could take one step in this direction when we obtain access to PIAAC data in combination with register data for the Nordic countries. This will allow us to use the JA measure of educational mismatch to analyze the effects of the time spent being over-educated and to analyze the differences between those who, with time, manage to find a well-matched job and those who remain over-educated.

5.6 Concluding remarks

There are clear differences in terms of the incidence found and in the mode group characteristics among over- and under-educated depending on which measure of educational mismatch is used. In terms of skill differences between mismatched and well-matched individuals the general pattern is the same, over-educated perform worse and under-educated perform better, on average, than their well-matched peers, but there are differences in the sizes of the skill differences depending on the measure.

If we want to answer the question of what the incidence of educational mismatch is, we need to be careful. One measure will give a very different answer than another measure, and we cannot (at least not with the data available for this study) know which of them is correct. One should thus be careful about drawing conclusions about the incidence of educational mismatch and whether the shares of under- or over-educated employees represent a socioeconomical problem, especially for incidences from cross-sectional studies such as PIAAC.

The two measures mainly used in this paper, SA (hiring) and JA, do, however, show very similar patterns when looking at educational mismatch over age, tenure, and graduation-year groups as well as in terms of skill differences between well-matched and mismatched individuals with respect to the same. This tells us that in terms of incidence levels, the choice of measure is of great importance for the results, but in terms of an analysis of explanations for educational mismatch, the choice of measure might not be as important. This will allow future studies that try to explain the existence of educational mismatch to use panel data to study the persistence of educational mismatch at the individual level. The JA measure can be constructed from register data on jobs and education and this will be much less costly than building a panel dataset of individual employees' self-assessed mismatch and should give similar results, given the findings of common patterns with respect to time (age, tenure, and time since graduating) between measures. A study using micro-level register panel-data would be much more able to draw conclusions on the potential socioeconomical costs of educational mismatch when the persistence of the mismatch states can be analyzed.

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Appendix

Data for figure 1

Table A1. *Estimated incidence of educational mismatch for each measure*

	Measure	Under	Adequately	Over
Denmark	SA (hiring)	0.16	0.53	0.31
	SA (doing)	0.15	0.45	0.40
	JA	0.27	0.54	0.19
Finland	SA (hiring)	0.29	0.49	0.22
	SA (doing)	0.24	0.36	0.40
	JA	0.16	0.61	0.23
Norway	SA (hiring)	0.20	0.46	0.34
	SA (doing)	0.16	0.40	0.44
	JA	0.15	0.66	0.19
Sweden	SA (hiring)	0.36	0.37	0.27
	SA (doing)	0.29	0.30	0.41
	JA	0.23	0.64	0.13
Nordic mean	SA (hiring)	0.25	0.47	0.28
	SA (doing)	0.21	0.38	0.41
	JA	0.20	0.61	0.19

Note: The Nordic mean is the unweighted average of the incidences in the four Nordic (PIAAC) countries

Test of slope in incidence by age, tenure, and number of years since graduating

The following results of the test of the slope in incidence with respect to age in the first case and tenure in the second case are estimated using the following model:

$$mismatch = a_0 + a_1 \cdot time + e$$

where *mismatch* is a dummy variable taking the value 1 if an individual is under (over)-educated, *time* is age (5-year groups) in table A2, tenure (grouped) in table A3, and the years since graduation in table A4. a_1 is the estimated slope.

Table A2. *Estimated slope of mismatch incidence by age*

		SA (hiring)		JA	
	Incidence	Age	S.E.	Age	S.E.
Denmark	Under	0.004***	0.0005	0.004***	0.0006
	Over	-0.005***	0.0006	-0.001**	0.0006
Finland	Under	0.010***	0.0006	0.004***	0.0005
	Over	-0.003***	0.0006	-0.001**	0.0005
Norway	Under	0.007***	0.0006	0.003***	0.0005
	Over	-0.007***	0.0006	-0.002***	0.0005
Sweden	Under	0.012***	0.0008	0.005***	0.0005
	Over	-0.004***	0.0007	-0.002***	0.0006

Note: *, **, *** denote significance at the 10, 5, and 1 percent levels, respectively

Table A3. *Estimated slope of mismatch incidence by tenure*

		SA (hiring)		JA	
	Incidence	Tenure	S.E.	Tenure	S.E.
Denmark	Under	0.008***	0.0011	0.010***	0.0010
	Over	-0.009***	0.0011	-0.005***	0.0009
Finland	Under	0.015***	0.0013	0.007***	0.0009
	Over	-0.008***	0.0010	-0.004***	0.0009
Norway	Under	0.012***	0.0011	0.006***	0.0011
	Over	-0.014***	0.0010	-0.005***	0.0009
Sweden	Under	0.019***	0.0013	0.009***	0.0012
	Over	-0.009***	0.0011	-0.006***	0.0008

Note: *, **, *** denote significance at the 10, 5, and 1 percent levels, respectively

Table A4. *Estimated slope of mismatch incidence by years since graduation*

		SA (hiring)		JA	
	Incidence	Years s. grad.	S.E.	Years s. grad.	S.E.
Denmark	Under	0.009***	0.0008	0.008***	0.0008
	Over	-0.006***	0.0009	-0.004***	0.0009
Finland	Under	0.018***	0.0009	0.009***	0.0008
	Over	-0.004***	0.0009	-0.005***	0.0009
Norway	Under	0.014***	0.0008	0.007***	0.0008
	Over	-0.010***	0.0011	-0.005***	0.0008
Sweden	Under	0.024***	0.0011	0.011***	0.0010
	Over	-0.009***	0.0010	-0.006***	0.0008

Note: *, **, *** denote significance at the 10, 5, and 1 percent levels, respectively

Mean skill score differences between mismatched and well-matched individuals by two different measures of mismatch (literacy and problem-solving)

Table A5. *Mean skill score differences in literacy between mismatched and well-matched for two measures of mismatch*

	Measure	Under-educated	Over-educated
Denmark	SA (hiring)	9***	-5***
	JA	10***	-7***
Finland	SA (hiring)	4*	-1
	JA	10***	-8***
Norway	SA (hiring)	9***	-4**
	JA	17***	-13***
Sweden	SA (hiring)	6***	-5**
	JA	13***	-8***

Note: Differences estimated using regression with controls for age, gender, and education.
*, **, *** denote significance at the 10, 5, and 1 percent levels, respectively

Table A6. *Mean skill score differences in problem-solving in technology-rich environments (PSL-TRE) between mismatched and well-matched for two measures of mismatch*

	Measure	Under	Over
Denmark	SA (hiring)	12***	-5***
	JA	9***	-5***
Finland	SA (hiring)	5**	-1
	JA	16***	-3*
Norway	SA (hiring)	9***	-3*
	JA	16***	-7***
Sweden	SA (hiring)	3*	-5***
	JA	16***	-6**

Note: Differences estimated using regressions with controls for age, gender, and education.
*, **, *** denote significance at the 10, 5, and 1 percent levels, respectively

Figure A1. *Skill differences in literacy between over-educated and well-matched by age group for two measures of mismatch*

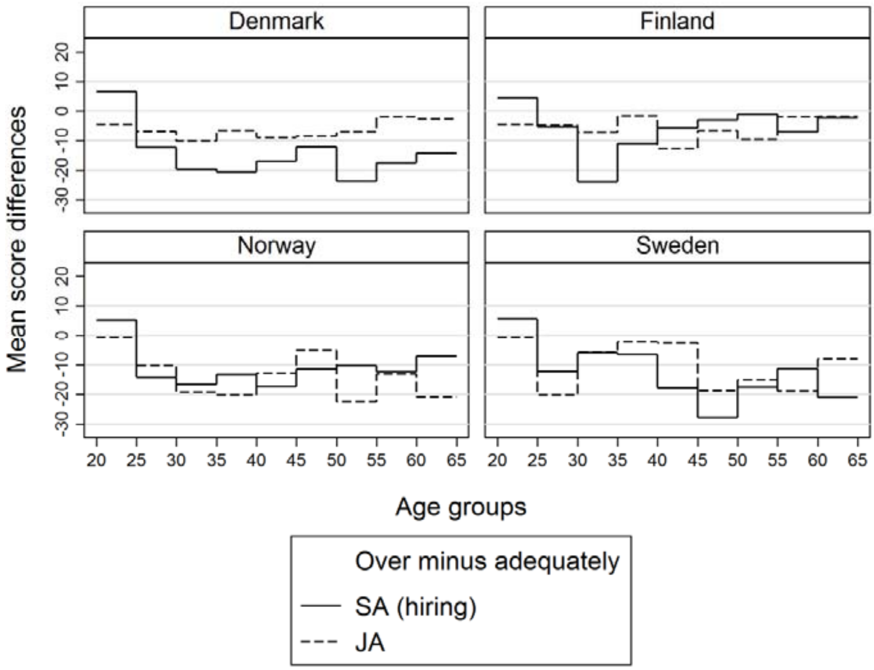
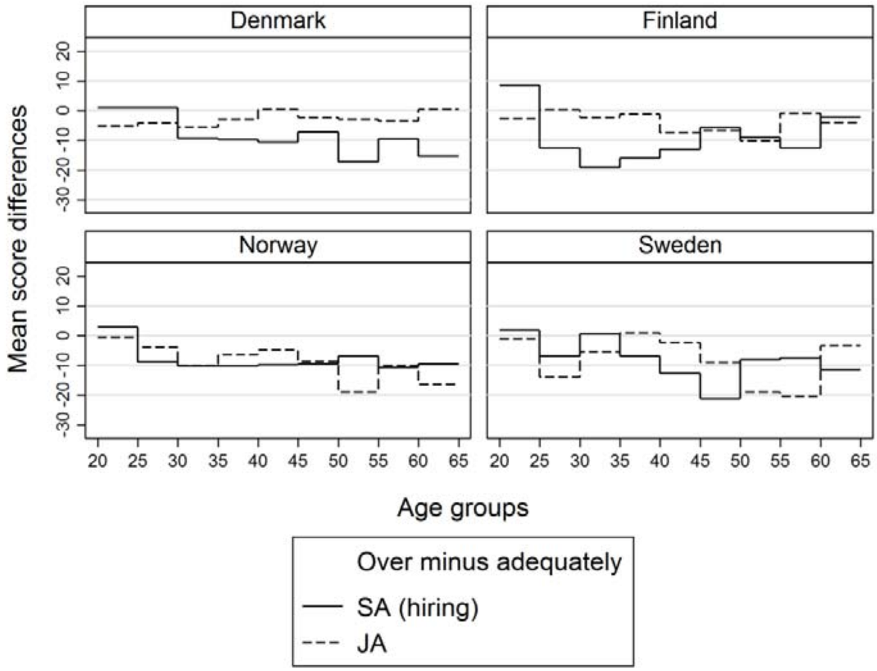


Figure A2. *Skill differences in PSL-TRE between over-educated and well-matched by age group for two measures of mismatch*



Erik Mellander

6

The role of work experience for skills: Findings for the Nordic countries based on the PIAAC survey *

Abstract: With a recursive model, individual work experience is estimated as depending on age, education, and family responsibilities; next, predicted work experience and other variables explain skills. Results: i) Two children yields a female-male work experience difference of –3 years, compared to no children. ii) There is essentially no association between work experience and literacy skills, while for numeracy 5 years of work corresponds to 0.3 standard deviations in skills; intermediate effect for problem-solving skills; iii) Two years of work experience make up for one year of education, for numeracy skills; less favorable trade-off for problem solving and literacy skills.

* Excellent research assisstance provided by Patrik Lind is gratefully acknowledged.

6.1 Introduction

Can work experience make up for the lack of a degree? There seems to be a general perception of the existence of a trade-off between education and work experience.[1] Still, scientific attempts to measure the magnitude of this trade-off are scarce. This is not surprising: the data requirements are quite demanding, especially if one wants to be able to make cross-country comparisons.

To begin with, a good measure of adult skills and competencies is needed – implicit in the initial question is the ending "in the formation of skills". Only three large scale international surveys have been devoted to the measurement of adult skills and competencies: the International Adult Literacy Survey (IALS) conducted in 1994–1998, the Adult Literacy and Life skill survey (ALL) in 2002–2006, and the Programme for the International Assessment of Adult skills and Competencies (PIAAC), in 2011–2012. Of these, the PIAAC survey is the largest in terms of the number of participating countries: 24,[2] compared to 22 in IALS and 12 in ALL. Also, PIAAC is the most comprehensive: while IALS measured literacy skills, ALL literacy and numeracy skills, PIAAC provides information on skills in literacy, numeracy, and "problem solving in technology-rich environments".[3]

Secondly, information about work experience and education is required. Among the IALS, ALL and PIAAC surveys only the PIAAC contains information about both the respondent's work experience and education. In addition to a purely quantitative measure of work experience (number of years), PIAAC also provides extensive qualitative information about the circumstances under which the work experience has been gained – sector, industry, and occupation, and if combined with on-the-job training.

Presumably due to data limitations, only two earlier studies have considered the relation between education and work experience in the formation of skills; both were based on the IALS.

The first study, Desjardins (2003), considers determinants of literacy skills in 18 countries, including the Nordic countries Denmark, Finland and Norway. A latent

1 A google search on "education vs work experience", in June 2014, resulted in 665 000 000 hits, most of which discuss the issue from the perspective of human resource management.

2 Nine additional countries will join PIAAC in 2014.

3 For an overview of the IALS and ALL surveys, and their relation to the PIAAC survey, see Thorn (2009). The PIAAC survey is documented in OECD (2013).

variable "education" is estimated by means of highest level of schooling completed and number of years in formal education. A crude measure of work experience is employed: a 0/1 indicator equal to 1 for respondents in the labor force, i.e. for employed and unemployed alike. In addition, a latent variable "job" is estimated as a function of that indicator and variables capturing qualitative aspects on work experience – occupational status, incidence of job-related training, and an index of literacy practices at the respondent's workplace.

On average, across the 18 countries, a standard deviation increase in the latent variable "education" yields a third of a standard deviation increase in literacy skill scores. In Denmark, Finland and Norway the corresponding estimates are 0.26, 0.42, and 0.20, respectively. Considerable variation is thus found within the Nordic region.[4] With respect to work experience, a one standard deviation increase in labor force participation results in an increase of 0,07 standard deviation in skills, on average, and by 0,09, 0,08, and 0,09 in Denmark, Finland, and Norway, respectively. Hence, when work experience is measured in terms of labor force participation, the trade-off between work experience and education is about 1:5 (0.07 / 0.33) across all the 18 countries – education is five times more important for literacy skills than is work experience. For Denmark, Finland and Norway the trade-offs are 1:3 (0.09 / 0.26), 1:5 (0.08 / 0.42), and almost 1:2 (0.09 / 0.20), respectively.

When, instead, work experience is measured by the latent variable "job" the trade-off increases strongly, to the advantage of work experience. Averaged over all the 18 countries, the trade-off becomes 1:1.4 (0.23 / 0.33), while for Denmark, Finland, and Norway it becomes 1:0.7 (0.35 / 0.26), 1:2 (0.21 /0.42), and 1:0.67 (0.20 / 0.30), respectively. In Denmark and Norway, work experience thus matters more for literacy than education, when "job" is used to measure work experience. Similar results are found for several countries outside the Nordic region, too. In conclusion: Desjardins (op. cit.) finds a trade-off between education and work experience. However, he cannot observe work experience directly and the proxies that he uses yield very different estimates of the magnitude of the trade-off.

The other study, Edin and Gustavsson (2008), exploits an IALS panel data set for Sweden, consisting of 622 individuals observed in 1994 and 1998. Like Desjardins (2003), Edin and Gustavsson (op.cit.) lack direct information about work

4 These estimates, like the following ones, are from Table 4, panel A, in Desjardins (2003).

experience. Respondents that had a job both in 1994 and 1998 and, for the period in between, fulfilled a minimum work requirement and had not attended formal education were classified as having "uninterrupted work experience". By means of this proxy, a quadratic relation is found between work experience and skills. The effects are positive and increasing up until the age of 26, at which point they start to decrease, turning negative just before the age of 35. When controlling for initial skills, the increase in skills between the ages of 20 and 26 is approximately 10 literacy skill points, or 0.23 standard deviations. Thus, while limited to a short period early in the life cycle, the estimate is of the same magnitude as the average estimated skill effect of a one standard deviation increase in the latent variable "job" in Desjardins' (2003) study.

The Edin and Gustavsson (2008) results regarding the trade-off between education and work experience are based on an analysis of how changes in skill scores between 1994 and 1998 are affected by incidence (yes/no) of time out of work and participation in formal training. That is to say, instead of examining the extent to which work experience can make up for lack of education, they investigate whether education can compensate for reductions in work experience. Controlling for education and initial skills, they find that the trade-off is 1:0.78.[5] Thus, work experience is found to be more important for skills than education, just like Desjardins (2003) found for Denmark and Norway, when using the latent "job" variable as measure of work experience.

This paper contributes to the literature on the trade-off between work experience and education in skill formation, along two dimensions. First, unlike earlier studies, it employs direct information on work experience and models the determinants of work experience. Second, while previous analyses have examined the trade-off relative to literacy skills, this paper also considers numeracy skills and skills in problem solving using IT. Moreover, in doing so, it utilizes a more extensive set of indicators on qualitative aspects on work experience than has been employed earlier, to control for differences in impacts of work experience on skills, depending on the contexts in which the work experience has been gained.

Section 2 discusses general considerations regarding the relation between work experience and skills, suggesting a recursive structure implying that work experience

[5] Cf. the first column in Table 4 in Edin and Gustavsson (2008): 1:0.78 = 9.486 / 7.395.

can be considered in a first step and skill formation in a second, where predicted work experience enters as one of the explanatory variables. Section 3 considers the modeling and estimation of years of work experience. Section 4 concerns the estimation of skill formation equations and the trade-offs between work experience and education. Section 5 summarizes and concludes.

6.2 The relation between work experience and skills: general considerations

In general, it is conceivable that work experience and skills are mutually interdependent. The strength of this interdependence is an open question, however. To discuss this issue, it is convenient to start with a general formulation of the determination of work experience:

$$\textit{work exp} = f\,(\textit{age, education, gender, \#children, skills}) + \varepsilon_1\,, \qquad (1)$$

where ε_1 is a stochastic residual term, assumed to be uncorrelated with the arguments of the function *f*.

