Scandinavian Journal of Educational Research
Vol. 48, No. 3, July 2004

Scientific Literacy and Socio-economic Background among 15-year-olds—A Nordic Perspective

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ABSTRACT *This article examines the relationship between the cultural, social and economic capital of students from the Nordic countries and their level of scientific literacy, based on data from the Programme for International Student Assessment (PISA) 2000 study. The analysis shows that the relationship between the home's economic capital and students' level of scientific literacy is relatively weak in all the Nordic countries, a result that is consistent with previous research. However, the relationship between the cultural capital of the home and the level of scientific literacy is found to be surprisingly strong in several of these countries. The results presented in the article may be interpreted as a need in science education for a special focus on students from lower cultural backgrounds. To ensure that students from lower socio-economic backgrounds also achieve an adequate level of scientific literacy, it is argued that a cultural approach in science education is relevant and important.*

Key words: *scientific literacy; socio-economic background*

INTRODUCTION

The relationship between socio-economic status and school performance has been given a lot of attention by researchers within the field of sociology of education. Ho and Willms (1996) claim that perhaps the most enduring finding in the sociology of education is that schooling outcomes are related to the socio-economic status (SES) of the child's parents. According to Ho and Willms, most of the work in this field has been directed at determining the processes that contribute to this relationship, including structural processes at the level of the school, community or larger society and micro-level processes associated with individual and group actions. Ethnographic research has bridged the gap between theories at both levels by introducing cultural elements that mediate processes at the macro-level and by demonstrating how social and individual influences reinforce each other (Mehan, 1992).

Socio-economic status is also an important focus in the PISA study. Socio-economic status is regarded as one of the strongest predictors of achievement at

ISSN 0031-3831 print; ISSN 1430-1170 online/04/030287-19 © 2004 Scandinavian Journal of Educational Research
DOI: 10.1080/00313830410001695745

school, and several questions in the student questionnaire aim to tap information about students' social background. The definition of SES in PISA is based on three sub-concepts that could be said to constitute the definition. 'Economic capital' refers to what people in everyday language often mean by the word 'capital': financial resources. 'Cultural capital' refers to the degree of familiarity with high-status cultural practices. Typical examples of such practices are listening to classical music, reading literature, attending theatre, etc. 'Social capital' implies a social network that can be used in different situations and contexts for a variety of purposes. In PISA, socio-economic status is defined as the sum of these three forms of capital. This means that a person or a family can possess different amounts of each form of capital. Therefore, the concept of socio-economic status as defined in PISA is not unproblematic, because it consists of components that differ a lot qualitatively.

In this article, the relationship between the scientific literacy and socio-economic background of 15-year-olds is examined in the Nordic countries, based on empirical findings from the PISA 2000 study. Three main research questions are addressed. Firstly, the empirical relationship between overall scientific literacy and socio-economic background is studied. Then the differences between the product and the process dimensions of scientific literacy in relation to SES will be focused. Finally, a lifelong perspective is taken, whereby the empirical relationships between three learning strategies and SES are explored. Before elaborating on the concept of socio-economic status, the definition of scientific literacy as used in PISA will be introduced.

Scientific Literacy in the PISA Study

Current thinking about the desired outcomes of science education for all citizens emphasises the development of a general understanding of important scientific concepts and explanatory frameworks, of the methods by which science derives evidence to support claims for its knowledge, and of the strengths and limitations of science in the real world. It values the ability to apply this understanding to real situations involving science, in which claims need to be assessed and decisions made. Millar and Osborne (1998) have identified the focus of a modern science curriculum as being 'the ability to read and assimilate scientific and technical information and assess its significance' (p. 25). It has been claimed that this should be the outcome of science education for all students. For the minority of students who will become the scientists of tomorrow, this will be extended to an in-depth study of scientific ideas and the development of the ability to 'do science'. Against this background, it is considered that the essential outcome of science education is that students should become scientifically literate. Scientific literacy is defined within the PISA framework as 'the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and changes made to it through human activity' (Organisation for Economic Co-operation and Development, 2000, p. 76).