In (1), the first four variables constitute restrictions on the time that can be used for gaining work experience. The older you are the more work experience you can have; the longer time spent in education, the less time available for work; finally, gender and #children capture constraints on work experience due to family responsibilities (which may differ between males and females). The skill factor, on the other hand, reflects influences on work experience from the demand side of the labor market, i.e. employer considerations. The more highly skilled you are the more likely you are to be offered a job and also the more likely to keep the job, both of which contribute to increase your work experience.

The influence of skills on work experience is not obvious, however. For one thing, it can be difficult and/or costly for a prospective employer to determine a job seeker's skills. If so, the employer might be content with the easily available information about the applicant's education, thus reducing the importance of skills in connection with hires. Moreover, while an employed person's skills are much easier to determine than the skills of a prospective employee, many factors beside skills are important for the possibilities to keep a job – seniority, business conditions, and technological changes, to name a few. Accordingly, skills may not be that important for the chances to hold on to a job, either. These arguments may be used to simplify the relationship between skills and work experience.

Specifically, if skills are not essential determinants of work experience, given the other variables in (1), then the mutual interdependence between skills and work experience can be approximated by means of a recursive relation, where skills are first determined by age, education, gender, and #children and the resulting projection then substituted in an equation for skills.[6] For simplicity, this will be the framework applied here. Equation (1) thus simplifies to:

$$work\ exp = g(age,\ education,\ gender,\ \#children) + \varepsilon_1\ . \qquad (1a)$$

Proceding with a general formulation of the determination of skills, we propose that it be expressed according to:

$$skills = h(age,\ education,\ parental\ background,\ \hat{}work\ exp,$$

$$on\text{-}the\text{-}job\ training,\ sector,\ industry,\ occupation) + \varepsilon_2\ , \qquad (2)$$

where ε_2 is another stochastic disturbance term, assumed to be uncorrelated with the arguments of the *h* and *g* functions but possibly correlated with the stochastic disturbance ε_1 in equation (1a).

In (2), age is supposed to capture the negative relation between skills and age documented in OECD (2013). Education accounts for skills acquired through schooling. Parental background is supposed to capture both genetic factors that matter for skills and influences from the individual's upbringing and home environment. The learning of skills at work is partitioned into a quantitative aspect, years of work experience, the ^ denoting predicted value[7], and a qualitative aspect, subsumed under the concept on-the-job training. Additional qualitative aspects

[6] The use of recursive systems was pioneered by the Scandinavian econometrician and statistician Herman Wold (born in Norway, with his career in Sweden), see, e.g., Wold (1954). For an easily accessible treatment of recursive systems, cf. Wonnacott and Wonnacott (1970, Ch. 9.3).

[7] The reason for substituting predicted work experience, i.e. ^work exp, for actual work experience is that this will ascertain that an unbiased estimate of the influence of work experienceon skills can be obtained even if the stochastic disturbances ε_1 and ε_2 should happen to be correlated, as long as they, in turn, are not correlated with the arguments of the *g* function in (1a).

on work experience are captured by the control variables for sector, industry and occupation, the underlying idea being that the skills gained from work experience presumably depend on the individual's work environment and the specific tasks that (s)he performs.

Comparing equations (1a) and (2) we see that while age and education are included in both equations, the variables gender and #children are only present in equation (1a). Similarly, the variables parental background, sector, industry, occupation, and on-the-job training are only included in equation (2). These specifications correspond to what is called exclusion restrictions. For example, the variables gender and #children are excluded from equation (2).

The presence of exclusion restrictions is what makes it possible to empirically separate the equations from one another. Put differently, they identify the two equations. For example, varying gender and #children, which affect the work experience function, g, but not the skills function, h, we can identify points on the skill function h corresponding to different combinations of the variables age and education, which constitute arguments in both the g and h functions. Conversely, changes in, e.g., on-the-job training, which affects the skill function but not the work experience function, can be used to trace out the work experience function for different combinations of age and education.

But this line of reasoning begs the question about the standing of the variable education. Is it not reasonable to believe education to be affected by work experience and skills? That might well be the case. However, in this context we are not interested in trying to explain why the level of education differs across individuals; we are content with being able to make statements about work experience and skills when education is accounted for. Therefore, we treat education as determined outside of the present context, or predetermined. This is admissible as long as there are no left-out variables in the g and h functions that affect both work experience and education or skills and education, respectively. With respect to the work experience function, that condition might be violated if the leaving out of the skills variable resulting from the substitution of the g function for the function f is not justified. If so, the estimated influence of education in the work experience function g will be biased. But this potential problem is not serious; we are not very interested in how education, in particular, affects work experience, we are content as long as the equation (1a) yields a good overall prediction of work experience.

6.3 The determination of work experience

This section first considers restrictions that are imposed throughout the empirical analysis in this paper. Next, the variables considered in this section are defined. Then, in Section 3.2, some descriptive analyses are performed on these variables. Finally, in Section 3.3, the empirical counterpart to the work experience equation (1a) is specified and estimated.

6.3.1 Sample and variable definitions

The sample will be limited to individuals aged 20–65. The reason for excluding the 16–19 year olds is that in the Nordic countries almost all individuals in this age range attend upper secondary school, implying that the work experience they have gained stems from short term jobs during vacations and/or work by the hour, during evenings and weekends. Such types of work will presumably be quite different from later employment, taken on for the purpose of earning a living. Moreover, it is reasonable to assume that employment during vacations and odd hours is rather weakly related to skill accumulation.

The endogenous variable, i.e. the variable to be explained, work experience, is defined in terms of number of years. This definition is made operational by means of a minimum work requirement, stating that an individual for which at least 6 months was spent in full-time or part-time work in year *t*, is assigned one year of work experience in year t. Only individuals with positive work experience, according to this definition are included in the analysis.[8]

The explanatory, right hand side variables, are straightforward. The age variable is measured in number of years. Education refers to highest level of education completed. Using lower secondary education as the reference category, it is represented by three binary dummy variables, one for upper secondary education, one for short tertiary education[9], and one for longer tertiary education.[10] Gender is measured by means of a binary variable equal to one for females and equal to zero for males. The number of children variable runs from 0 to 4, where 4 includes all numbers at least equal to 4.

8 Cf. Variable C_Q09 in the PIAAC Background questionnaire.

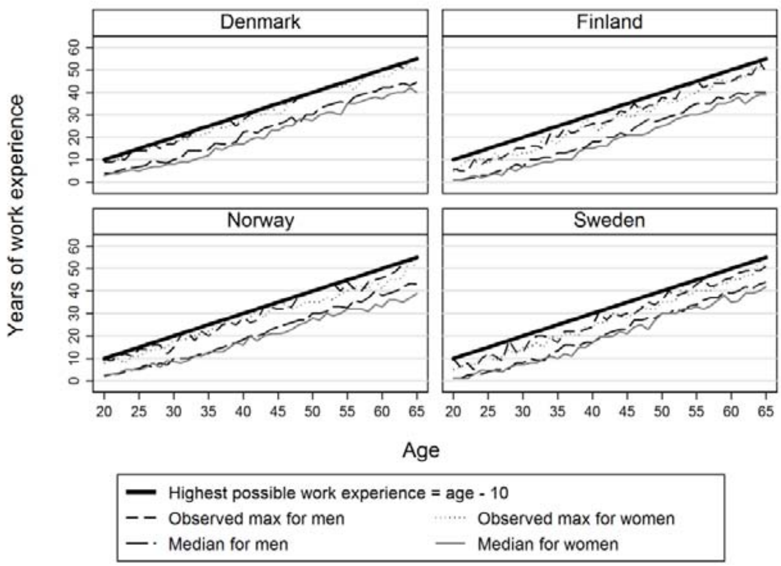
9 In terms of the the ISCED classification system, this category is ISCED5B.

10 Corresponding to the Bachelor, Master or PhD levels.

6.3.2 Descriptive analysis

We first consider how work experience varies by cohort and gender, cf. Figure 1. There are two things to note about this figure. First, quite a few of the male cohorts contain individuals with the maximum number of years of work experience. In particular, this is the case with respect to Denmark, where also quite a few female cohorts include women with maximal work experience. In Finland and Sweden, on the other hand, maximum work experience is attained by very few cohorts. Norway is in between these two extremes.[11]

Figure 1. *Years of work experience (vertical axis) by age (horizontal axis) and gender*



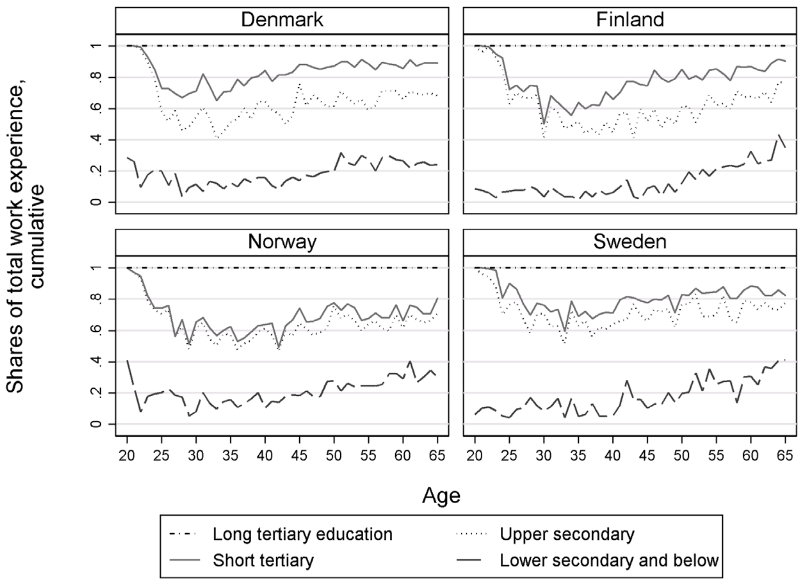
Note: The maximum and median values have been weighted by sampling weights.

11 Some of the observations with maximum work experience are likely to be due to measurement errors. Actually, the original data have been adjusted. In the instructions to the PIAAC interviewers, 55 years have been set as upper limit to the number of years of work experience. When applied to oldest respondents, this constraint implies that work experience has been gained each year since the age of ten. However, apparently the interviewers have applied this same upper limit to younger respondents, as well. In some cases this has resulted in answers that obviously are out of range. To circumvent this problem the upper limit has been linearly extrapolated to younger respondents, such that for each cohort the maximum limit implies that work experience has been gained continuously since age ten. Responses exceeding this upper limit have been adjusted downwards, to the limit.

Second, in Finland, Norway, and Sweden the median work experience of males exceeds that of females in three out of four cohorts; in Denmark in nine out of ten. We will consider this issue further, but first we will look at the relation between work experience and education.

Obviously, the longer time spent in education, the less time available for gaining work experience. Figure 2 shows the shares in the respective countries' total work experience accounted for by the four educational categories. It can be seen that the Nordic countries are guite similar in this respect. In particular, going from the oldest cohorts, the 65-year olds, to individuals approximately 30 years old, we see that in every Nordic country the shares of work experience decrease for all levels of education, except long tertiary education. However, the size of increase in the share of long tertiary education differs across countries, being largest in Finland and smallest in Sweden. Also, there are considerable cross-country differences with respect to the youngest cohorts. For instance, among the 20-year olds those with only lower

Figure 2. *Shares of total work experience by age and level of education*



Note: The shares have been weighted by sampling weights.

secondary education account for about 10 % of work experience in Sweden and Finland but for 30 and 40% in Denmark and Norway, respectively.

Returning to the gender difference in work experience depicted in Figure 1, a reasonable conjecture is that it is related to (differences in) household responsibilities. Figure 3 examines this conjecture, using number of children as a proxy for household responsibilities. In the construction of Figure 3, work experience has first been purged of the influence of age that is evident in Figure 1. The purging simply amounts to regressing years of work experience on age, by ordinary least squares (OLS) applied to the following regression:

$$work\ exp = a_0 + a_1 \times age + e \, , \tag{3}$$

where a_0 and a_1 are unknown parameters and e a stochastic residual term. The estimate of the residual, $\hat{e}$, is the purged work experience, i.e.

$$work\ exp\ purged\ of\ age = \hat{e} = work\ exp - \hat{a}_0 - \hat{a}_1 \times age \, , \tag{4}$$

where $\hat{a}_0$ and $\hat{a}_1$ are the OLS estimates of a_0 and a_1. In words, work experience purged of age measures the variation in work experience around the mean work experience, at a given age.

The horizontal axes in Figure 3 measures the individual's number of children, 0, 1, 2, 3, 4+. The dots show the median purged work experience for the five categories of children. Thus, e.g., the median number of purged work experience among Danish individuals with one child is just below two for males and zero for females.

The solid and dotted lines in Figure 3 have been obtained by means of two additional OLS regression analyses, applied to the purged work experience. Specifically, the solid lines have been obtained from estimation of the following equation:

$$\hat{e} = u_0 + u_1 \times \#children + u_2 \times \#children \times D_{female} + v \tag{5}$$

where D_{female} is a gender dummy variable equal to 1 for females and 0 for males; u_0, u_1 and u_2 are parameters, and v the residual. The solid line in the diagram for males is computed according to

$$\hat{u}_0 + \hat{u}_1 \times \#children \, . \tag{6}$$

The fact that solid line is upward sloping says that the estimate $\hat{u}_1$ is positive. Accordingly, for men the number of years of work experience is *increasing* in the number of children. This holds for all of the Nordic countries – the only difference is that the slopes are somewhat steeper in Norway and Denmark than in Sweden and Finland. Presumably, the reason for the positive slopes is that with more children men work more, because they have a larger number of persons to support.

In the diagram for females, the solid line is computed according to:

$$\hat{u}_0 + \hat{u}_1 \times \textit{\#children} + \hat{u}_2 \times \textit{\#children}\ . \qquad (7)$$

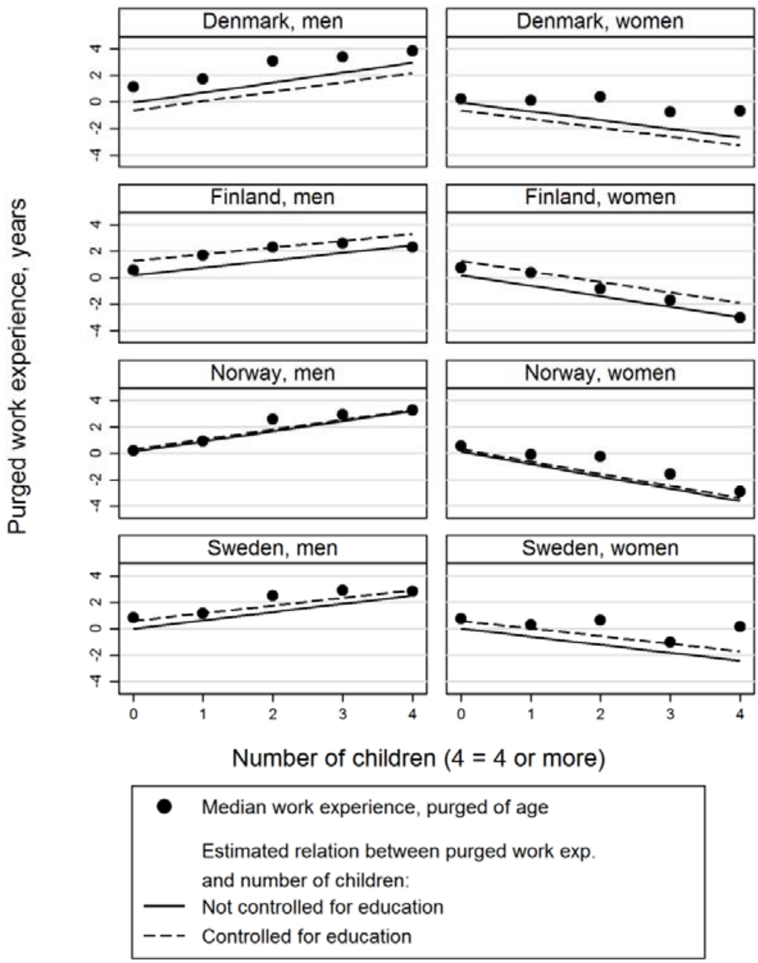
The solid line for females is downward sloping. This indicates that the estimate $\hat{u}_2$ is negative, and larger (in absolute value) than the estimate $\hat{u}_1$. For females, work experience is thus *decreasing* in the number of children. Again, this holds for each of the Nordic countries. However, the differences in slopes across countries are larger than the corresponding differences for males. Here, the negative slope is largest for Norway and smallest for Sweden.

The fact that work experience is positively related to number of children for males while the relation is negative for females is likely to be the most important reason why women have less work experience than men at almost every age, as shown in Figure 1.

The dotted lines in Figure 3 are obtained similarly to the solid lines, the difference being that dummy variables for the different levels of education in Figure 2 are added as right hand side variables in the regression (5). It can be seen that, qualitatively, the results are unchanged when the individuals' levels of education are accounted for. Accounting for education shifts the regression line slightly upwards (in Finland, Sweden and Norway) or slightly downwards (in Denmark), without changing its slope. The changes are small, however; the only country where the difference appears to matter is Finland, where the controlling for education increases the purged work experience with approximately one year.

In Denmark, and partly in Norway and Sweden, the dots indicating the median values of purged work experience, by number of children, are distinctly above the regression lines. Since the regression lines correspond to the *mean* values of purged work experience by number of children, this implies that for these countries the distributions of purged work experience associated with different numbers of children are skewed to the right – the distributions have more of their mass towards the right tail of the distributions than to the left tail, implying that the median exceeds the mean.

Figure 3. *Work experience (purged of age) and number of children*



Note: The median work experiences and the OLS regressions underlying the solid and the dotted lines have been weighted by sampling weights.

6.3.3 Predicted work experience

The information gained from the descriptive analysis above is used to specify an explicit functional form for equation (1a), and estimate this regression by means of multivariate regression analysis. The estimated equation is then used to compute predicted work experience.

The equation estimated by OLS is given by:

$$\begin{aligned} \textit{work exp} = {} & b_0 + b_1\, \textit{age} + b_2\, \textit{age}^2 + b_3\, D_{\text{upper sec}} + b_4\, D_{\text{short tert}} \\ & + b_5\, D_{\text{long tert}} + b_6\, D_{\text{female}} + b_7\, \#\textit{children} \\ & + b_8\, D_{\text{female}} \times \#\textit{children} + \varepsilon. \end{aligned} \tag{8}$$

The quadratic term in age is included to capture non-linearities in the relation between work experience and age. Education is measured in terms of highest level completed, and relative to the lowest level – lower secondary education, by means of binary dummy variables corresponding to upper secondary education, short teriary education and long tertiary education, respectively. Gender and number of children are included both separately and by means of an interaction term, to capture the gender difference illustrated in Figure 3.