The Economic, Cultural and Social Capital

It is widely acknowledged that differences in economic capital create differences in school performance. This view implicitly assumes that education is related to costs and that well-off parents are better able to cover such costs for their children. In PISA, the effect of financial resources cannot be assessed directly. However, the PISA student questionnaire contains questions about the occurrence of different objects in the student's home, and this information is used as an indication of economic status (OECD, 2001). Information about parents' income levels can also be obtained indirectly from data on parents' occupations, as given by students. Income and educational levels, again, are derived from the occupations by using a system created by Hauser and Warren (1997). Previous research has suggested that economic resources are not among the most important explanatory factors for differences in school performance in modern welfare states such as the Nordic countries. The main reason for this is the obvious fact that in these countries family expenses related to the child's education are limited, due to a large degree of public financing.

Another type of resources looked at in PISA is often referred to as 'cultural capital', a concept borrowed from the French sociologist Pierre Bourdieu. According to Bourdieu's (1977, 1984) cultural reproduction theory, one would anticipate strong direct links between parents' cultural background and student performance in many countries. One of the key aspects of cultural capital is language. According to Bourdieu, language is not simply an instrument of communication. It also provides, together with a richer or poorer vocabulary, a more or less complex system of categories, whether logical or aesthetic. The child's language depends partly on the complexity of the language transmitted by the family. This can be described as the student's language heritage (Bourdieu & Passeron, 1990). Bourdieu draws a distinction between what could be labelled working-class language, which is often referred to as vulgar or common, and bourgeois language, which by contrast is said to be pure and correct. Bourgeois language is characterised by abstraction, formalism, intellectualism and euphemistic moderation. The authority of language is strongly related to the pedagogic authority of schools. Bourgeois language practices are also strongly related to other high-status cultural expressions, such as knowledge of classical literature and music. This knowledge together constitutes a person's cultural capital, and cultural capital is strongly related to values and preferences. The concept of 'taste' is used by Bourdieu to describe the preferences of different social groups (Bourdieu, 1984). As a consequence of this, an affinity for high-status cultural expressions could be used as an indication of cultural capital, as is done in PISA. According to Bourdieu's theories, a lack of cultural capital is assumed to distance students from academic and school culture, which can often have consequences for the students' school careers and for the future of students facing exclusion and selection processes within the education system.

A third type of resources is social capital. Coleman (1988) uses the concept of social capital as part of a general theoretical strategy, taking rational action as a starting point, but rejecting the extreme individualistic premises that often accompany it. According to Coleman, social capital is defined by its function. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that in its absence would not be possible. Willms (2001) claims that, during the past decade, theorists have stressed that learning societies also depend on relationships among people, within both communities and organisations. They have invoked the term 'social capital' to embody the nature of relationships among people and how these facilitate collective action, the strength of social networks, and the norms and values of a community. Social capital refers to resources in the form of social ties that can be used in different situations for different purposes, for example, in relation to children's school careers. The traditional hypothesis about social capital is that students do better at school if they have a close social network surrounding them where parents, children and teachers collaborate and know each other well. Social capital is assumed to be particularly important for individuals who possess relatively little economic and cultural capital, compensating in a way for their relative disadvantage.

MEASURING THE CONCEPT OF SOCIO-ECONOMIC STATUS

Ganzeboom and Marks (2001) argue that within the field of research on social background, the different theoretical traditions are not always closely related to empirical results. They claim that there has been a tendency for theoretical work to proceed without many references to empirical findings. At the same time, empirical studies are often criticised for not applying relevant concepts, or for using inappropriate measures for relevant concepts. Ganzeboom and Marks claim that theories within the field have to be tested by using empirical data and that they need to have the potential to be used to explain a wide range of observed phenomena. Since the empirical results of PISA are provided within the framework of the theoretical traditions as presented above, it is possible to have theory-guided discussions based on the data. The questions asked in studies such as PISA are not randomly chosen; they are derived from a theoretical framework.

In PISA 2000, several constructs related to socio-economic status were derived from the student questionnaire. For all these composite variables, the internal consistency measured by Cronbach's alpha was at or above 0.70. Cronbach's alpha is a measure of internal consistency based on item covariances (Crocker & Algina, 1986). In Table I the constructs are grouped according to their relationship to the three outlined forms of capital. This classification should be regarded as one possibility among others, and it is clear that in certain ways the validity of the classification could be questioned. The classification presented is, however, supported by factor analysis of the constructs.