The estimates of the parameters in equation (8), by country, are provided in Table 1.[12] The table shows that this simple specification works well – it accounts for around 80 perecent of the variation in individuals' work experience in the Nordic countries. Accordingly, the requirement discussed in Section 2, i.e. that the work experience regression should yield good predictions of work experience, is empirically satisfied.

Table 1 shows that, as expected, work experience increases with age – and non-linearly so, in all countries but Norway. The association between level of education and work experience varies across countries, with the exception of long tertiary edu-

[12] The standard errors of the reported estimates in this regression, like in all the regressions in the following, account for the fact that stratified random sampling has been employed in the PIAAC survey, resulting in sampling error. To this end, a procedure called jackknife replication has been applied. This procedure amounts to creating 80 subsamples from the original (country) samples, (re)weighting these subsamples such that they mirror the design of the full sample, and running regressions on each subsample. The standard errors are then computed as the square root of the sum of squared differences between the subsample estimates and the estimate based on the whole sample, cf. Pokropek and Jakubowski (2013).

cation, which in all of the countries is strongly and significantly negatively related to work experience, again in accordance with a priori expectations.

Finally, family responsibilities, captured by the number of children variable and the interaction between this variable and the female dummy variable, are positively related to male work experience and negatively related to female work experience, in line with Figure 3. For example, having two children increases the male's work experience by, at least, 1.42 years (0.710 × 2), in Denmark, to, at most, 1.706 years (0.853 × 2), in Norway, compared to having no children. For females, on the other hand, the same number of children reduces work experience, from –1.038 years (0.710 × 2 – 1.229 × 2) in Denmark down to – 2.064 years (0.853 × 2 – 1.885 × 2) in Norway. Thus, within a couple the female–male difference will be between –2.458 years (–1.038 – 1.420) in Denmark and –3.770 years (–2.064 –1.706) in

Table 1. *Linear regressions, by country; dependent variable: years of work experience; standard errors in prenthesis*

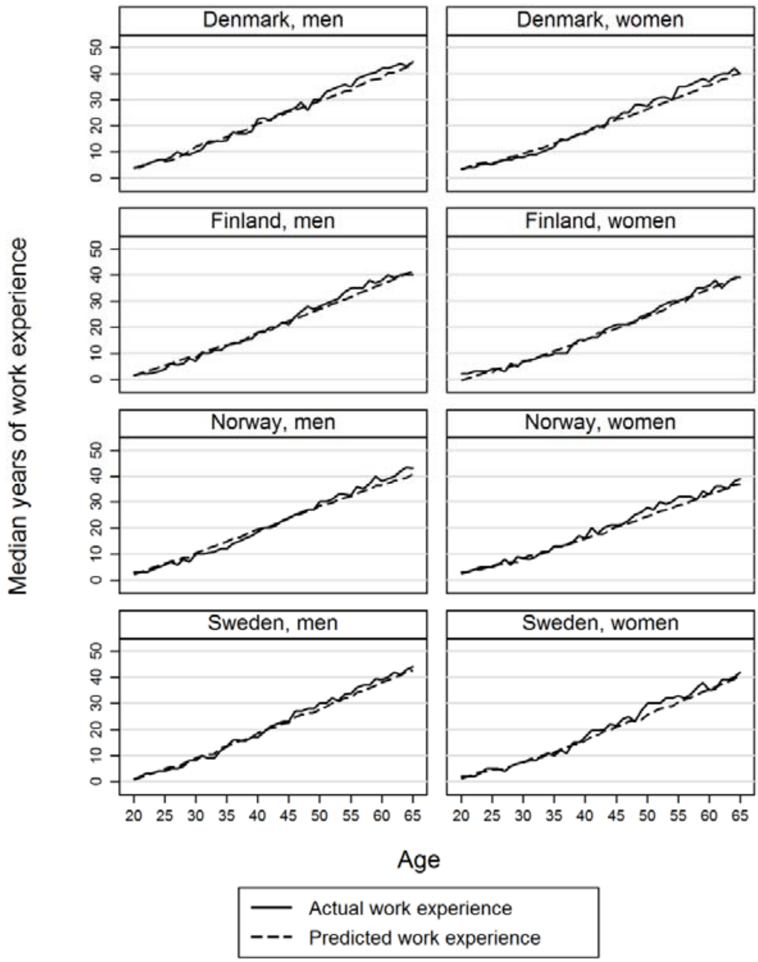
Variable	Denmark	Finland	Norway	Sweden
Intercept	−14.052*** (0.983)	−13.306*** (0.927)	−14.466*** (1.200)	−15.199*** (1.130)
Age	0.767*** (0.054)	0.655*** (0.047)	0.789*** (0.062)	0.740*** (0.059)
age^2	0.0013** (0.0006)	0.0027*** (0.0005)	0.0005 (0.0008)	0.0020*** (0.0007)
$D_{\text{upper sec}}$	1.920*** (0.249)	−0.366 (0.415)	0.685** (0.303)	0.324 (0.335)
$D_{\text{short tert}}$	0.657** (0.272)	−0.795* (0.442)	1.584*** (0.445)	−0.707* (0.374)
$D_{\text{long tert}}$	−1.531*** (0.313)	−2.616*** (0.411)	−1.479*** (0.287)	−2.746*** (0.327)
D_{female}	−0.324 (0.271)	0.545* (0.283)	0.549* (0.314)	0.594** (0.269)
#children	0.710*** (0.093)	0.728*** (0.106)	0.853*** (0.127)	0.772*** (0.114)
$D_{\text{female}} \times$	−1.229***	−1.520***	−1.885***	−1.377***
#children	(0.139)	(149)	(0.177)	(0.159)
R^2	0.782	0.813	0.773	0.832
N	6 620	4 808	4 333	3 891

Notes:
-. Standard errors account for sampling error.
- *, **, and *** denote significant at the 10, 5 and 1 % levels, respectively.

Norway, compared to a couple without children. Averaged across the Nordic countries, the difference is close to –3 years, which is quite substantial; as can be seen in Figure 1, the accumulated (median) female work experience at the age of, e.g., 45 is around 20 years.

Figure 4 illustrates the predictive power of the regression equation (8). For each country, actual median work experience by age and gender is plotted against the cor-

Figure 4. *Actual and predicted median years of work experience by age and gender*



Note: Both actual and predicted values on work experience are weighted by sampling weights.

responding predicted values. To this end, the actual median values of work experience for males and females, by age, are first reproduced from Figure 1. The estimated parameters in Table 1 are then used to compute predicted work experience for all of the individuals in the samples for the different countries. For each age category, and separately for males and females, the median predictions are then picked out and plotted in Figure 4. As already indicated by the R^2s in Table 1, it can be seen that, overall, the predictions are quite good. For instance, in none of the eight diagrams is the predicted median work experience negative for the 20 year olds, although no constraint to this effect has been imposed on the regression model. However, the regression model slightly underpredicts the median work experience of men 50+. It also tends to underpredict the median work experience of women between 45 and 60 years of age; the error is very small with respect to Finnish females, however.

6.4 Skill formation

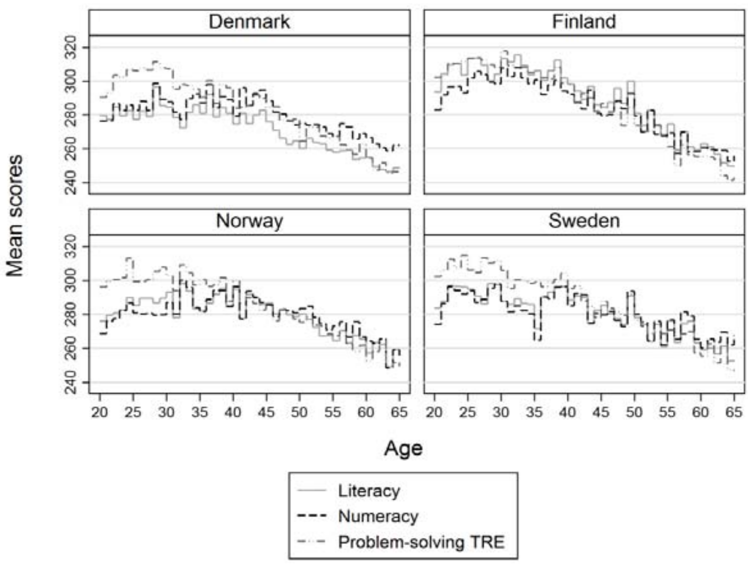
In this section, the details of equation (2) are considered, starting with the fact that in PIAAC there are several skill measures. It will be shown how these measures covary, by age, in the Nordic countries. Similarly, there are several indicators on parental background and on-the-job training. It will be investigated how these indicators are related and if their influences on skills can be separated. In addition, controls for the characteristics of the respondent's employment situation will be considered – indicators of industry, sector, and occupation.

6.4.1 Alternative skill measures

PIAAC contains three alternative outcome variables: literacy skill scores, numeracy skill scores, and scores in problem-solving in technology-rich environments (PS_TRE). These scores are subject to measurement error, due both to genuine uncertainty about the respondents' true skills and to the fact that, because of time and cost constraints, no respondent takes all tests. Based on the respondent's response pattern and background characteristics a conditional, individual, score distribution can be determined, however. Ten random draws – ten "plausible values" – are obtained from these individual distributions. The reported results are averages over these plausible values.[13] In Figure 5, the resulting mean scores are plotted by age, for the Nordic countries.

According to Figure 5, the literacy and numeracy sores are rather close to one another in all four of the Nordic countries. The PS_TRE scores differ from the literacy and numeracy scores, however. Among individuals below 40, the PS_TRE scores are higher than the literacy and numeracy scores. As a result, the mean skill scores in the three skill domains are highest in PS_TRE, cf. Table 2. However, in Finland the mean literacy score is as high as the mean PSA_TRE score, which is in line with Figure 5, showing that the tendency to higher skill scores in PS_TRE is weaker in Finland than in the other Nordic countries.[14]

Figure 5. *Mean scores in literacy, numeracy and problem solving in technology rich environments (PS_TRE), by age*



Note: The scores have weighted by sample weights and are based on plausible values. The means presented represent averages from ten sets of draws of individual-specific plausible values.

13 The derivation of the plausible values is based on Item Response Theory (IRT). For an introduction to IRT and the estimation of the conditional score distributions, cf. Baker (2001).

14 The standard errors in Table 2 account for both the PIAAC sampling error and for the measurement errors in the plausible values. This involves 80 replications for each one of the ten mean scores corresponding to the ten sets of plausible values, cf. footnote 12, plus ten additional computations to capture the variance in the plausible values, altogether 810 (10 × 80 + 10) computations; see Pokropek and Jakubowski (2013).

Table 2. *Skill scores for 20–65 year olds: means and standard deviations, by country*

		Skill domains		
		Literacy	Numeracy	PS_TRE
Denmark	Mean	272	280	282
	Standard deviation	47.7	51.0	43.1
	N	6 617	6 617	5 540
Finland	Mean	288	283	288
	Standard deviation	50.7	51.6	43.1
	N	4 808	4 808	3 905
Norway	Mean	281	281	286
	Standard deviation	46.4	52.9	40.5
	N	4 330	4 330	3 784
Sweden	Mean	281	282	287
	Standard deviation	49.6	53.6	44.5
	N	3 891	3 891	3 448

Notes:
- The acronym PS_TRE reads Problem solving in technology-rich environments.
- The means are weighted by sample weights.
- The standard errors account for both sampling error and measurement error.

6.4.2 Measures of parental background

The measures used to control for parental background are the highest level of education attained by the respondent's father or male guardian and the respondent's mother or female guardian, respectively.[15] There is no information about to what extent this information refers to biological parents. As measured, the influence of parental background on skills will thus stem from a mixture of genetic factors, on the one hand, and upbringing and home environment aspects, on the other hand.

The levels of education of the parents/guardians are aggregated into the following three categories:

- lower secondary education (ISCED 1,2,3cshort; reference category)
- upper secondary education (ISCED 3 excl 3cshort,4)
- tertiary education (ISCED 5,6).

[15] Questions J_Q06b and J_Q07b in the PIAAC Background Questionnaire.

For the empirical analysis it is of interest to investigate the covariation in the levels of education of the mother/female guardian and of the father/male guardian. That covariation can be examined by means of Table 3, showing the relative frequencies of different combinations of educational levels attained by the parents/guardians. If educational levels within pairs of parents/guardians are positively correlated the table will exhibit the largest (relative) frequencies along, or close to, the main diagonal. The table also displays a scalar measure of the covariation, namely the (matrix) trace, defined as the sum of the matrix' diagonal elements.[16] In Table 3, the trace is equal to the share (in percent) of the parent/guardian pairs for which the female and the male have the same level of education.

In the table, Finland stands out in several respects. The trace of the Finnish matrix is highest among all the Nordic countries. Specifically, in Finland 68.5% of the parent/guardian pairs are characterized by the partners having the same level of education, as opposed to 55.8% in Norway, at the other end of the spectrum. Another interesting feature is that Finland also shows the highest share of mothers/female guardians with only lower secondary education, 54.6%. Again, Norway is at the other extreme; 50.1% of the Norwegian mothers/female guardians have lower secondary education. And also with respect to highly educated mothers/female guardians the Fins lag behind – 10.7% have tertiary education, compared to 22.9% in Sweden. Surprisingly, the findings are quite similar för fathers/male guardians. The Fins have the highest share of fathers/male guardians with only lower secondary education, 54.5%. Moreover, in Finland the share of fathers/male guardians with tertiary education is distinctly lower than in the other Nordic countries, 12.6%. In Norway this share is twice as large, 25.2%.

With respect to the regression analysis to be conducted, two remarks can be made with respect to Table 3. The first is that the associations between the educational levels of mothers/female guardians and fathers/male guardians do not appear to be so strong so as to create multi-collinearity problems.[17] The second observation is that for some of the respondents information is lacking about the level of education for at least one parent/guardian. These shares are obtained by adding together the row and column sums for the *Not available* category, yielding

16 See, e.g.. Greene (1993, pp. 33–34).

17 Thus, assortative mating – see, e.g. Greenwood et al. (2014) – does not seem to pose a problem for our empirical analysis.

Table 3. *Relative frequencies, %, of different combinations of educational levels among the respondents' parents/guardians*

Father/male guardian → **Mother/female guardian ↓**	*Lower secondary*	*Upper secondary*	*Tertiary*	*Not Available*	*Sum/* **Trace**
Denmark	(N:2746)	(N: 2319)	(N:1492)	(N:63)	(N:6620)
Lower secondary	31.7	18.1	4.1	0.6	54.5
Upper secondary	5.1	14.2	5.4	0.1	24.8
Tertiary	2.2	4.7	13.4	0.1	20.4
Not available	0.0	0.1	0.0	0.2	0.3
Sum/ **trace**	*39.0*	*37.1*	*22.9*	*1.0*	**59.5**
Finland	(N:2634)	(N:1492)	(N:605)	(N:77)	(N:4808)
Lower secondary	43.5	9.0	1.4	0.7	54.6
Upper secondary	9.5	18.5	5.3	0.4	33.7
Tertiary	1.3	3.4	5.9	0.1	10.7
Not available	0.2	0.2	0.0	0.6	1.0
Sum/ **trace**	*54.5*	*31.1*	*12.6*	*1.8*	**68.5**
Norway	(N:1537)	(N:1608)	(N:1138)	(N:50)	(N:4333)
Lower secondary	28.3	16.4	4.8	0.6	50.1
Upper secondary	6.6	15.1	8.2	0.2	30.1
Tertiary	1.7	5.4	12.1	0.1	19.3
Not available	0.0	0.1	0.1	0.3	0.5
Sum/ **trace**	*36.6*	*37.0*	*25.2*	*1.2*	**55.8**
Sweden	(N:1995)	(N:817)	(N:942)	(N:137)	(N:3891)
Lower secondary	41.0	7.2	4.4	1.4	54.0
Upper secondary	6.4	8.3	5.5	0.8	21.0
Tertiary	3.8	5.3	13.2	0.6	22.9
Not available	0.6	0.2	0.2	1.1	2.1
Sum/ **trace**	*51.8*	*21.0*	*23.3*	*3.9*	**63.6**

Notes:
- The trace is defined as the sum of the matrix' diagonal elements.
- The relative frequencies are weighted by sample weights.

1.3%, 2.8%, 1.7%, and 6.0% for Denmark, Finland, Norway and Sweden, respectively. This should accounted for in the regression analysis.

The information in this subsection will enter the regression analysis in the form of the following binary indicators:

$D_{\text{Mo Upper sec}}$ = mother/female guardian, upper secondary education

$D_{\text{Mo Tert}}$ = mother/female guardian, tertiary education

$D_{\text{Fa Upper sec}}$ = father/male guardian, upper secondary education

$D_{\text{Fa Tert}}$ = father/male guardian, tertiary education

$D_{\text{Na Ma/Fa}}$ = information not available about the education of the mother/female guardian *or/and* the education of the father/male guardian.

6.4.3 On-the-job training indicators

The PIAAC Background Questionnaire contains several indicators of on-the-job training, during the 12 months preceding the participation in the survey. Four of them are considered here:

- job-related formal training: Yes/No[18]
- training sessions or training by supervisors/co-workers: # times[19]
- seminars or workshops: # times[20]
- courses or private lessons: # times[21]

From the literature on training it is known that the incidence of training is over-represented among well-educated and young(er) employees. Furthermore, it has been established that individuals that participate in any form of training often participate on several occasions.[22] Together these two stylized facts suggest that our four on-the-job training indicators might be highly correlated. If so, they might

18 [(B_Q04a =1 and B_Q05c = 1 and B_Q10a = 1) and (B_Q10c = 2, 3, or 4)] and [(B_Q10b = 1, 2, or 3) or (B_Q10b = 4 and B_Q11 = 1 or 2)].

19 B_Q12c = 1 and B_Q12d € (1,50).

20 B_Q12e = 1 and B_Q12f € (1,50).

21 B_Q12g = 1 and B_Q12h € (1,50).

22 On these findings, see, e.g., Bassanini et al. (2007).

give rise to multi-collinearity problems, making it difficult to assess the influence of on-the-job training on skills and, in particular, to separate the influences from different forms of training.

Pairwise, bivariate, correlations are not informative about multi-collinearity. Even if all the pairwise correlations among the on-the-job training indicators are modest multi-collinearity might still be a problem. One way to determine if that is the case is to examine the correlation matrix by means of matrix algebra methods.[23] Another, simpler, option employed here is to regress one of the on-the-job training indicators on the other ones and check how much of the variation in the left hand side indicator that is accounted for by the right hand side indicators. If the share of explained variation is high, that signals a problem of multi-collinearity. The simplest way to deal with the problem is exclude one or several of the indicators from the regression analysis to be conducted with respect to skill formation.

Table 4 shows the result of regressing the indicator for training sessions or training by supervisors/co-workers on the other three training indicators. The conclusion is that multi-collinearity among the on-the-job training indicators does not constitute a problem. The indicators for on-the-job training in the form seminars

Table 4. *Regression of #times participated in training session or training by supervisors/coworkers on the other on-the-job training indicators; standard errors in parenthesis*

Variable	Denmark	Finland	Norway	Sweden
Intercept	0.714*** (0.062)	1.099*** (0.054)	0.663*** (0.044)	0.696*** (0.048)
Formal training;	0.656	0.492	0.076	–0.183
$D_{\text{form training}}$	(0.436)	(0.667)	(0.249)	(0.199)
Seminars & workshops;	0.476***	0.534***	0.343***	0.144***
sem_w-shps	(0.056)	(0.078)	(0.044)	(0.030)
Courses & lessons;	0.367***	0.225**	0.086**	0.086**
course_less	(0.137)	(0.096)	(0.037)	(0.048)
R^2	0.131	0.096	0.049	0.049
N	6620	4808	4333	3891

Notes:
- Standard errors account for sampling error.
- *, **, and *** denote significant at the 10, 5 and 1 % levels, respectively.

[23] These methods involve computation of the characteristic roots, or eigenvalues, of the correlation matrix, cf. Belsley (1991).

and workshops, and courses and lessons, respectively, are positively and significantly related to the indicator #times participated in training session or training by supervisors/coworkers, but the R^2s are very low.

6.4.4 Sector, industry, and occupation fixed effects

Work experience and/or on-the-job training may contribute differently to skills depending on the working environment. For instance, it is conceivable that work in IT-intensive industries may be more beneficial for human capital accumulation than employment in the construction industry. Likewise, within a given sector and industry environment some occupations are likely to be more conducive to skills build-up than others. To account for these possibilities binary indicator variables are used, signaling presence in sector/industry and possession of occupation.[24]

Sectors and industries

With respect to sector, three categories can be distinguished in the PIAAC Background Questionnaire: private, public and non-profit.[25] However, the occurrence of work in the non-profit sector is so rare that it is not meaningful to consider this sector separately.[26]

Regarding industries, the BQ contains a question about in what kind of business, industry or service the respondent works.[27] By means of the answer, the respondent is assigned a 4-digit industry code.[28]

To save on degrees of freedom in the empirical analysis, industries have been aggregated such that there is no need to separately account for sector – one of the aggregates corresponds to the public sector. The following five aggregates are indicated by means of binary indicator variables:

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24 It should be pointed out that the PIAAC Background Questionnaire provides information about the individual's occupation, industry, and sector at the time of the interview. Accordingly, it is not informative about the contexts of the individual's accumulated work experience.

25 Question D_Q03.

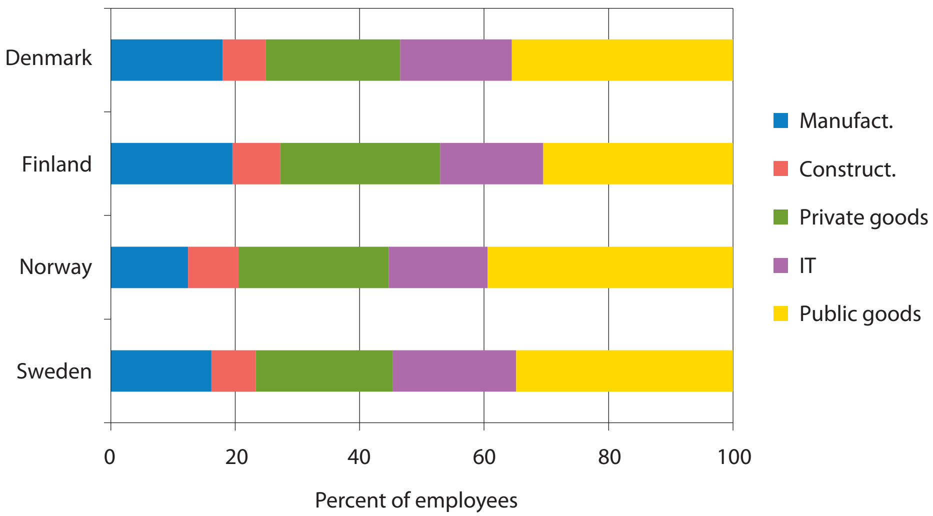
26 The non-profit sector activities have been included in the industry aggregates Private goods and services and Public goods and services, which are defined below.

27 Question D_Q02a.

28 Based on the United Nation International Standard Industrial Classification (ISIC) system.

- Manufacturing, mining and utilities; D_{manuf}[29]
- Construction; D_{constr}[30]
- IT-intensive industries; $D_{IT\text{-}intens}$[31]
- Private goods and services; $D_{priv\ g\&s}$[32]
- Public goods and services; $D_{publ\ g\&s.}$[33]

Figure 6. *Distributions of employees over industries, by country*



Notes:
- Industry shares are based on number of employees – no adjustment has been made for differences in work hours.
- The shares have been weighted by sampling weights.

29 ISIC C = Manufacturing + B = Mining and quarrying + D = Electricity, gas, steam, air conditioning supply + E = Water suppl; sewage, waste management and remediation activities + A = Agriculture, forestry and fishing.

30 ISIC F = Construction.

31 ISIC J = Information and communication + K = Financial and insurance activities + L = Real estate activities + M = Professional, svientific and technical activities + N = Administrative and support activities.

32 ISIC G = Wholesale and retail trade; repair of moter vehicles, motorcycles + H = Transportation and storage + I = Accommodation and food service activities + S = Other service activities + T = Household activities.

33 ISIC O = Public administration and defence; compulsory social security + P = Education + Q = Human health, social work activities + R = Arts, entertainment and recreation + U = Extraterritorial organizations.

Figure 6 shows that there are non-negligible differences in the distributions of employees over industries across the Nordic countries. The largest differences are found when Finland and Norway are compared. Employment in the Finnish manufacturing sector accounts for a much larger share in total Finnish employment than does its Norwegian counterpart. Instead, the Norwegian public sector makes up for a larger part of domestic employment than the Finnish public sector. The Danish and Swedish employment distributions are quite similar: the public sector accounts for close to 40%, IT-intensive industries and the production of private goods and services for about 20% each, and manufacturing and construction together for slightly more than 20%.

Occupations

Based on a question about job title, the respondents have been assigned a 4-digit occupational code.[34] Following Albæk et al. (2014), two occupational aggregates are used, defined by the following 1-digit codes:

ISCO0: Armed forces occupations
ISCO1: Managers
ISCO2: Professionals
ISCO3: Technicians and associate professionals
ISCO4: Clerical support workers
ISCO5: Service and sales workers
ISCO6: Skilled agricultural, forestry and fishery workers
ISCO7: Craft and related trades workers
ISCO8: Plant and machine operators and assemblers
ISCO9: Elementary occupations.

The two aggregates compiled are:

ISCO0 + ISCO1+ ISCO2 + ISCO3 + ISCO4, for which $D_{\text{ISCO 0-4}} = 1$,

and

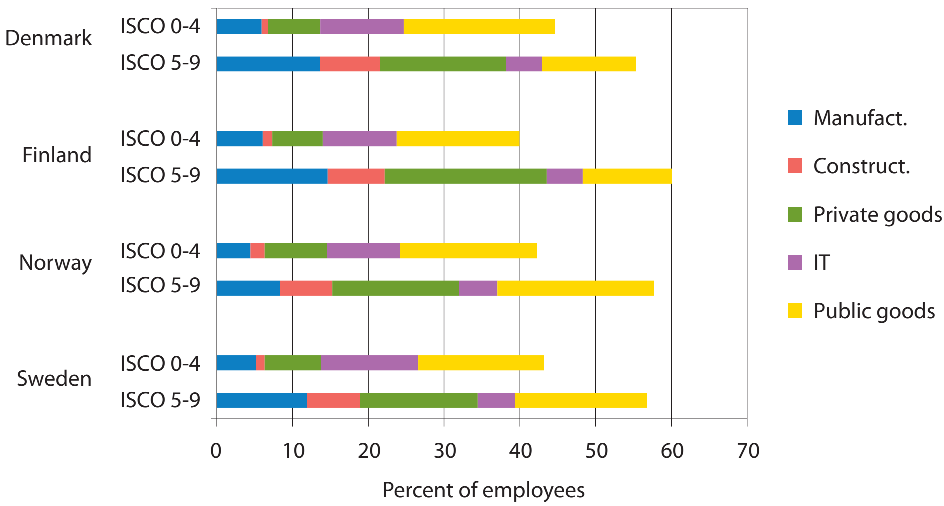
ISCO5 + ISCO6 + ISCO7 + ISCO8 + ISCO9, for which $D_{\text{ISCO 5-9}} = 1$.

[34] Question D_Q01a in the PIAAC Background questionnaire. The occupational classification employed is the International Standard Classification of Occupations (ISCO) of the International Labour Organization (ILO).

Albæk et al. (op.cit.) show that employees in the first category perform significantly better in literacy, numeracy and problem solving in technology-rich environments, in each of the Nordic countries.

Figure 7 shows how the two occupational aggregates are distributed across the industries considered in Section 4.4.1; the bars for the different countries in Figure 6 have simple been partitioned into two bars, corresponding to the above two occupational aggregates.

Figure 7. *Distributions of employees over occupations and industries*



Notes:

- Industry shares are based on number of employees – no adjustment has been made for differences in work hours.
- The shares have been weighted by sampling weights.

According to Figure 7, the partition into the two occupational groups the Nordic countries are quite similar; ISCO 0–4 accounts for between 40% and 45% of total employement and ISCO 5–9, hence, for 55–60%. Within these aggregates there is some variation across countries, however.

With respect to ISCO 0–4 aggregate, it can be noted that in Sweden employment in the IT-intensive industry is one-third larger than in Norway. Instead, Norway has the largest employment share in the private goods and services sector, one-fourth larger that the corresponding Finnish employment. ISCO 0–4 employment in the manufacturing sector also varies across countries; Finland has the largest employment and Norway the smallest.

Within the ISCO 5–9 aggregate, the share of employment in manufacturing differs markedly across the countries, Denmark and Finland having almost twice the share in Norway. The differences are also substantial with respect to the public sector; Norway's share is more than 70% larger than the Finnish share. In the contruction industry, finally, ISCO 5–9 employment is largest in Finland and smallest in Sweden.

6.4.5 Explaining skills

In this section, a regression equation is formulated, corresponding to the generally formulated skill function (2) and based on the discussions in the preceding subsections. Three version of this regression are estimated, using the skill scores in literacy, numeracy, and problem solving in technology-rich environments as dependent variables, respectively,

The regression equation is given by

$$\begin{aligned} \textit{skill score} = {} & c_o + c_1 \,\hat{}\textit{work exp} + c_2\ \textit{age} + c_3\, \textit{age}^2 \\ & + c_4 D_{\text{upper sec}} + c_5 D_{\text{short tert}} + c_6 D_{\text{long tert}} \\ & + c_7 D_{\text{Mo Upper sec}} + c_8 D_{\text{Mo Tert}} + c_9 D_{\text{Fa Upper sec}} + c_{10} D_{\text{Fa Tert}} + c_{11} D_{\text{Na Ma/Fa}} \\ & + c_{12} D_{\text{form training}} + c_{13}\ \textit{co-workers} + c_{14}\, \textit{sem\_w-shps} + c_{15}\, \textit{course\_less} \\ & + c_{16} D_{\text{constr}} + c_{17} D_{\text{IT-intens}} + c_{18} D_{\text{priv g\&s}} + c_{19} D_{\text{publ g\&s}} \\ & + c_{20} D_{\text{ISCO 0-4}} + \eta\,, \end{aligned} \tag{9}$$

where η denotes the random residual.

The reference person corresponding to equation (9) has:

i. at most lower secondary education
ii. a mother/female guardian with at most lower secondary education or for whom information about education is lacking
iii. a father/male guardian with at most lower secondary education or for whom information about education is lacking
iv. information about the educational levels of both his/her parents/guardians
v. not participated in any form of on-the-job training during the last 12 months
vi. employment in the manufacturing industry
vii. an occupation corresponding to ISCO levels 5, 6, 7, 8 or 9.

Note that by combining ii., iii., and iv. one can deduce that there is information available on the education of the reference person's mother/female guardian *and* father/male guardian.

Table 5a reports the estimation results when the literacy scores are used as skill measures, while Tables 5b and 5c show the corresponding results when numeracy scores and scores in problem solving are utilized as skill measures, respectively.

The first conclusion to be drawn from a comparison of Tables 5a–c is that the choice of skill measure matters. For instance, consider the relationship between predicted work experience, i.e. ^*work exp*, and skills. When skills are measured by literacy scores, ^*work exp* is found to be significantly (positively) related to skills only in Norway, cf. Table 5a. But when skills are expressed in terms of numeracy scores the relation between ^*work exp* and skills is significantly positive in all of the Nordic countries; the estimates imply that an additional year of work experience corresponds to between 3 and 3.7 points higher scores, in Finland and Denmark, respectivelty, cf. Table 5b. Put differently, 5 extra years of work experience correspond to between 0.29 and 0.36 standard deviation in numeracy skills, in Finland and Denmark, respectively, according to Tables 5b and 2. Finally, when skills are measured by scores in problem solving, Table 5c shows that the ^*work exp* variable is significant in Denmark, Finland, and Norway, but the magnitude of the estimated parameters is about half of those obtained when skills are measured in terms of numeracy scores.

Similarly, the estimated relations betweens skills and age are highly sensitive to the choice of skill measure. When skills are measured by literacy scores there are almost no significant parameters for *age* and age^2, cf. Table 5a. However, when numeracy scores and problem solving scores are used significantly negative relations to age are found in all of the Nordic countries. Specifically, literacy skills decrease slowly, if at all, by age, while numeracy skills diminish very rapidly with age, the impact on problem solving skills being in between these two extremes.[35]

Table 5a. *Linear regressions, by country; dependent variable: literacy; standard errors in parenthesis, accounting for sampling and measurement errors*

Variable	Denmark	Finland	Norway	Sweden
Intercept	261.6*** (10.12)	291.6*** (13.46)	257.3*** (10.63)	273.3*** (14.63)
^work exp	0.245 (0.443)	0.102 (0.624)	1.256*** (0.474)	0.986 (0.643)
age	- 0.722 (0.495)	-0.789 (0.606)	-0.041 (0.534)	-1.275* (0.689)
age^2	-0.001 (0.004)	-0.004 (0.005)	-0.017*** (0.005)	-0.001 (0.005)
$D_{\text{upper sec}}$	21.03*** (2.568)	18.28*** (3.073)	11.07*** (2.100)	25.15*** (2.643)
$D_{\text{short tert}}$	31.48*** (2.226)	31.70*** (3.144)	18.58*** (3.321)	36.95*** (2.981)
$D_{\text{long tert}}$	35.92*** (2.585)	41.77*** (3.551)	29.65*** (2.558)	44.90*** (3.398)
$D_{\text{Mo upper sec}}$	4.464*** (1.727)	3.336 (2.038)	7.184*** (1.656)	11.76*** (2.386)
$D_{\text{Mo tert}}$	12.36*** (2.229)	9.014*** (3.389)	12.08*** (2.631)	16.21*** (2.389)
$D_{\text{Fa upper sec}}$	3.059** (1.353)	4.272** (1.731)	5.872*** (1.826)	0.818 (2.308)
$D_{\text{Fa tert}}$	8.103*** (2.277)	6.779** (3.395)	12.27*** (2.049)	1.869 (2.170)
$D_{\text{Na Mo/Fa}}$	-6.586 (16.96)	-42.91*** (11.60)	-32.96* (18.89)	-0.765 (7.737)
D_{constr}	-3.629 (2.847)	1.785 (3.319)	-2.388 (3.633)	4.566 (4.110)

35 There is one exception to this general picture: for Sweden, literacy skills deteriorate fast with age, faster than problem solving skills (but at a slower pace than numeracy skills).