All the concepts in Table I were measured using composite variables, except *Books at home*, which is a single-item variable, and *Parental education*, which is a simple combination of two single items. In the Table, the construct *Highest family socio-economic index* appears twice. This is due to the fact that the International

TABLE I. Grouping of the constructs in PISA 2000 related to socio-economic status in relation to the three forms of capital

Cultural capital	Social capital	Economic capital
Home cultural competence	Home social capital	Home economy
Student cultural activity		Highest family socio-economic index
Home cultural possessions		
Home educational resources		
Books at home		
Highest family socio-economic index		
Parental education		

Socio-Economic Index (ISEI) used is based on a classification of parents' occupations which is an approximation for the sum of education and income, and education and income are related to cultural and economic capital respectively. The instruments used to measure the above constructs are presented in detail in Adams and Wu (2002). One specific comment on the measurement of social capital in PISA 2000 has to be mentioned. Social capital was measured by one single construct addressing social communication at home. Other important aspects of social capital such as social networks and communication outside the home or between parents and teachers were not measured.

RESULTS

One possible approach in studying the relationship between students' scientific literacy and SES is to do this construct by construct. However, several of the constructs are highly correlated (see Pilegaard Jensen & Turmo, 2003). As a consequence of this, multiple regression analysis is a relevant approach for studying how much of the variance in scientific literacy can be explained by combinations of the constructs presented in the previous section. It has to be stressed that the term 'explained' here does not imply cause–effect relationships. Results from multiple regressions can be difficult to interpret convincingly. This is partly due to the fact that the amount of variance explained by an independent variable introduced into the model is highly dependent on the other variables already present in the model. Therefore, and also taking the nature of the data into account, the focus in this section will be on the squared multiple correlation coefficients from the regressions. The R^2 value can be understood as the total variance explained by the combined independent variables in the model. In this respect, a squared multiple correlation coefficient is analogous to a squared correlation coefficient between two variables. In one case, that of social capital, there is only one construct categorised as measuring this concept in this article. In the case of social capital, the squared correlation coefficient for each of the Nordic countries will be presented.

TABLE II. R^2 values for cultural capital within the Nordic countries, and OECD mean

Country	R^2
Norway	0.18
Sweden	0.14
Denmark	0.21
Finland	0.10
Iceland	0.10
OECD mean	0.20

Note: The R^2 value can be understood as the total variance explained by the combined independent variables in the model. For example, $R^2 = 0.18$ for Norway in Table II means that 'cultural capital' and 'scientific literacy' have 18% o f the variance in common.

Regression Model: cultural capital

Table II shows the results of a multiple regression analysis with the constructs related to cultural capital as independent variables and the score in scientific literacy as the dependent variable. To summarise, this model consists of the following constructs: *Home cultural competence*, *Student cultural activity*, *Home cultural possessions*, *Home educational resources*, *Books at home*, *Highest family socio-economic index*, and *Parental education*.

The results in Table II show that there were differences between the Nordic countries in the extent to which the variance in the scientific literacy score was explained by cultural capital. Denmark and Norway were the two countries where cultural capital explained the most variance, whereas in Finland and Iceland only 10% of the variance was explained. The values for Denmark and Norway were close to the OECD average R^2 value.

Regression Model: social capital

There is only one construct presented in this article that is categorised as measuring home social capital. Table III shows the squared correlation coefficient between the score in scientific literacy and this construct.

Table III shows that in the Nordic countries in general, the variance in scientific literacy was explained less by social capital than by cultural capital. Social capital explained the most variance in Norway and Denmark, as in the case of cultural

TABLE III. R^2 values for social capital within the Nordic countries, and OECD mean

Country	R^2
Norway	0.02
Sweden	0.00
Denmark	0.02
Finland	0.00
Iceland	0.00
OECD mean	0.01

capital, while in the other Nordic countries none of the variance could be explained by social capital. On average across OECD countries, social capital explained 1% of the variance in scientific literacy.

Regression Model: economic capital

Table IV shows the results of a multiple regression analysis where the constructs related to economic capital were independent variables and the scientific literacy score was the dependent variable. This means that the independent variables were *Highest family socio-economic index* and *Home economy*.

The results in Table IV show how much of the variance in scientific literacy could be explained by economic capital. Here it has to be stressed that the construct *Highest family socio-economic index* also has an educational component. When this construct was included in the model, a larger percentage of the variance was explained than if we only used the variable *Home economy*. This was due to the fact that the model then had a component of cultural capital included. The Table shows that in Denmark economic capital explained the most variance in scientific literacy, while in Iceland only 2% of the variance could be explained.

TABLE IV. R^2 values for economic capital within the Nordic countries, and OECD mean

Country	R^2
Norway	0.06
Sweden	0.08
Denmark	0.10
Finland	0.05
Iceland	0.02
OECD mean	0.11

TABLE V. R^2 values for the overall model within the Nordic countries, and OECD mean

Country	R^2
Norway	0.19
Sweden	0.14
Denmark	0.21
Finland	0.10
Iceland	0.11
OECD mean	0.21

Regression Model: overall model

Table V shows the R^2 values from a multiple regression analysis where all the nine constructs presented in this article were used as independent variables and the score in scientific literacy was used as the dependent variable. These R^2 values show how much of the variance in scientific literacy could be explained by SES, as measured by the constructs presented in this article.

Table V shows that there were differences between the countries in the amount of variance in scientific literacy that could be explained by all the constructs combined together. In Denmark and Norway, SES explained the most variance, in Finland and Iceland the least.

In sum, the analysis showed that in all the Nordic countries cultural capital was the most important explanatory factor. Social and economic capital explained almost no additional variance in scientific literacy when the constructs related to cultural capital were already included in the model.

PROCESS AND PRODUCT DIMENSIONS OF SCIENTIFIC LITERACY: DIFFERENCES IN RELATION TO SOCIO-ECONOMIC BACKGROUND

'Process' and 'product' are two dimensions of scientific literacy often identified in the literature (see, for example, Driver *et al.*, 1996). In this section it will be explored whether there are differences between these two dimensions of scientific literacy in relation to socio-economic background. To study this, two sub-scores were generated from the PISA data, one based on the items that mainly test process competency and the other on the items that mainly test product competency. This was done for each of the five booklets that contained science items in PISA. To make the scores comparable across the booklets, two corrections of the sums were made. Firstly, the sums were corrected for the total number of score points for the product and the process dimensions in each booklet. Secondly, the sums were corrected for the mean p value of the items measuring the process and the product dimensions in the booklets. To compare the score values generated by this procedure with the plausible values used in PISA (see Adams & Wu, 2002), the correlation between the total score (the sum of all items) generated by this procedure and the five plausible values was calculated. The correlation coefficients were found to be 0.9 for all the

TABLE VI. Relationship between cultural capital and the process and product dimensions of scientific literacy within the Nordic countries, and OECD mean

Country	CULT-COM Coeff.	CULT-ACTV Coeff.	CULT-POSS Coeff.	HEDRES Coeff.	BOOKS Coeff.	HISEI Coeff.	EDUC-ATION Coeff.	Overall model R^2
Norway								
Process	0.21	0.18	0.24	0.24	0.25	0.19	0.15	0.12
Product	0.17	0.10	0.22	0.20	0.21	0.18	0.10	0.07
Sweden								
Process	0.19	0.10	0.18	0.12	0.24	0.21	0.11	0.09
Product	0.15	0.06	0.15	0.09	0.20	0.18	0.07	0.06
Denmark								
Process	0.26	0.17	0.20	0.18	0.25	0.24	0.27	0.13
Product	0.21	0.10	0.18	0.15	0.23	0.23	0.28	0.11
Finland								
Process	0.17	0.12	0.17	0.11	0.20	0.17	0.13	0.07
Product	0.11	0.08	0.12	0.12	0.14	0.13	0.10	0.05
Iceland								
Process	0.13	0.15	0.12	0.04	0.18	0.11	0.14	0.06
Product	0.12	0.11	0.12	0.06	0.17	0.11	0.14	0.04
OECD mean								
Process	0.18	0.18	0.21	0.17	0.27	0.24	0.23	0.12
Product	0.13	0.14	0.17	0.16	0.24	0.22	0.19	0.09

CULTCOM = Home cultural competence, CULTACTV = Student cultural activity, CULT-POSS = Home cultural possessions, HEDRES = Home educational resources, BOOKS = Books at home, HISEI = Highest socio-economic index, EDUCATION = Parental education.

five plausible values. This result can be regarded as near-perfect. Plausible values are used to simulate the effect of measurement error. The score values generated do not represent a 'true score' (see Crocker & Algina, 1986), but anticipate that measurement errors do not occur, or that all the five booklets measure exactly the same latent trait. Based on this approach, it could be expected that there would be some small differences between the correlation of SES with this generated score value and that with the plausible values. However, in the following section the focus will be on comparing the process score with the product score in relation to SES, both of these score values being generated by the same procedure.