$D_{IT\text{-}intens}$	4.715** (2.402)	8.151*** (2.285)	4.275* (2.359)	6.929*** (2.079)
$D_{priv\ g\&s}$	2.720 (1.949)	5.003** (2.100)	-2.603 (2.153)	4.850** (2.054)
$D_{publg\&s}$	-0.944 (1.621)	2.000 (2.033)	-1.444 (2.001)	-0.087 (1.846)
$D_{form\ training}$	-2.836 (4.610)	-7.235 (6.237)	3.050 (4.243)	-0.458 (5.056)
co-workers	-0.140 (0.192)	0.222 (0.214)	0.018 (0.230)	-0.134 (0.291)
sem_w-shps	0.795*** (0.282)	0.578 (0.455)	0.834** (0.381)	0.367* (0.218)
course_less	0.660 (0.503)	0.001 (0.425)	0.326 (0.612)	1.124*** (0.323)
$D_{ISCO\ 0\text{-}4}$	19.83*** (1.529)	15.20*** (1.819)	17.20*** (1.638)	20.99*** (1.768)
R^2	0.281	0.316	0.253	0.300

Table 5b. *Linear regressions, by country; dependent variable: numeracy; standard errors in parenthesis, accounting for sampling and measurement errors*

Variable	Denmark	Finland	Norway	Sweden
intercept	294.6*** (13.40)	327.4*** (13.60)	262.5*** (11.26)	320.7*** (14.20)
^*work exp*	3.676*** (0.536)	3.023*** (0.611)	3.328*** (0.493)	3.477*** (0.729)
age	- 2.594*** (0.623)	-3.061*** (0.615)	-1.013* (0.557)	-4.038*** (0.684)
age^2	-0.011** (0.004)	-0.005 (0.006)	-0.023*** (0.005)	0.007 (0.006)
$D_{upper\ sec}$	17.66*** (3.082)	17.32*** (2.880)	15.88*** (2.457)	27.66*** (2.756)
$D_{short\ tert}$	32.48*** (2.831)	34.39*** (3.337)	26.06*** (3.805)	43.16*** (3.608)
$D_{long\ tert}$	45.52*** (2.598)	49.81*** (3.546)	40.41*** (2.981)	57.40*** (3.776)
$D_{Mo\ upper\ sec}$	4.940** (1.992)	3.315 (2.157)	7.518*** (2.029)	7.950*** (2.348)
$D_{Mo\ tert}$	11.69*** (2.184)	10.77*** (3.177)	11.08*** (2.774)	15.62*** (2.652)
$D_{Fa\ upper\ sec}$	3.426** (1.627)	4.747*** (1.715)	6.652*** (2.006)	4.321 (2.704)

$D_{Fa\ tert}$	7.629*** (2.057)	5.949* (3.533)	13.19*** (2.161)	1.958 (2.440)
$D_{Na\ Mo/Fa}$	-20.55 (15.59)	-26.76** (11.67)	-55.06** (25.56)	-0.847 (8.539)
D_{constr}	-0.828 (3.163)	6.888** (3.202)	5.923 (4.142)	9.153** (4.388)
$D_{IT\text{-}intens}$	4.312** (1.968)	5.883*** (2.591)	7.673*** (2.627)	3.576 (2.344)
$D_{priv\ g\&s}$	0.751 (2.108)	1.087 (2.183)	-1.420 (2.390)	4.055* (2.352)
$D_{publg\&s}$	-5.758*** (1.729)	-5.958*** (2.104)	-3.805* (2.254)	-6.214** (2.651)
$D_{form\ training}$	-0.740 (5.455)	-16.29*** (6.171)	2.061 (4.768)	1.379 (4.821)
co-workers	-0.030 (0.195)	0.385 (0.249)	-0.123 (0.247)	0.138 (0.400)
sem_w-shps	0.769** (0.329)	0.147 (0.465)	0.974** (0.394)	0.312 (0.277)
course_less	1.559** (0.607)	-0.025 (0.410)	-0.390 (0.686)	0.904*** (0.343)
$D_{ISCO\ 0\text{-}4}$	22.23*** (1.674)	19.91*** (1.993)	19.78*** (1.929)	24.66*** (2.253)
R^2	0.259	0.277	0.250	0.270

Table 5c. *Linear regressions, by country; dependent variable: problem solving; standard errors in parenthesis, accounting for sampling and measurement errors*

Variable	Denmark	Finland	Norway	Sweden
Intercept	317.9*** (10.53)	319.1*** (11.99)	309.8*** (9.680)	302.2*** (12.62)
^*work exp*	1.657*** (0.464)	1.295** (0.538)	1.674*** (0.375)	0.606 (0.636)
age	- 1.768*** (0.503)	-1.307** (0.579)	-1.625*** (0.461)	-1.386** (0.461)
age^2	-0.011*** (0.004)	-0.016*** (0.006)	-0.010** (0.005)	-0.003 (0.004)
$D_{upper\ sec}$	9.623*** (2.332)	12.42*** (2.521)	11.98*** (2.155)	22.49*** (2.572)
$D_{short\ tert}$	22.83*** (2.432)	24.23*** (2.712)	20.43*** (3.804)	27.06*** (3.240)
$D_{long\ tert}$	29.33*** (2.563)	33.34*** (3.755)	30.59*** (2.623)	35.57*** (3.383)

$D_{\text{Mo upper sec}}$	4.844** (1.953)	4.112** (1.751)	8.353*** (1.778)	9.523*** (2.116)
$D_{\text{Mo tert}}$	8.661*** (2.141)	8.711*** (3.096)	9.882*** (2.341)	12.54*** (2.488)
$D_{\text{Fa upper sec}}$	0.710 (1.467)	6.004*** (1.393)	5.173*** (1.522)	3.956** (1.950)
$D_{\text{Fa tert}}$	4.904** (1.993)	8.099*** (2.938)	7.156*** (1.717)	3.259 (2.110)
$D_{\text{Na Mo/Fa}}$	9.471 (19.82)	-1.408 (10.03)	22.67** (10.26)	1.395 (6.766)
D_{constr}	-13.63*** (2.988)	-8.244*** (2.916)	-2.390 (2.878)	-4.292 (3.712)
$D_{\text{IT-intens}}$	0.950 (2.373)	1.866 (2.135)	3.067 (2.125)	2.044 (2.534)
$D_{\text{priv g\&s}}$	-2.277 (1.907)	-2.283 (1.888)	-2.090 (2.289)	-3.099 (1.962)
$D_{\text{publg\&s}}$	-9.077*** (1.783)	-7.755*** (1.898)	-7.647*** (2.084)	-6.975*** (1.862)
$D_{\text{form training}}$	-1.999 (6.522)	-11.40 (6.951)	9.620** (4.227)	1.853 (4.377)
co-workers	0.082 (0.175)	-0.013 (0.196)	0.165 (0.223)	0.088 (0.353)
sem_w-shps	0.609* (0.318)	0.340 (0.425)	1.171*** (0.405)	0.504** (0.197)
course_less	1.409*** (0.508)	-0.653* (0.339)	0.574 (0.592)	0.803*** (0.292)
$D_{\text{ISCO 0-4}}$	17.52*** (1.637)	16.34*** (1.651)	13.04*** (1.530)	19.81*** (2.035)
R^2	0.340	0.398	0.346	0.372

In contrast to Figure 5, where skills initially appear to be increasing with age, Tables 5a–c show that the (non-linear) relations between skills and age are negative and non-increasing over the entire age span 20–65. The reason for the different impressions provided by Figure 5 and Tables 5a–c is that while Figure 5 merely shows the bivariate, unconditional, relations between skills and age, Tables 5a–c provide the estimated relations between these two variables when a large number of other factors are controlled for – work experience, education, family background, industry/sector, occupation, and on-the-job training. As the (partial) relations between skills and age provided by the regressions correspond to an individual that is neither studying, nor working,[36] the fact that skills decrease monotonously is not very surprising. It merely reflects the fact that, unlike real capital (machines and structures), human capital is not depreciated by use but by lack of use.

As expected, the individual's education is strongly positively related to skills, however measured, in all of the Nordic countries; see the estimates for $D_{\text{upper sec}}$, $D_{\text{short tert}}$, and $D_{\text{long tert}}$ in Tables 5a–c. It can also be seen that the strength of the relation is monotonously increasing in the level of education. Another common feature is that level of education appears to matter the most for numeracy skills. With two exceptions, the parameter estimates in Table 5b are larger in magnitude than in Tables 5a and 5c.[37] In two cases, the Table 5b parameters for $D_{\text{long tert}}$ in Finland and Sweden, the estimates are so large that they are (close to) one standard deviation in skills; cf. Table 2. With respect to differences across countries, the parameter estimates are always largest for Sweden, at all levels of education and for all measures of skills. Except when skills are measured by scores in problem solving, Norway is consistently at the other end of the spectrum.

The results in Tables 5a–c provide information about the extent to which work experience can make up for formal education. Table 6 illustrates this trade-off. The table shows the years of work experience required to make up for short tertiary education, and long tertiary education, respectively.

Table 6 shows that, essentially, there is no trade-off between work experience and education with respect to literacy skills, simply because these skills are not significantly related to work experience, except in Norway.[38]

Second, with respect to numeracy skills, working instead of studying appears to be a viable option. Presuming that short tertiary educations and long tertiary educations correspond to around two and four years of full-time studies, respectively, Table 6 shows that, on average across the Nordic countries, the periods of work experience required to make up for these educations are slightly more than twice as long as the period of study.

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36 This follows from the fact that the relation between age and skills is obtained by setting all the slope coefficients in the skill regressions to zero, except those associated with *age* and *age*^{2}. This is equivalent to, i.a., constraining the individual to have compulsory education only, and no work experience.

37 The two exceptions are the Danish and Finnish estimates for $D_{\text{upper sec}}$ which are larger in Table 5a than in Table 5b.

38 And the trade-off in Norway is weak; 15 years of work are needed to make up for a long teriary education.

Table 6. *The skill trade-off between education and work experience: years of work experience required to make up for short and long tertiary education, respectively, given upper secondary education, by skill domain*

	Denmark	Finland	Norway	Sweden
Literacy				
Short tertiary	0	0	6.0	0
Long tertiary	0	0	14.8	0
Numeracy				
Short tertiary	4.0	5.6	3.1	4.5
Long tertiary	7.6	10.7	7.4	8.6
PS_TRE				
Short tertiary	8.0	9.1	5.0	0
Long tertiary	11.9	16.2	11.1	0

Notes:

- The acronym PS_TRE reads Problem Solving in Technology Rich Environments.
- The non-zero entries in the table have been derived from the significant estimates for ^*work exp*, $D_{\text{upper sec,}}$ $D_{\text{short tert}}$ and $D_{\text{long tert}}$ in Tables 5a-c. For example, the number 8.0 in the column for Denmark, has been obtained from Table 5c, according to: (22.83 – 9.623) / 1.657 and says that with respect to numeracy, four years of work experience correspond to the same skills as those obtained by completing a short tertiary education. Zero entries correspond to insignificant ^*work exp* estimates.

Third, more work experience is required to make up for education when it comes to problem solving skills, than in the dase of numeracy skills. For example, compensating for a short tertiary education entails a period of work experience that is between 2.5 (in Finland) and 4 (in Denmark) times as long as the study period needed to obtain the degree.

Concerning qualitative aspects on work wexperience, Tables 5a–c show that, to some extent, the sector and industry where the individual works matter for his/her skills. In particular, employment in IT-intensive industries is generally significantly positively associated with literacy and numeracy skills, compared to employment in the manufacturing industry. However, surprisingly, this is not case with respect to skills in problem solving, in any of the Nordic countries. Another common finding is that employment in the public sector, compared to employment in manufacturing, is significantly negatively associated with problem solving skills and numeracy skills. Overall, the impact of industry is not very strong, however; the estimates correspond to less than 0.2 standard deviations in skills.[39]

The individual's occupation is found to be considerably more important. The binary variable $D_{\text{ISCO 0-4}}$ indicating qualified, white-collar occupations is strongly significantly and positively related to all three skills in each of the Nordic countries. The estimates roughly correspond to 0.35–0.45 standard deviations in skills.

The results concerning the variables $D_{\text{form training}}$, *co-workers*, *sem_w-shps*, and *course_less* do not provide strong support for the massive resources that the Nordic countries devote to on-the-job training, cf. OECD (2012). For instance, the most common form of on-the-job training, training sessions or traning by supervisors/co-workers (the *co-workers* variable) is not anywhere near significantly related to any of the three skills, in any of the Nordic countries. The only form of on-the-job training that in general is significantly positively related to skills is participation in seminars and workshops (the *sem_w-shps* variable). The positive association is very weak, however: all the significant estimates correspond to less than one score point per seminar/workshop attended.

Finally, it should be noted that a considerable amount of the variation in skills is still to be explained; the regressions in Table 5a–c explain between 25% and 40% of the skill variation. The highest R^2s are consistently found for Finland, and the smallest for Norway.

6.5 Concluding discussion

The recursive model employed in this paper is analytically convenient. The potential problem with the recursive set-up, that some of the estimates in the equation for work experience might be inconsistent, is not very important in this context, as long as the predictive power of the work experience regression is good. And this has been shown to be the case: around 80% of the variation in years of work experience is explained by means of regression model accounting the respondent's age, level of education, gender, and number of children.

An important result, which is obtained for all four of the Nordic countries, is that family responsibilities, proxied by number of children, has fundamentally

39 There is one exception: for Denmark, working in the construction industry is strongly negatively related to problem solving skills. The estimate corresponds to -0.29 standard deviations in skills, compared to working in the manufacturing industry.

different impacts on the years of work experience among men and women. Men's work experience is increasing in the number of children while the opposite is true for women. For a couple with two children this results in a difference to the man's advantage of 2.5 years in Denmark and 3.8 years in Norway.[40] These estimates might seem surprisingly large, especially in view of the fact that the median female work experience as late as at age 45 is around 20 years in all of the Nordic countries.[41] However, while parental benefits that could be shared between the mother and the father where introduced in the Nordic region already in the 1970s, it was not until in the 1990s that universal access to child care was granted; cf. Karila (2012).

The second stage of the empirical analysis shows that the relation between (predicted) work experience and skills depends on the type of skill considered.[42] With respect to literacy skills a significant relation with work experience is found only for Norway, when controls for the respondent's age, level of education, industry and sector of employment, occupation, participation in on-the-job training, as well as the levels of education of her/his mother/female guardian and father/male guardian are employed. Moreover, the association is weak. For example, 5 years of work experience increase literacy skills by 0.14 standard deviations. This result is in contrast with the findings in Desjardins (2003) and Edin and Gustavsson (2008) where work experience is reported to be significantly related to literacy skills in all of the Nordic countries. One possible explanation for the difference in results is that this study, unlike the two just mentioned, employs direct information on work experience.

With respect to skills in numeracy and problem solving in technology-rich environments, which could not be considered by Desjardins (2003), and Edin and Gustavsson (2008), this study finds significant relations with work experience across the Nordic region, however.

For numeracy skills, positive, significant and substantial relations are found for all of the Nordic countries. The estimates are quite similar; 5 years of work experience correspond to from 0.29 standard deviations higher skills in Finland to 0.36 standard deviations in Denmark. With respect to problem solving, the estimated

40 These gender differences in work can be derived from Table 1. The differences are conditional on age and education. This means that they are equal to mean values of differences at given ages and levels of education.

41 Cf. Figure 1.

42 The discussion in this paragraph and the following three paragraphs refer to Tables 5a–c.

relations to work experience are significant for Denmark, Finland, and Norway, but not in Sweden. In terms of standard deviations in skills, the significant estimates are about half the size of those obtained with respect to numeracy skills.

Regarding education, skills are found to be monotonously increasing in educational levels, in all skill domains. Relative to compulsory education, long tertiary education may correspond to up to one standard deviation in skills. The strength of the associations differs across skill domains, however; education matters more for numeracy skills than for literacy and problem solving skills. There are also differences across countries: the parameter estimates are always largest for Sweden, at all levels of education and for all measures of skills, Norway being at the other end of the spectrum.

The trade-offs between work experience and education implied by the results are illustrated by a thought experiment amounting to comparing two individuals of the same age and with upper secondary education, one of which has gone on to higher studies while the other has started working after upper secondary school. The number of years required for the latter individual to obtain the same skills as the one attending higher education before entering the labor market is then assessed.[43]

The trade-off is found to vary markedly across skill domains and countries but not very much by type of higher education. In accordance with the results on work experience discussed above, for literacy skills possibilities to make up for education through work experience exist only in Norway, where the trade-off is weak. For short tertiary and long tertiary educations the number of years of work experience required to attain the same level of skills are 6 and 14.8 respectively. Assuming that short and klong tertiary educations require about two and four years of study, respectively, the trade-offs thus become 1:3 and 1:3.7. These estimated trade-offs imply that it takes much more work experience to compensate for education than do the corresponding estimates in Desjardins (2003), discussed in the introduction of this paper.

With respect to numeracy skills, working is a fairly good option, however, at least at least in Norway and Denmark. In these countries 3.1 and 4.0 years are required to make up for a short (two-year) tertiary education, implying trade-offs equal to 1:1.55 and 1:2, respectively. For long (four-year) tertiary educations the

[43] The results discussed in this and the following three paragraphs are derived from Table 6. The computations account for the fact that the individuals' skills are reduced as they age, irrespective of whether they work or study.

corresponding trade-offs are 1:1.85 and 1.9, respectively. For Sweden and Finland the trade-offs are higher, 1:2.25 and 1:2.8, for short tertiary educations and, for long tertiary educations, 1:2.15 and 1:2.68, respectively.

Overall, the trade-offs are less favorable, from the viewpoint of work experience, with respect to problem-solving skills. Again, Norway is the country in which work experience can best make up for education; the trade-off is 1:2.5 for short tertiary educations and 1:2.78 for long tertiare education. At the other end of the spectrum lies Sweden where there is no trade-off at all, due to work experience not being significantly related to problem solving skills.

An explanation for why work experience can make up for education to a larger extent in Norway and Denmark than in Sweden and Finland might be sought in different connections between education and work across the Nordic countries. In Sweden and Finland both academic and vocational educations are school-based, making the connection weak. Denmark, on the other hand, has a dual apprenticeship system, similar to the German system. And Norway features a unique experience based trade certificate, making it possible to obtain a formal qualification entirely through work experience, cf. Skule et al. (2002).

The significance of qualitative aspects on work experience for skills has also been considered (cf. Tables 5a–c). The industry and sector where the individual works are not found to be very important. Somewhat surprisingly, the same result has been established with respect to on-the-job training, casting doubt on the effectiveness of the extensive resources that the Nordic countries spend on workplace training, cf OECD (2012).[44] In contrast, the association between occupation and skills is sizeable in magnitude. Persons working in mentally demanding professions have skills that are 0.35–0.45 standard deviations higher than those of individuals in predominantly manually demanding occupations.

44 For skills in problem solving, Norway constitutes an exception: job-related formal training (yes/no) is rather strongly related to skills: participation corresponds to 0.2 standard deviations higher skills.

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7

A comparison of PIAAC and PISA results

Abstract: This article is looking at differences and similarities between the Nordic results in literacy and numeracy in PIAAC 2012 (Programme for the International Assessment of Adult Competencies) and PISA 2000, 2003 and 2009 (Programme for the International Student Assessment). It is important to underline that even though the two surveys are close to each other in defining the skills being measured, there are differences between the two assessments: PISA seeks to measure how well 15 years old students approaching the end of the compulsory schooling are prepared to meet the challenges of today's knowledge societies; PIAAC focuses on how adults (16–65) maintain and use their basic skills. Despite these differences, the comparisons of the ranking of Nordic results reveals that the overall patterns of performance on the literacy scales are quite consistent for the age-cohorts being compared. Finland is outperforming the other Nordic countries in both studies. The comparison of numeracy results (PISA 2003 and PIAAC 2012) reveals almost the same pattern; Finland scores significantly higher than their neighbor countries, but here the country ranking is slightly changed.