Table VI shows the correlation between the process and the product dimensions of scientific literacy and the SES constructs measuring cultural capital. The R^2 values for the overall model are also shown (all the cultural capital constructs as independent variables). The results show that the differences between the two dimensions were small regarding the correlation coefficients for the single constructs, but in most cases the coefficients were marginally larger for the process dimension; in other words, the correlation between the process dimension and the cultural capital constructs was somewhat stronger. Overall, cultural capital could explain more of the variance in the process dimension than in the product

TABLE VII. Relationship between social capital and the process and product dimensions of scientific literacy within the Nordic countries, and OECD mean

Country	HOME SOCIAL CAPITAL Coeff.	Overall model R^2
Norway		
Process	0.11	0.01
Product	0.08	0.01
Sweden		
Process	0.04	0.00
Product	0.01	0.00
Denmark		
Process	0.11	0.01
Product	0.09	0.01
Finland		
Process	0.02	0.00
Product	0.00	0.00
Iceland		
Process	0.02	0.00
Product	0.05	0.00
OECD mean		
Process	0.08	0.01
Product	0.06	0.01

dimension. The largest difference between the dimensions was found in Norway (12% compared to 7%).

The correlation coefficients between the process and the product dimensions of scientific literacy and the construct measuring social capital are shown in Table VII. The results show that the differences between the two dimensions were relatively small. As in the case of cultural capital, they were in most cases marginally in favour of the process dimension.

Table VIII shows the correlation coefficients between the two dimensions of scientific literacy and the construct measuring economic capital (wealth). Again, the differences were in general small. Denmark and Iceland showed the largest differences, and these were in favour of the product dimension. The table also shows the R^2 values for a regression model where the two constructs that measure economic capital were used as independent variables. The results show that there were only small differences between the two dimensions of scientific literacy.

Table IX shows the overall model for the relationships between the process and product dimensions of scientific literacy and SES in the Nordic countries. The results in the Table show that in all the Nordic countries the process dimension was more strongly related to SES. This was also the case on average in the OECD countries. In the Nordic countries, the largest difference between the two dimensions was found in Norway. The results in Table IX are very similar to the results for the overall model in Table VI. Social and economic capital explain almost no additional variance in the two dimensions of scientific literacy when the constructs related to cultural capital are already included in the model.

TABLE VIII. Relationship between economic capital and the process and product dimensions of scientific literacy within the Nordic countries, and OECD mean

Country	WEALTH Coeff.	Overall model R^2
Norway		
Process	0.06	0.04
Product	0.05	0.03
Sweden		
Process	0.04	0.04
Product	0.05	0.03
Denmark		
Process	0.09	0.06
Product	0.15	0.06
Finland		
Process	0.08	0.03
Product	0.07	0.02
Iceland		
Process	− 0.05	0.02
Product	0.03	0.01
OECD mean		
Process	0.11	0.06
Product	0.11	0.06

A LIFELONG PERSPECTIVE—THE RELATIONSHIP BETWEEN LEARNING STRATEGIES AND SOCIO-ECONOMIC BACKGROUND

Learning strategies can be seen as important tools that enable students to develop their scientific literacy throughout life. Students will need cross-curricular competencies to help them with lifelong learning, and learning strategies can be seen as one category of such competencies. In this section the relationship between the learning strategies of 15-year-olds and their socio-economic background will be studied. The rationale for this is the use of learning strategies as a predictor for the future development of students' scientific literacy. If a student has a high level of scientific literacy at the age of 15 but a poor repertoire of learning strategies, this could be a threat to the further development of his or her scientific literacy. An opposite situation can also be imagined in which a student has a low level of scientific literacy but a good repertoire of learning strategies. This could lead to a higher level of scientific literacy in the future, if other important conditions such as motivational factors are satisfied. However, it has to be noted that there is empirical evidence showing that these two situations are not typical (see, for example, Turmo, 2003). It is also obvious that learning strategies are very far from being perfect indicators of future learning related to scientific literacy, but they are used here as one of the many important factors that have the potential to influence future learning.