7.1 PISA and PIAAC assessment frameworks

Both the Programme for the International Student Assessment (PISA) and the Programme for the International Asessment of Adult Competencies (PIAAC) are the large-scale assessments of people's key competences, conducted by the Organisation for Economic Co-operation and Development (OECD). Thus, they have many similarities in focus and defining their key concepts. Both studies focus on assessing reading literacy, numeracy, and problem solving. The problem solving assessment has been included in PISA only in 2003 and 2012, but reading literacy and mathematical literacy (and scientific literacy) are part of every PISA cycle. Although PISA has been repeated every third year since 2000, the main assessment area varies in each study. Thus, the most valid and extensive reading literacy data come from 2000 and 2009 assessments; the most valid and extensive mathematical literacy data come from 2003 and 2012 (OECD, 2010a; OECD, 2013a).

PISA and PIAAC use slightly different terms when referring to the key competences measured. In PISA, the concept of "reading literacy" is used instead of "literacy," as in PIAAC (e.g., OECD, 2010a). Reading literacy communicates explicitly the focus of the assessment, which is narrower than literacy as a whole. PIAAC, however, uses the concept of literacy although the assessment in practice focuses on reading literacy (OECD, 2013b).

The precise definitions of (reading) literacy are essentially the same in both assessments: both definitions state that (reading) literacy is understanding, using, and evaluating or reflecting upon written texts; both include reading engagement; and both emphasize that reading is for achieving one's goals, developing one's knowledge and potential, and participating in society (OECD, 2010a, p. 37; OECD, 2013b, p. 59). The only differences in defining the concept in PISA and PIAAC are minor word order issues. This view of reading literacy emphasizes the functional aspect and the situational nature of reading for a range of purposes.

In the area of using mathematical information, there is not as much overlap between PISA and PIAAC as there is with literacy. PISA uses the concept of mathematical literacy and defines it as follows: "An individuals' capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals in recognizing the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens" (OECD, 2013a, pp. 28, 37). PIAAC, however, uses the concept of numeracy defined as "the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life" (OECD, 2013b, p. 59). Certainly, there are some similarities in the definitions: both see mathematical literacy or numeracy as using mathematical information and ideas in different situations and contexts. Also, communicating these ideas effectively is one aspect of this competence also implicitly covered by the PISA definition.

Despite the similarities between the two surveys in how skills are defined, there are significant differences between the two assessments, as they have not the same but complementary goals: PISA seeks to identify ways in which students can learn better and educational systems can be developed; PIAAC focuses on how adults develop, maintain, and use their skills (OECD, 2010a; 2013a; 2013b). These different goals produce differences. Firstly, there are no common items in PISA and PIAAC, which means that different measures reflecting the different contexts in which 15-year-old students and older adults live, are used. Thus, the results from the two surveys cannot be compared directly and treated as being on the same scale in any of the domains they have in common. (OECD, 2013c, p. 86.) Additionally, the reading literacy assessment in PISA has so far been implemented as a paper-and-pencil test, whereas computer-based assessment was used for many of the informants in PIAAC.[1] Secondly, the target populations in the two studies are different. PISA focuses on 15-year-olds' ability to use their knowledge and skills to meet real-life challenges (OECD, 2010a, 2013a), e.g., in the PISA 2009 study, the average age of students across OECD countries was 15 years and 9 months (OECD, 2010a, p. 171). The target population for PIAAC consisted of the non-institutionalized 16–65-year-olds residing in the country at the time of data collection irrespective of nationality, citizenship, or language status (OECD, 2013b, p. 26). However, in most of the countries participating in PIAAC, including the four Nordic countries Denmark, Finland, Norway, and Sweden, respondents aged 16–27 are members of cohorts that have taken part in PISA (OECD, 2013b, p. 86).

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1 A paper-and-pencil version was presented for informants that did not manage the computer-based assessment (approximately 25% of the informants altogether).

In both surveys, a representative probability-based sample from the target population was drawn. The PIAAC sample sizes in the Nordic countries varied between 4 469 (Sweden) and 7 328 (Denmark, where persons aged 55–65 and recent immigrants were oversampled. Denmark also included 1 800 persons who participated in PISA 2000 in their PIAAC sample) (OECD, 2013b, p. 54). The PISA 2009 sample sizes in the Nordic countries ranged from 4 567 (Sweden) to 5 924 (Denmark) (OECD, 2010a, p. 173).

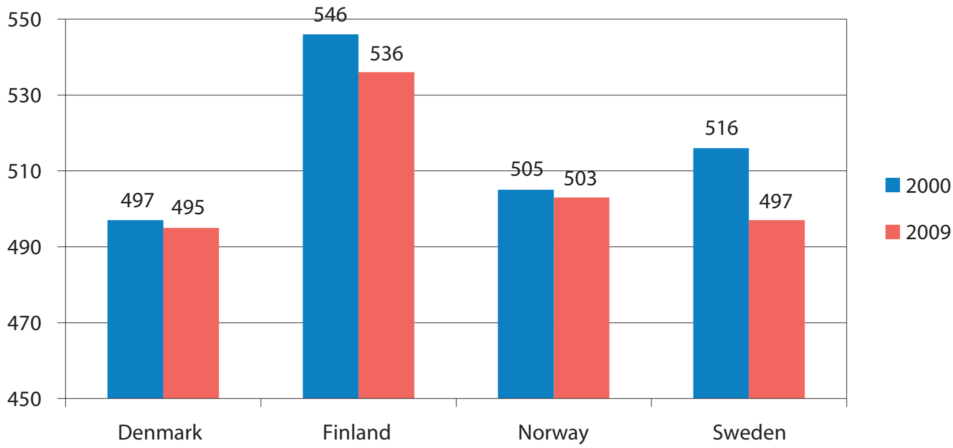
7.2 PISA results in the four Nordic countries

Reading literacy and mathematical literacy performance. PISA 2000 was the first international assessment of 15-year-olds' skills in reading literacy, mathematical literacy, and science literacy, and as all the Nordic countries spend considerable resources on providing a high-quality public educational system, politicians expected the results to be in the upper part. The results in this survey were, however, surprising for many countries: in Denmark and Norway, the results were not significantly different from the OECD-average.

Next, Nordic students' performance in reading literacy and mathematical literacy are reviewed. PISA results in the four Nordic countries have been elaborately reported in the Northern Lights on PISA series (e.g., Lie, Linnakylä, & Roe, 2003; Mejding & Roe, 2006; Egelund, 2012). Thus, only a general overview is presented here, and the focus is on the cycles in which reading literacy or mathematical literacy have been main assessment areas.

In the first PISA study in 2000, the main assessment area was reading literacy. In the 2000 results, Finland was the best-performing country among the 27 OECD countries and four non-OECD countries, with a mean score of 546 (OECD, 2010b, p. 146). The gap with the other Nordic countries, Denmark, Norway, and Sweden, was clear, as Figure 1 shows. Still, Swedish students' mean performance was well above the OECD average of 500, while Norway and Denmark performed at the OECD average level (OECD, 2001; 2010b, p. 146). In 2009, when reading literacy was again the main assessment area, Finland was the second best OECD country after Korea and also the best performing European country. On this cycle, Norway with its average score of 503 was the second best Nordic country and was well above the OECD average (493[2]). Denmark and Sweden were at the OECD average level (OECD, 2010a, p. 197).

Figure 1. *Reading literacy mean scores in PISA 2000 and 2009 in the four Nordic countries*



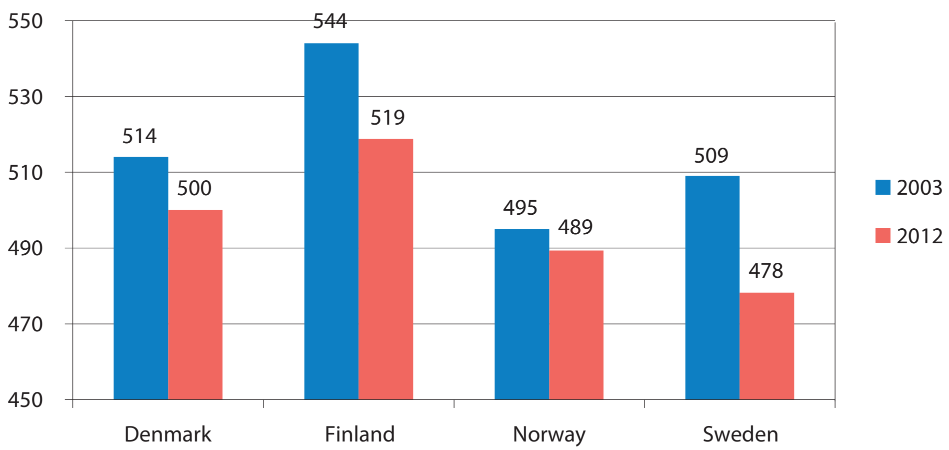
Comparison between the reading literacy results from 2000 and 2009 showed that Denmark and Norway had managed to maintain their performance level (Figure 1), but in Sweden, the decline in the average score was clear. Also, in Finland, the average score had decreased by 10 points. This was not a statistically significant change, but still indicated a negative development that was confirmed by the PISA 2012 results, which showed a further 12 score point decrease in Finland. Also, in Sweden, the decrease in reading performance continued in 2012 and the mean score was 483. Denmark and Norway, however, succeeded in keeping their performance at the same level in 2012. (OECD, 2013a, p. 382.)

In the 2003 mathematical literacy assessment, the results of the Nordic countries varied (Figure 2). Finland was the highest-performing Nordic country and also the best OECD country, with a mean score of 544. Danish and Swedish students' mean performance was also above the OECD average, whereas Norwegian students'

[2] The OECD average was set to 500 in the first cycle of the assessment. In consequent cycles, the OECD average has varied due to different numbers of participating OECD countries and their changed results in PISA (see OECD 2010b, p. 136).

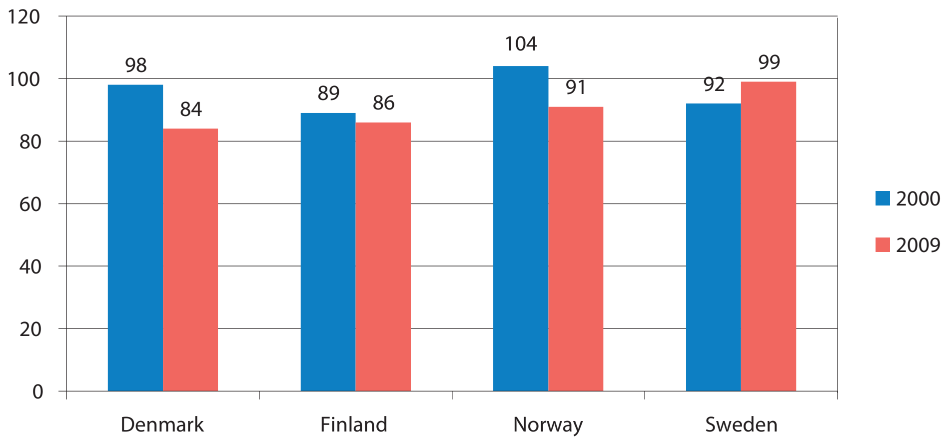
performance was slightly but statistically significantly below the OECD average of 500 (OECD, 2004). In 2012, Finland was still the best-performing Nordic country, with a mean score of 519. Denmark's average performance was above the OECD average, which had decreased to 494 score points after 2003. Norwegian students' average performance was at the OECD's average level, but Sweden was below it (OECD, 2013a, p. 305). Of the Nordic countries, only in Norway there was no statistically significant change in mathematical literacy from 2003 to 2012 (OECD, 2013a, p. 55). In all other Nordic countries studied, there was a decrease in the average mean score. In Sweden, the decline in mathematical literacy performance was the greatest among the Nordic countries (Figure 2), but also in Finland, the decrease was clear. In Denmark, too, the change was statistically significant, although clearly smaller than in Sweden and Finland. It is noteworthy that in Denmark and Sweden, the change seems to be a steady one, whereas in Finland it is accelerating (OECD, 2013a, p. 55).

Figure 2. *Mathematical literacy mean scores in PISA 2003 and 2012 in the four Nordic countries*



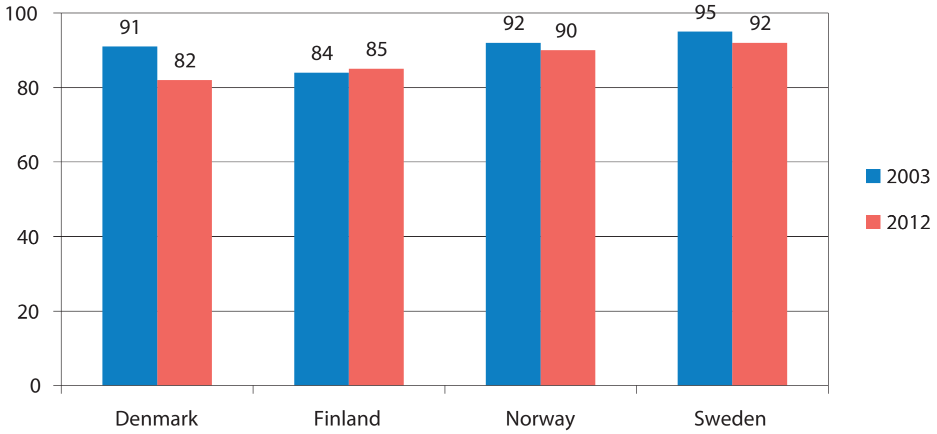
Distribution of learning outcomes. In the Nordic countries, the equity of education has a long tradition and follows the radical application that emphasizes the equity of learning outcomes (Husén, 1974; Malin, 2005). Also, the OECD now emphasizes combining the quality of education and equity in the most successful school systems (OECD, 2010c). One simple measure of educational equity is standard deviation, which illustrates the gap between low and high performers. In the 2000 reading literacy assessment, the standard deviation for the OECD average score was set to 100 (OECD, 2001). As shown in Figure 3, in every Nordic country but Norway, the standard deviation was below that of the OECD average. Among the four Nordic countries, it was the smallest in Finland. In 2009, in every Nordic country but Sweden, the standard deviation was smaller than or nearly the same as in 2000, indicating that the gap between low and high performers had narrowed or stayed at the same level. In Sweden, the opposite was true. It is to be noted that the standard deviation in the OECD countries on average was only 93 score points in 2009 (OECD, 2010a). Still, Denmark, Finland, and Norway were below this.

Figure 3. *Standard deviation in reading literacy in PISA 2000 and 2009 in the four Nordic countries*



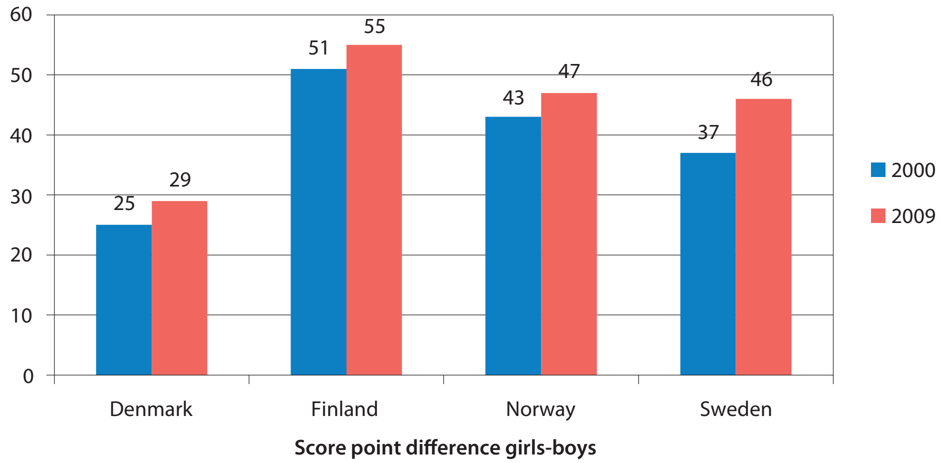
In mathematical literacy, the standard deviation was below or at the OECD average in the four Nordic countries studied both in 2003 and 2012. In 2003, the OECD average standard deviation was set to 100 (OECD, 2004), and the country closest to that standard deviation was Sweden (Figure 4). In 2012, the OECD average was 92 (OECD, 2013a). In the 2012 assessment, Sweden and Norway had the standard deviation at or near the OECD average; Denmark and Finland were below the average. Overall, in the Nordic countries, the gap between the low and high performers has stayed nearly the same. The only exception is Denmark, which has succeeded in narrowing the gap in mathematical literacy.

Figure 4. *Standard deviation in mathematical literacy in PISA 2003 and 2012 in the four Nordic countries*



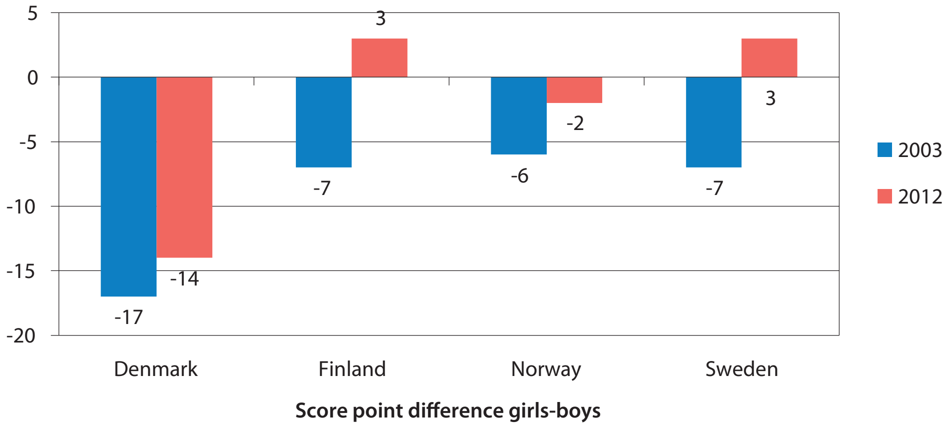
Another equity issue that is most relevant for reading literacy is the gender difference. Both in 2000 and in 2009 PISA assessments, girls have outperformed boys in reading in all participating countries. The average gender difference was 32 score points for girls in 2000 and 39 score points in 2009 (OECD, 2001, p. 123; OECD, 2010a, p. 57). Among the Nordic countries, Denmark has shown both in 2000 and 2009 the narrowest gender gap, and Finland has shown the largest (Figure 5). Notably, the gender gap has not narrowed from 2000, but widened, especially in Sweden. Research based on PISA data has shown that at least in the Nordic countries, the gender gap in reading is relatively smaller in tasks related to non-continuous texts than continuous ones and with multiple-choice items than open constructed responses (Roe & Taube, 2003), reflecting boys' reluctance to read continuous texts and write their responses. Additionally, the gender gap is evident also in reading engagement: Nordic boys are less active and less diversified readers and show less interest in reading than girls (see Roe & Taube, 2012). In fact, the OECD has estimated that if boys had the same average value of index of reading for enjoyment than girls, the gender gap in reading would be reduced significantly in most European countries, and in many countries it would be reduced to less than half of the current gender gap. For instance, in Denmark, it would be reduced to only a few score points. (OECD, 2010d, p. 90.)