Studying the mentioned relationship, in accordance with PISA (OECD, 2001) the selected learning strategies were *memorisation*, *elaboration* and *control strategies.*

TABLE IX. Relationship between SES and the process and product dimensions of scientific literacy within the Nordic countries, and OECD mean

Country	Overall model *(R^2)*
Norway	
Process	0.12
Product	0.08
Sweden	
Process	0.09
Product	0.07
Denmark	
Process	0.13
Product	0.11
Finland	
Process	0.07
Product	0.05
Iceland	
Process	0.07
Product	0.05
OECD mean	
Process	0.12
Product	0.10

The theoretical background for these strategies and the instruments used in PISA to measure them are presented elsewhere (Turmo, 2003) along with a detailed analysis of the empirical relationships between the three learning strategies and scientific literacy. Table X gives the proportion of variance in the three learning strategies explained by cultural capital compared with the corresponding values for scientific literacy. In other words, the values tell us how strongly the use of the learning strategies was related to students' cultural background.

The results in Table X show that in all the Nordic countries the relationship between cultural capital and memorisation strategies was stronger than on average across OECD countries. This was in contrast to the values for scientific literacy. In Norway, Sweden and Denmark, memorisation strategies were far less dependent on cultural capital than was the score in scientific literacy, which was also the case in the OECD on average. In Finland and Iceland, however, the differences were much smaller. Of all the countries that participated in PISA, these two countries were among those where memorisation strategies were most strongly related to socio-economic background.

Table X further shows that the relationship between elaboration strategies and cultural capital was at or above the OECD average in all the Nordic countries except in Denmark. The relationship was strongest in Sweden and Iceland. It is interesting to notice that in Sweden, Finland and Iceland the relationship between elaboration strategies and cultural capital was approximately as strong as the relationship between scientific literacy and cultural capital. In Iceland the explained variance was in fact somewhat larger for the first-mentioned relationship.

TABLE X. R^2 values for cultural capital within the Nordic countries, and OECD mean: scientific literacy and the three learning strategies as dependent variables

		Learning strategies		
Country	Scientific literacy	Memorisation strategies	Elaboration strategies	Control strategies
Norway	0.18	0.05	0.09	0.08
Sweden	0.14	0.04	0.12	0.10
Denmark	0.21	0.04	0.06	0.06
Finland	0.10	0.05	0.09	0.10
Iceland	0.10	0.06	0.11	0.12
OECD mean	0.20	0.03	0.09	0.09

The relationships between cultural capital and control strategies are also given in Table X. A very similar pattern to that for elaboration strategies emerges. Again, relationships stronger than on average across OECD countries were found in Sweden, Finland and Iceland. In Iceland the relationship between cultural capital and control strategies was stronger than the relationship between cultural capital and scientific literacy.

The relationships between social capital and the three learning strategies are shown in Table XI. As in the case of cultural capital, the average relationships in the OECD between social capital and control strategies and elaboration strategies were stronger than those between social capital and memorisation strategies. However, in social capital there was a difference between the amount of variance explained for elaboration strategies and that explained for control strategies. In the Nordic countries there was a general tendency for social capital to explain as much or more of the variance in all the three learning strategies than in scientific literacy. Among the Nordic countries, social capital could explain the most variance in scientific literacy in Norway and Denmark; at the same time it explained the least variance in the three learning strategies in Denmark, Norway and Finland. As in the case of

TABLE XI. R^2 values for social capital within the Nordic countries, and OECD mean: scientific literacy and the three learning strategies as dependent variables

		Learning strategies		
Country	Scientific literacy	Memorisation strategies	Elaboration strategies	Control strategies
Norway	0.02	0.02	0.03	0.04
Sweden	0.00	0.04	0.04	0.05
Denmark	0.02	0.02	0.02	0.04
Finland	0.00	0.03	0.01	0.03
Iceland	0.00	0.05	0.05	0.08
OECD mean	0.01	0.02	0.03	0.06

TABLE XII. R^2 values for economic capital within the Nordic countries, and OECD mean: scientific literacy and the three learning strategies as dependent variables

		Learning strategies		
Country	Scientific literacy	Memorisation strategies	Elaboration strategies	Control strategies
Norway	0.06	0.01	0.02	0.01
Sweden	0.08	0.00	0.02	0.02
Denmark	0.10	0.00	0.01	0.01
Finland	0.05	0.00	0.01	0.00
Iceland	0.02	0.01	0.02	0.02
OECD mean	0.11	0.00	0.01	0.02

cultural capital, Iceland was the Nordic country where social capital could explain the most variance in the three learning strategies.