Figure 5. *Gender gap in reading literacy in PISA 2000 and 2009 in the four Nordic countries*



In mathematical literacy, boys clearly outperformed girls in Denmark in both 2003 and 2012 (Figure 6), although the gap has slightly narrowed. In other Nordic countries, the gender difference was smaller in both assessments, but in Finland and Sweden, boys showed a slightly lower average performance than girls in 2012. However, in 2012, the gender difference was statistically significant only in Denmark (OECD, 2013a, p. 305), meaning that in practice, there was no difference in boys' and girls' average performance in mathematical literacy. In 2003, it was statistically significant in all Nordic countries but Norway (OECD, 2004, p. 97). Thus, Finland and Sweden have managed to narrow the gender gap. The OECD average in gender differences in mathematical literacy was 11 score points for boys both in 2003 and 2012 (OECD, 2004, p. 356; OECD, 2013a, 9 p. 305).

Figure 6. *Gender gap in mathematical literacy in PISA 2003 and 2012 in the four Nordic countries*



7.3 A comparison of literacy results in PISA 2000 and 2009 and in PIAAC 2012 in the Nordic countries

As PISA and PIAAC focus on similar literacy skills, using assessment tasks from 15-year-olds' and adults' contexts, respectively, it is of interest to see if the pattern of performance in literacy from PISA 2000 and 2009 also yields for the same cohorts in PIAAC 2012.

The students who participated in PISA 2000 were 27 years old in PIAAC 2012. To ensure a large enough sample, 26- and 28-years-olds are also included in the comparison displayed in Table 1. The order of achievement in the Nordic countries was the same in PISA 2000 and PIAAC 2012, with Finland outperforming the other countries (see Table 1). Norwegian students performed slightly better than Danish students in literacy in PISA 2000, while Swedish students performed significantly better than Danish and Norwegian students, but were also pronounced behind Finland. There were no significant differences between Sweden, Norway, and Denmark in PIAAC 2012, but the ranking of the countries from PISA 2000 was confirmed in PIAAC 2012.

The students who participated in PISA 2009 were 18 years old in PIAAC 2012 (see Table 2). Seventeen- and 19-year-olds were included in the comparison displayed in Table 2 to ensure a sufficient sample size. In PISA 2009, Finland was still

Table 1. *Mean literacy scores in PISA 2000 (aged 15) and PIAAC 2012 (aged 26–28)*

	PISA 2000 (aged 15)			PIAAC 2012 (aged 26-28)		
	Mean	s.e.	SD	Mean	s.e.	SD
Denmark	496.9	2.4	98.1	285.6	3.0	49.5
Finland	546.5	2.6	89.4	306.7	3.0	46.1
Norway	505.3	2.8	103.6	288.6	3.6	51.1
Sweden	516.3	2.2	92.2	291.4	3.8	55.7
Nordic average	516.2	1.2	95.8	293.1	1.7	50.6
OECD average	493.7	0.7	96.1	286.4	0.7	45.0

Note. Australia, Austria, Canada, Germany, and the United States are not included in PIAAC OECD average values due to lack of individual values of age.

outperforming the other Nordic countries (see Table 2), and the pattern of performance in literacy from PISA 2009 did partly yield for the same cohort in PIAAC 2012. Finnish 17–19-years-olds did also outperform their Nordic neighbors in PIAAC 2012. The order of achievement in the Nordic countries was however somewhat different in PISA 2009 and PIAAC 2012, as Norway was ranked as number two of the Nordic countries in PISA 2009 and number four in PIAAC 2012. There were no significant differences in literacy achievement between Sweden and Denmark in PISA 2009. In PIAAC 2012, the only significant difference for this cohort was between Finland and the other Nordic countries.

Table 2. *Mean literacy scores in PISA 2009 (aged 15) and PIAAC 2012 (aged 17–19)*

	PISA 2009 (aged 15)			PIAAC 2012 (aged 17-19)		
	Mean	s.e.	SD	Mean	s.e.	SD
Denmark	494.9	2.1	83.6	272.5	2.1	38.2
Finland	535.9	2.3	86.4	290.0	2.8	41.9
Norway	503.2	2.6	91.2	269.6	2.8	41.4
Sweden	497.4	2.9	98.6	273.5	3.0	44.1
Nordic average	507.9	1.2	89.9	276.4	1.3	41.4
OECD average	493.4	0.5	93.1	276.8	0.7	39.7

Note. Australia, Austria, Canada, Germany, and the United States are not included in PIAAC OECD average values due to lack of individual values of age.

Gender differences in literacy performance. While PISA 2000 displayed pronounced gender differences in literacy skills in favor of the girls among 15-year-olds in all participating countries (OECD, 2001), this was not the case among 16–65-year-olds in PIAAC 2012 (OECD, 2013b). As the effect of gender on literacy skills might differ by age and not necessarily be consistent, the cohort from PISA 2000 is compared to the same cohort (26–28-year-olds) in PIAAC 2012 (see Table 3). PISA 2000 and PIAAC 2012 apply different scales. Therefore, effect sizes (Cohen's d) are calculated to compare possible gender differences. Cohen's d[3] expresses the size of the gender differences as the share of a standard deviation. Cohen's d = 0.1 is equal to 1/10 of a standard deviation and Cohen's d = 0.5 is equal to 1/2 standard deviation, etc. According to Cohen (1992), an effect size of 0.2 is considered to be small, 0.5 is considered to be a moderate effect size, and 0.8 is reckoned as a large effect size.

Table 3 shows the differences in mean performance in PISA 2000 and PIAAC 2012 as well as the effect sizes. PISA 2000 shows a quite consistent pattern across the Nordic countries, where females perform better than males in literacy. The gender differences were a little higher in the Nordic countries than on average in the OECD. The effect of gender on literacy was highest in Finland (moderate effect) and lowest in Denmark (small effect). For the same cohort, PIAAC 2012 shows a somewhat similar pattern, with the smallest gender differences in Denmark (d = 0.00) and Sweden (d = 0.02), and the largest gender differences in Finland (d = 0.25).

Table 3. *Gender difference in literacy in PISA 2000 (aged 15) and PIAAC 2012 (aged 26–28)*

	PISA 2000 (aged 15)			PIAAC 2012 (aged 26-28)		
	Diff.	SD	Cohen's d	Diff.	SD	Cohen's d
Denmark	24.8	98.1	0.25	-0.2	49.5	0.00
Finland	51.2	89.4	0.57	11.6	46.1	0.25
Norway	43.2	103.6	0.42	9.0	51.1	0.18
Sweden	37.0	92.2	0.40	1.0	55.7	0.02
Nordic average	39.1	95.8	0.41	5.3	50.6	0.11
OECD average	31.6	96.1	0.33	2.4	45.0	0.05

Note. Australia, Austria, Canada, Germany, and the United States are not included in PIAAC OECD average values due to lack of individual values of age.

[3] Cohen's d = (M1-M2)/SD,

The gender differences in literacy were considerably smaller in PIAAC 2012 than in PISA 2000, with zero or small effects.

Table 4 shows gender differences in mean performance in PISA 2009 and PIAAC 2012 as well as effect sizes. In line with PISA 2000, PISA 2009 shows a consistent pattern across the Nordic countries, where females perform better than males in literacy. Except for Denmark, the gender differences were a little higher in the Nordic countries than the average in the OECD. Gender differences in PISA 2009 were also somewhat higher than in PISA 2000 in these countries. As in PISA 2000, the effect of gender on literacy was highest in Finland (moderate effect) and lowest in Denmark (small effect). For the same cohort, PIAAC 2012 shows a somewhat different pattern, with the smallest gender differences in Norway (d = 0.04) and Sweden (d = 0.07) and the largest gender differences in Denmark (d = 0.22). The gender differences in literacy were considerably smaller in PIAAC 2012 than in PISA 2009, with almost no effect to a small effect.

Table 4. *Gender difference in literacy in PISA 2009 (aged 15) and PIAAC 2012 (aged 17–19)*

	PISA 2009 (aged 15)			PIAAC 2012 (aged 17-19)		
	Diff.	SD	Cohen's d	Diff.	SD	Cohen's d
Denmark	28.8	83.6	0.34	8.5	38.2	0.22
Finland	55.1	86.4	0.64	7.6	41.9	0.18
Norway	47.3	91.2	0.52	1.7	41.4	0.04
Sweden	45.5	98.6	0.46	2.9	44.1	0.07
Nordic average	44.2	89.9	0.49	5.2	41.4	0.12
OECD average	39.1	93.1	0.42	0.6	39.7	0.02

Note. Australia, Austria, Canada, Germany, and the United States are not in-cluded in PIAAC OECD average values due to lack of individual values of age.

7.4 A comparison of numeracy results in PISA 2003 and in PIAAC 2012 in the Nordic countries

Mathematics was the primary focus in PISA 2003, and Denmark, Finland, Norway, and Sweden were among the 41 participating countries (OECD, 2004). Finland was the best-performing OECD country (Ibid.). As for literacy, it is of interest to see if the pattern of performance in mathematics from PISA 2003 also yields for the same cohort in numeracy in PIAAC 2012. The students who participated in PISA 2003 were 24 years old in PIAAC 2012. To ensure a large enough sample, 23- and 25-year-olds were included in the comparison displayed in Table 5.

The order of achievement in the Nordic countries was slightly different in PISA 2003 and PIAAC 2012. Finland outperformed the other countries in both surveys, but while Denmark was ranked second in mathematics in PISA 2003, Sweden was ranked second in PIAAC 2012. The Danish cohort outperformed the Norwegian cohort in mathematics in PISA 2003, whereas there were no differences between these countries in PIAAC 2012.

Table 5. *Mean mathematics scores in PISA 2003 (aged 15) and mean numeracy scores in PIAAC 2012 (aged 23–25)*

	PISA 2003 (aged 15)			PIAAC 2012 (aged 23-25)		
	Mean	s.e.	SD	Mean	s.e.	SD
Denmark	514.3	2.7	91.3	283.6	3.8	51.0
Finland	544.3	1.9	83.7	297.2	3.4	49.8
Norway	495.2	2.4	92.0	283.4	3.6	54.3
Sweden	509.0	2.6	94.7	293.3	3.2	49.8
Nordic average	515.7	1.2	90.4	289.4	1.7	51.2
OECD average	499.7	0.6	93.6	278.8	0.8	47.6

Note. Australia, Austria, Canada, Germany, and the United States are not included in PIAAC OECD average values due to lack of individual values of age.

Gender differences in numeracy performance. Table 6 presents the gender differences in mean performances in PISA 2003 and for the same age cohort in PIAAC 2012. In both surveys, men performed better than women in numeracy. However, in PISA 2003, the gender differences were small in all of the Nordic countries. The largest gender effect in PISA 2003 was found in Denmark (d = -0.18), where it was about double the size of the other countries. In PIAAC 2012, the gender differences were largest in Finland (d = -0.56). In Norway (d = -0.24), the gender difference was also larger than in PISA 2003, but in Denmark and Sweden, they were equally small in both surveys. Unlike in PISA 2003, in PIAAC 2012, the Nordic average was larger than the OECD average due to the gender differences in Finland and in Norway.

Table 6. *Gender differences in numeracy in PISA 2003 (aged 15) and PIAAC 2012 (aged 23–25)*

	PISA 2003 (aged 15)			PIAAC 2012 (aged 23-25)		
	Diff.	SD	Cohen's d	Diff.	SD	Cohen's d
Denmark	-16.6	91.3	-0.18	-7.9	51.0	-0.15
Finland	-7.4	83.7	-0.09	-27.8	49.8	-0.56
Norway	-6.2	92.0	-0.07	-12.9	54.3	-0.24
Sweden	-6.5	94.7	-0.07	-3.8	49.8	-0.08
Nordic average	-9.2	90.4	-0.10	-13.1	51.2	-0.26
OECD average	-10.6	93.6	-0.11	-7.6	47.6	-0.16

Note. Australia, Austria, Canada, Germany, and the United States are not included in PIAAC OECD average values due to lack of individual values of age.

7.5 Summary of the results

Adults in Finland, Sweden, and Norway have shown relatively high average performance in PIAAC literacy and numeracy assessments, as has Denmark in numeracy (OECD, 2013b, pp. 258, 263, 269). It is noteworthy, however, that in PISA, none of the Nordic countries has managed to improve their performance in reading literacy from PISA 2000 or in mathematical literacy from PISA 2003. Denmark and Norway have managed to keep their performance level in reading, while in Finland and Sweden in particular, there has been a decrease in reading literacy mean scores. In mathematical literacy, Norway is the only Nordic country that has not shown a decrease in average performance.

Comparing PISA and PIAAC results requires caution. The scales of the two assessments are not comparable since there are no common items. Thus, it is only possible to study the relative positions of the Nordic countries in the country rankings to see if the results in PISA and in the corresponding age group of PIAAC are consistent. This comparison reveals that the overall patterns of performance in reading literacy of the Nordic countries are quite consistent across surveys and age groups. In reading literacy, Finland clearly outperformed Denmark, Norway, and Sweden in all PISA cycles and both PIAAC age groups studied. The differences between the three other Nordic countries were generally smaller for both age groups in PIAAC and PISA 2009, since in all of them, Denmark, Norway, and Sweden are within four to nine score points from each other. PIAAC results confirm the pattern of performance in reading established in PISA. In this respect, the literacy studies validate each other.

In numeracy also, the overall pattern of performance was the same across surveys in the sense that Finland outperformed the other countries in both PISA 2003 and PIAAC. There were, however, slight changes in country ranking for the three other countries. It is to be noted that the mean scores of the 23–25-year-olds in PIAAC were all within 14 score points, which is equal to a quarter of the Nordic average standard deviation.

Since the scales between PISA and PIAAC studies are not comparable, the score point difference between female and male respondents cannot be compared either. Therefore, Cohen's d, which expresses the size of the gender differences as the share of a standard deviation, was used in this study. In reading literacy, gender differences in PISA were considerably larger than in PIAAC, and they have widened since 2000 in all of the Nordic countries studied. In PISA, the effect of gender on literacy was highest in Finland and lowest in Denmark, varying from one-quarter of a standard deviation to more than one-half of a standard deviation in 2000 and from one-third of a standard deviation to nearly two-thirds of a standard deviation in 2009. In the corresponding age groups in PIAAC, the gender differences were small, disappearing, or being reduced significantly. This discrepancy between 15-year-olds in PISA and young adults in PIAAC needs further investigation.

In the mathematical literacy assessment of PISA, boys have either outperformed girls or performed at the same level, but the gender difference was clearly smaller than the gender difference in reading literacy. While in reading literacy the gender differences were clearly smaller in PIAAC than in PISA, in numeracy, the opposite was true in Finland and in Norway. In fact, in Finland, the gender difference in the age group of 23–25-year-olds is six times larger in relation to the standard deviation than at the age of 15, and in Norway, the difference is three and half times larger. The relative gender difference in Denmark and Sweden, however, was practically the same in both PISA and in the corresponding age group in PIAAC. The gender difference in 15-year-olds' reading literacy and in young adults' numeracy (particularly in Finland and Norway) is a black spot in educational equity in the Nordic countries.

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Antero Malin

8

Summary – Skills and age

Four Nordic countries, including Denmark, Finland, Norway, and Sweden, together with 20 other countries, participated in the first round of the international survey of adults' skills – Programme for the International Assessment of Adult Competencies (PIAAC). The survey was conducted by the Organisation for Economic Co-operation and Development (OECD). The target population of the survey was the non-institutionalized population, aged 16–65 years, residing in the country at the time of data collection, irrespective of nationality, citizenship, or language status. The data collection took place from August 1, 2011 to March 1, 2012 (OECD, 2013).

PIAAC measures and evaluates the key cognitive and workplace skills thought to be needed for individuals to participate in society and for economies to prosper. A major part of PIAAC is the direct assessment of the following key information-processing skills: literacy, numeracy, and problem solving in the context of technology-rich environments. They have also been called "cognitive foundation skills" (CFS) in PIAAC. The international PIAAC results published in October 2013 (OECD, 2013) showed that the four Nordic countries were ranked among the five best-performing countries in problem solving in technology-rich environments; among the seven best-performing countries in numeracy skills; and with the exception of Denmark, which was slightly below the OECD average, among the six best-performing countries in literacy skills.

The articles published in this book all use PIAAC 2012 data from the four Nordic countries. The data is publicly available on the OECD's website[1]. In subsequent analyses, the Nordic register data will be combined with the Nordic PIAAC data. This work is currently carried out by the PIAAC Nordic Network, consisting of the representatives in the Nordic countries who were involved in the PIAAC data collection and reporting[2]. This data will also be released for use by interested researchers.

This book is the product of the research group "Skill acquisition, skill loss, and age (SASLA). A comparative study of Cognitive Foundation Skills (CFS) in Denmark, Finland, Norway, and Sweden." The research concentrates on the following questions:

1. What are the associations between age and cognitive foundation skills (CFS) in literacy, numeracy, and problem solving with ICT? Are there differences between categories of adults, defined by, e.g., educational level, gender, immigrant status, educational, and employment/unemployment experiences?
2. How are the associations between age and CFS to be explained? What is the relative importance of cohort effects and age effects, i.e., of when you were born and how old you are? Do the data support the hypothesis that we lose CFS as we age?
3. What are the similarities and differences among the Nordic countries with respect to CFS and age? From the Programme for the International Student Assessment (PISA) we know that Finnish 15-year-olds score higher on literacy than youth in other Nordic countries. Do we see the corresponding difference in other age categories, e.g., 25–30-year-olds? What factors in youth and adult education may account for differences?