The results in Table XII show that the relationships between all the three learning strategies and economic capital were weaker than those between scientific literacy and economic capital. This was the case in all the Nordic countries and also on average in the OECD. However, it is interesting to note that the relationships between the learning strategies and economic capital were marginally stronger in some of the Nordic countries than in the OECD on average, whereas the relationship between scientific literacy and economic capital was weaker in all the Nordic countries when compared to the OECD average.

Table XIII compares the proportion of variance in scientific literacy and the three learning strategies explained by socio-economic background as a whole. The results show that on average in the OECD the use of the three learning strategies was more weakly related to socio-economic background than was the level of scientific literacy. However, there were interesting differences between the three learning strategies. Memorisation strategies were most weakly, and control strategies most strongly, related to SES. In all the Nordic countries, elaboration and control strategies were more strongly related to SES than memorisation strategies, which

TABLE XIII. R^2 values for overall SES within the Nordic countries, and OECD mean: scientific literacy and the three learning strategies as dependent variables

		Learning strategies		
Country	Scientific literacy	Memorisation strategies	Elaboration strategies	Control strategies
Norway	0.19	0.05	0.09	0.09
Sweden	0.14	0.05	0.12	0.11
Denmark	0.21	0.04	0.07	0.07
Finland	0.10	0.05	0.09	0.10
Iceland	0.11	0.08	0.11	0.13
OECD mean	0.21	0.05	0.09	0.11

was also the trend for the OECD as a whole. Among the Nordic countries, Iceland was the country with the strongest relationship between SES and the three learning strategies. In this country the learning strategies were as strongly related to SES as was students' level of scientific literacy, and the strength of the relationship with the learning strategies was above the OECD average for all the three strategies. In scientific literacy, by contrast, Iceland had a value far below the OECD average. It is also interesting to note that the two Nordic countries with the strongest scientific literacy–SES relationships, Norway and Denmark, had in general the weakest relationships between SES and the three learning strategies.

DISCUSSION

The empirical relationship between students' scientific literacy and their socio-economic background is highly dependent on the measures that are used. In this article, three different aspects of SES were introduced: cultural capital, social capital and economic capital, and the measures taken from the PISA study were related to these three domains of SES. The results show that there are important differences between the Nordic countries in how much of the variance in scientific literacy can be explained by these three domains. In statistical analysis it is obvious that co-variances between two or more variables do not necessarily imply direct cause–effect relationships. However, if theory and previous research tell us that there is a mechanism for a cause–effect relationship between the variables, then co-variance provides strong support for such an interpretation of the findings. The theoretical framework presented in the introductory parts of this article suggests that there should be a cause–effect relationship between cultural capital and students' levels of scientific literacy. The same should be the case for social capital. In the case of economic capital, one would not anticipate a strong cause–effect relationship in modern welfare states such as the Nordic countries. In the PISA data, we have seen that there are surprisingly strong relationships between cultural capital and the level of scientific literacy, while the relationship with economic capital is weak. In this respect the findings are consistent with the theories presented in the introductory parts of the article. In the analysis presented in this article the hierarchical structure of the PISA data, that is, the fact that students are nested within schools, was not taken into consideration. Intra-correlations at the school level might be significant, and Hierarchical Linear Modelling (HLM) analysis might have resulted in some minor deviations from the results presented in this article.

From an international perspective, the surprising finding is the strength of the relationship between the level of scientific literacy and SES in some of the Nordic countries. The Nordic countries are in general often perceived as countries with high levels of equality. Based on this, one would anticipate that the relationship between SES and the levels of scientific literacy would, in international terms, be weak in these countries. The results from PISA do not fully support such a picture. In some of the Nordic countries there are surprisingly strong relationships between students' scientific literacy and their overall SES. In the case of Norway, the strength of the relationship between cultural capital and students' scientific literacy is close to the

OECD average. The same holds true for social capital. There are several other countries with weaker relationships. The relationships between economic capital and students' scientific literacy found in the Nordic countries, however, are among the weakest in the participating countries. It should also be mentioned that in Finland and in Iceland the relationship between scientific literacy and sociocultural capital is relatively weak, much weaker than in the OECD on average and in Norway and in Denmark.