The articles in this book aim to find some answers to these questions. The central overarching point of interest is the association between age and skills. The association between age and the three key information-processing skills is a complicated issue. There are numerous socio-demographic and other background factors that

1 See: http://www.oecd.org/site/piaac/publicdataandanalysis.htm

2 See: http://www.sfi.dk/Default.aspx?ID=10740

are also associated with age and skills and that modify the association. This means that in estimating the association between age and skills, we should control for all these relevant background factors and adjust the results accordingly.

The research project is funded by NordForsk, research programme "Education for tomorrow". Basic funding to NordForsk is provided by the Nordic Council of Ministers as well as the main stakeholders, which are the Danish Agency for Science, Technology and Innovation, the Academy of Finland, the Research Council of Norway, the Swedish Research Council, and the Icelandic Centre for Research RANNIS.

8.1 The main empirical findings

Egil Gabrielsen and Kjersti Lundetræ (Article 2) compared the distributions of key information-processing skills in the Nordic countries. In PIAAC, Finland outperformed the other Nordic countries in both literacy and numeracy, while Sweden had a slightly higher rate of respondents on the two highest levels in problem solving compared to their Nordic neighbors. In general, the Nordic countries were among the top five or six countries. The only exception is Denmark, which was slightly below the OECD average in literacy. In all Nordic countries adults between 25 and 44 years of age had the best literacy and numeracy skills, while the oldest group, 55–65 years of age, performed significantly lower than the younger age groups. The youngest part of the respondents, 16–34 years of age, performed best on problem solving in technology-rich environments.

In addition, only small gender differences were found in literacy, while men clearly outperformed women in numeracy in all Nordic countries. There were also more men than women performing at the highest level in problem solving. A large and significant difference was observed in all skill domains measured between respondents who were born in the country compared to adults born outside the country. A high educational level was strongly related to a high level of skills. Also, adults permanently outside the labor market or unemployed had significantly lower skills in literacy, numeracy, and problem solving than those employed or categorized as students.

Karsten Albæk, Torben Fridberg, and Anders Rosdahl (Article 3) analyzed the use of skills at work in the Nordic countries and the amount of cognitive foundation skills (CFS) measured in PIAAC, i.e., literacy, numeracy, and problem solving in the context of technology-rich environments. They looked at development over age of both measured skills and their use at work in the following two aggregate categories of occupations, based on the International Standard Classification of Occupations (ISCO): the group ISCO 0–4 contains major occupations 0 to 4 from the International Standard Classification of Occupations (ISCO) categories and the group ISCO 5–9 contains major occupations from 5 to 9. The amount of measured skills declined with age from age category 35–44 to age category 55–65. The decline was present in both the group ISCO 0–4 and in the group ISCO 5–9; the amount of the decline appeared to be of about the same magnitude. However, the decrease in human capital over age as measured by CFS was not reflected in decreases in the use of these skills over age. The use of CFS at work was approximately constant from age category 25–34 to age category 55–65. This constancy was present in both the group ISCO 0–4 and in the group ISCO 5–9.

There were substantial differences between the amount and the use of CFS between the group ISCO 0–4 and the group ISCO 5–9. For age category 25–34, both the amount and the use of CFS were substantially higher in the group ISCO 0–4 than in the group ISCO 5–9. Workers with high levels of CFS in the Nordic countries thus appeared to sort into occupations with relatively intensive use of these skills. One conjecture in relation to the development of CFS through age brackets might be that the deterioration of skills over age is more pronounced in occupations with a limited use of CFS relative to occupations with more intensive use of these skills. The analysis showed that this hypothesis is rejected by the present data for the Nordic countries. The decline in measured CFS appeared to be of about the same magnitude in both the group ISCO 0–4 and in the group ISCO 5–9. The "use it or lose it" hypothesis was not supported by the evidence in the paper.

Sari Sulkunen and Antero Malin (Article 4) describe the participation in adult education and training (AET) in the Nordic countries and the participation activity by age, educational level, occupation, gender, and proficiency of key information-processing skills. Adult education and training is an essential part of life-long learning as it may help adults to halt the decline in their key competencies and develop them further. The overall participation in adult education in the four Nordic countries studied, excluding 16–24-year-olds still in their initial cycle of studies, was equally high. The Nordic countries, i.e., Denmark, Finland, Norway, and Sweden, together with the Netherlands, were among the five PIAAC participating countries in which the participation rates in adult education exceeded 60%.

In all the Nordic countries non-formal adult education was clearly more common than formal education. Participation in AET varied by age, education, and occupation in every Nordic country studied. The analysis also showed that participation in adult education was associated with adults' skills. Those who participated in AET in the 12 months preceding the survey had better skills on average. However, the adjusted (for respondents' age, education, gender, occupation, and native language) score point differences showed very small variation between those who had participated in AET and those who had not.

The overall participation rate in adult education (both formal and non-formal) was the highest in the youngest age groups and lowest in the oldest age group. Among 24-year-olds or younger, the overall participation rate varied from 73% to 86%, while among the 55-year-olds and older it varied from 41% to 49%. In Denmark and Norway, the participation rate was highest in the youngest age group, but in Finland and Sweden, the participation rate was highest among 25–34-year-olds; however, this was only slightly higher than in the youngest age group.

The formal adult education showed a clear association with age in each Nordic country. On average, nearly half of 24-year-olds and younger adults participated in formal education during the year preceding the survey, although the participation rate in this age group varied a lot between the Nordic countries. In the other age groups, the differences between countries were much smaller. The participation rate clearly declined by age, and participation in formal adult education was very rare in the oldest age group (55–65-year-olds). In non-formal adult education, the differences between age groups were less striking. In all four Nordic countries the participation rate was highest and relatively even in the age groups 25–54. In each Nordic country, the oldest adults aged 55 or older in the survey were least active in non-formal education. Nevertheless, among the oldest age group nearly half of all adults participated in some type of non-formal adult education or training; nonetheless, this age group still has the greatest needs in developing key competences further.

In addition, females were slightly more active than men in participating in AET, and higher educational level was associated with more active participation. In each Nordic country, adults in skilled occupations had the highest participation rate in non-formal AET. In addition, with the slight exception of Finland, adults in elementary occupations participated most actively of all occupational groups in formal adult education.

Patrik Lind (Article 5) studied the association between educational mismatch, skills, and age. The PIAAC data makes it possible to contrast three commonly used measures of educational mismatch. Of these, two are self-assessment (SA) measures, SA-hiring and SA-doing. The third is a job analysis (JA) measure, based on the International Standard Classification of Occupations (ISCO 08). There were large differences in incidence of over- and under-education depending on the measure used, and the characteristics of the mismatch groups varied depending on the measure as well. Skill differences between well-matched and mismatched groups were similar across measures. Moreover, conditional on age and tenure, the three measures showed similar patterns with respect to both incidence and skill differences.

There was a tendency for the incidence of over-education to be higher among younger survey participants and lower among the older participants, and there was a small but significant decrease in the share of older over-educated participants. The pattern for under-education was the opposite of that of over-education. The incidence of under-education was higher among the older participants and lower among the younger participants, and the increase in incidence with age was significant.

The skill differences between under-educated and well-matched as well as between over-educated and well-matched individuals are interesting. There was a consistent pattern where the over-educated, on average, performed worse than their peers who had the same educational level (as well as age and gender) but with a job that matched their education. The under-educated, who had a job that usually requires a higher level of education than they currently have, performed, on average, better than similar individuals (in terms of education, age, and gender) who had a lower-level job matched to their educational level.

The estimated skill differences among the age groups between over-educated and adequately educated tended to be negative for all but the youngest age group. The only common pattern was the difference between the youngest age group (20–24) and the rest. However, these estimated differences were not statistically significantly different from zero. Therefore, based on this analysis, we cannot say that over-educated individuals performed worse than well-matched individuals in any age group.

Erik Mellander (Article 6) studied the role of work experience for skills. In this article, individual work experience was estimated as depending on age, education, and family responsibilities. Next, predicted work experience and other variables, including age, were used to explain skills.

For all four of the Nordic countries, the number of children in a family had fundamentally different impacts on the work experiences of men and women. Two children yielded a female-male work experience difference of –3 years, compared to no children. There was essentially no association between work experience and literacy skills. However, the relation between numeracy and work experience was significantly positive in all of the Nordic countries. Five years of work corresponds to a 0.3 standard deviation in numeracy. For problem-solving skills in a technology-rich environment, a positive relation was found in Denmark, Norway, and Finland, but the magnitude was only about half of that for numeracy.

The estimated relations between skills and age were highly sensitive to the choice of skill measure. After controlling for work experience, education, family background, industry/sector, occupation, and on-the-job training, there was almost no association between age and literacy skills. However, when numeracy scores and problem-solving scores were used to measure skills, significantly negative relations to age were found in all four of the Nordic countries. Specifically, literacy skills decreased slowly, if at all, by age, while numeracy skills diminished very rapidly with age. The impact on problem-solving skills was in between these two extremes. The non-linear relations between skills and age were negative and non-increasing over the entire age span (20–65).

Kjersti Lundetræ, Sari Sulkunen, Egil Gabrielsen, and Antero Malin (Article 7) compared the results of PIAAC and PISA. It is noteworthy that in PISA, none of the Nordic countries has managed to improve their performance in reading literacy since PISA 2000 or in mathematical literacy since PISA 2003. Denmark and Norway have managed to maintain their performance level in reading, while in Finland and Sweden, there has been a decrease in reading literacy mean scores. In mathematical literacy, Norway is the only Nordic country that has not shown a decrease in average performance.

Comparing PISA and PIAAC results requires caution. Even though the two surveys are close to each other in defining the skills being measured, there are differences between the two assessments. PISA seeks to measure how well 15-years-old students approaching the end of the compulsory schooling are prepared to meet the challenges of today's knowledge societies, while PIAAC focuses on how adults (aged 16–65) maintain and use their basic skills. In addition, the scales of the two assessments are not directly comparable since there are no common items. Thus, it is only possible to study the relative positions of the Nordic countries in the country rankings to see if the results in PISA and in the corresponding age group of PIAAC are consistent. The corresponding age group for PISA 2000 (literacy) is adults aged 26–28 in PIAAC; for PISA 2003 (numeracy), adults aged 23–25; and for PISA 2009 (literacy), adults aged 17–19.

The comparison revealed that the overall patterns of performance in reading literacy in the Nordic countries were quite consistent across surveys and age groups. In reading literacy, Finland clearly outperformed Denmark, Norway, and Sweden in all PISA cycles and in both PIAAC age groups studied. The differences between the three other Nordic countries were generally smaller for both age groups in PIAAC and PISA 2009. PIAAC results confirmed the pattern of performance in reading established in PISA. In this respect, the literacy studies validate each other.

In numeracy as well, the overall pattern of performance was the same across surveys in the sense that Finland outperformed the other countries in both PISA 2003 and PIAAC. There were, however, slight changes in country ranking for the three other countries. It should be noted that the mean scores of the 23–25-year-olds in PIAAC were all within 14 score points, which is equal to a quarter of the Nordic average standard deviation.

In reading literacy, gender differences in PISA were considerably larger than in PIAAC, and they have widened since 2000 in all of the Nordic countries studied. In PISA, the effect of gender on literacy was highest in Finland and lowest in Denmark, varying from one-quarter of a standard deviation to more than one-half of a standard deviation in 2000, and from one-third of a standard deviation to nearly two-thirds of a standard deviation in 2009. In the corresponding age groups in PIAAC, the gender differences were small, disappearing, or being reduced significantly. This discrepancy between 15-year-olds in PISA and young adults in PIAAC needs further investigation.

In the mathematical literacy assessment of PISA, boys have either outperformed girls or performed at the same level, but the gender difference was clearly smaller than the gender difference in reading literacy. While in reading literacy the gender differences were clearly smaller in PIAAC than in PISA, in numeracy the opposite was true in Finland and in Norway. In fact, in Finland, the gender difference in the age group of 23–25-year-olds was six times larger in relation to the standard deviation than at the age of 15; in Norway, the difference was three and a half times larger. The relative gender difference in Denmark and Sweden, however, was practically the same in both PISA and in the corresponding age group in PIAAC.

8.2 Age and skill formation

The empirical results (based on PIAAC data) of the articles in this book show that age is associated with skill formation in several diverse ways. Age and education are the most important factors explaining the variation in literacy, numeracy, and problem solving in the context of technology-rich environments. A high educational level is strongly related to a high level of skills. Adults between 25 and 44 years of age have the best literacy and numeracy skills, while the oldest group, 55–65 years of age, performs significantly lower than the younger age groups in these skills. The youngest part of the respondents, 16–34 years of age, performs best on problem solving in technology-rich environments.

The amount of measured skills declines with age from age category 35–44 to age category 55–65. The decline is also present if the effect of occupation is controlled. The amount of the decline appears to be of about the same magnitude in the occupational groups ISCO 0–4 and ISCO 5–9. However, the decrease in human capital over age as measured by literacy, numeracy, and problem solving in the context of technology-rich environments is not reflected in decreases in the use of these skills at work over age. The use of these skills at work is approximately constant from age category 25–34 to age category 55–65. This constancy is present in both ISCO groups.

The estimated relations between skills and age are sensitive to the choice of skill measure. Also, more factors associated with skills are needed when estimating the association between age and skills. After controlling for work experience, education, family background, industry/sector, occupation, and on-the-job training, there is almost no association between age and literacy skills. However, significantly negative relations to age are found in numeracy and problem solving in all of the Nordic countries. Specifically, literacy skills decrease slowly, if at all, by age, while numeracy skills diminish very rapidly with age. The impact on problem-solving skills falls in between these two extremes. After controlling for the factors above, the non-linear relations between skills and age are negative and non-increasing over the entire age span (20–65 years).

Adult education and training (AET) is an essential part of life-long learning as it may help adults to halt the decline in their key competencies and develop them further. However, participation in formal AET is highly dependent on age since younger people are generally much more active than older people. Those who participate in AET have better skills. However, if this difference is adjusted for respondents' age, education, gender, occupation, and native language, score point differences show very small variation between those who had participated in AET and those who had not. In this respect, participation in AET does not seem to be associated with better skills assessed in PIAAC.

There is a tendency for the incidence of over-education to be higher among the younger participants and lower among the older participants. On the other hand, the incidence of under-education is higher among the older participants and lower among the younger participants, and the increase in incidence with age is significant. There is a consistent pattern where the over-educated, on average, perform worse than their peers who have the same educational level (as well as age and gender) but with a job that matches their education. The under-educated, who have a job that usually requires a higher level of education than they currently have, perform, on average, better than similar individuals (in terms of education, age, and gender) who have a lower-level job matched to their educational level. The estimated skill differences by the age groups between over-educated and adequately educated participants tend to be negative for all but the youngest age group. However, based on this analysis, we cannot say that over-educated participants perform worse than well-matched participants in any age group since these estimated differences are not statistically significantly different from zero.

The comparison of PISA and PIAAC results reveals that the overall patterns of performance in reading literacy and numeracy in the Nordic countries are quite consistent across surveys and respective age groups. The skill formation during basic education is reflected in the adults' performance. This is also confirmed by the Danish PISA-PIAAC survey, which examined how the 15–16-year-old students who participated in PISA 2000 performed 12 years later in the PIAAC survey (Rosdahl, 2014). Overall, there was a positive correlation between the reading proficiency of the PISA-PIAAC respondents in PISA 2000 and in PIAAC 2011/12. The higher the level was in PISA 2000, the higher the average reading score was in PIAAC. The report concludes that the trend is that the best readers in 2000 are still the best in 2011/2012 and that the poorest readers in 2000 have remained the poorest readers in 2011/2012.

Although the research articles in this book have revealed clear patterns in the association between age and skills, more socio-demographic and other background characteristics are needed in the analysis to clarify this association. What adults do, both at work and outside work, is closely related to skill proficiency. Adults who engage more often in literacy- and numeracy-related activities and who use ICTs more, both at work and outside of work, have higher proficiency in literacy, numeracy, and problem solving in technology-rich environments. Engagement in relevant activities outside of work has an even stronger relationship with the skills assessed in PIAAC than engagement in the corresponding activities at work (OECD, 2013, p. 188).

PIAAC also measured the use of generic skills at work (task discretion, learning at work, influencing skills, co-operative skills, self-organizing skills, gross physical skills, and dexterity) as self-assessment. One interesting question is whether the use of generic skills at work plays a role in skill formation and maintaining the skills. In addition, work-placed learning activities need more attention in maintaining skills.

The importance of everyday activities is supported by the first results of the German project Competencies in Later Life (CiLL). It is a parallel study to the German Programme for the International Assessment of Adult Competencies (PIAAC). While PIAAC focuses mainly on people being active in the labor market (16 to 65 years old), CiLL collected data from older adults mainly "beyond" the working age population (66 to 80 years old). CiLL assessed the same three skill domains as PIAAC: literacy, numeracy, and problem solving in technology-rich environments. The first results published in the spring of 2014 show that the skills at the age of 66 to 80 are highly influenced by the same factors as in PIAAC among 16 to 65 years of age, e.g., initial education, vocational and academic qualification, age, and language (native/non-native). The competence assessment in CiLL was supplemented by qualitative case studies, which reveals the importance of challenges in different areas of everyday life for learning and competence development for elderly people (CiLL, 2014).

Based only on the cross-sectional PIAAC data, we cannot reliably conclude that we lost skills as we age. However, one of the important conclusions of the British Whitehall II survey, which is a longitudinal survey in which the participants have been followed for a quarter of a century, is that cognitive decline is already evident at the age of 45–49 (Singh-Manoux et al., 2012). In understanding the association between age and skills, more detailed analyses of PIAAC data and comparisons with earlier adult skill surveys, i.e., the International Adult Literacy Survey (IALS) and the Adult Literacy and Life Skills Survey (ALL), are needed.

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FOUR NORDIC COUNTRIES, i.e. Denmark, Finland, Norway, and Sweden, together with 20 other countries, participated in the first cycle of the international survey of adults' skills – Programme for the International Assessment of Adult Competencies (PIAAC). A major part of the survey consists of proficiency tests in literacy, numeracy, and problem solving in technology-rich environments.

The articles published in this book draw mostly on the PIAAC data from the four Nordic countries. As the title suggests, the overarching theme in this book is the association between age and the three cognitive foundation skills.

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