In addition, the analysis shows that in the Nordic countries the process dimension of scientific literacy is somewhat more strongly related to overall SES than the product dimension. This is particularly the case in Norway. The main reason for this difference is the fact that the process dimension is more strongly related to cultural capital than the product dimension. The Nordic countries further show surprisingly strong relationships between learning strategies and socio-economic background. However, it has to be underlined that the data on the learning strategies were based on students' self-reports only and do not necessarily reveal their real behaviour.

What do these findings mean for science education in the Nordic countries? If we anticipate that the main resource for students' scientific literacy is science classes in schools, science education in several of the Nordic countries seems to be better adapted to students from homes with high cultural capital compared to students from homes with low cultural capital. An unequal distribution of scientific literacy between different groups in the population can be a serious problem for a democracy. An important question arises: how can we in science education better meet the needs of students from home cultures that are not consistent with school culture?

Aikenhead (1996) argues that science itself is a subculture of western or Euro-American culture. Scientists share a well-defined system of meanings and symbols, by means of which they interact socially. This system was institutionalised in Western Europe in the seventeenth century and became a predominantly white male middle-class western system. Science has norms, values, beliefs, expectations and conventional actions that are generally shared in various ways by communities of scientists. The subculture of science has been characterised as mechanistic, materialistic, mathematically idealised, objective, impersonal, rational, etc. Closely aligned with the subculture of science, school science expects a student to acquire the norms, values, beliefs, expectations and conventional actions of science (i.e. the subculture of science) and make them a part of his or her personal world to a varying degree. In this way, Aikenhead introduces school science as a subculture of the general school culture.

According to Bourdieu's (1977, 1984) theories, lack of cultural capital at home creates a distance between students and academic or school culture. Aikenhead also recognises this mechanism, but suggests a further differentiation concerning school culture by introducing the concept of 'the subculture of school science'. Costa (1995) gathered qualitative data from 43 high school students enrolled in chemistry or earth science at two schools with diverse student populations. She concluded that although there was great variety in the students' descriptions of their worlds and the world of science, there were also distinctive patterns among the relationships between the students' worlds of family and friends and their success at school and in the science classroom. Costa described these patterns in terms of five categories.

1. *Potential scientists*: The worlds of family and friends are congruent with the worlds of both school and science.
2. *Other smart kids*: The worlds of family and friends are congruent with the world of school but inconsistent with the world of school science.
3. *'I don't know' students*: The worlds of family and friends are inconsistent with the worlds of both school and science.
4. *Outsiders*: The worlds of family and friends are discordant with the worlds of both school and science.
5. *Inside outsiders*: The worlds of family and friends are irreconcilable with the world of school, but are potentially compatible with the world of science.

Aikenhead (2001) proposes an additional category to Costa's 5-category scheme: 'I want to know' students. These are students who are just as interested in science as Costa's potential scientists but who find school science somehow intimidating, though not as intimidating as Costa's 'I don't know' students. According to Aikenhead, this sixth category can be described as follows:6. *'I want to know' students*: Adventurous border crossings that lead to a modest yet effective understanding of science (there are hazards, but students want to know). Their self-image and lifestyle resonate with the world of science, but the intelligibility, plausibility, or fruitfulness of western science concepts is often a challenge to them (p. 186).

The mechanisms at work can be formulated as follows: congruent worlds support smooth transitions between the cultures, different worlds require transitions to be managed, diverse worlds lead to hazardous transitions, and highly discordant worlds cause students to resist transitions, which therefore become virtually impossible. However, it is interesting to note that even though the subculture of science has been characterised as Euro-American, Japanese, Korean and Hong Kong students scored very high on the PISA science test, higher than most European and American students. The Euro-American flavour of the subculture of science does not seem to negatively influence East-Asian students' learning of science. The explanation for this may be complex, but strong motivational factors might play a major role for these students. Another interpretation might be that the Euro-American flavour of science is not that significant for these students after all.

Several scholars have argued that science should be taught embedded in a social and technological milieu that has scope and force for students' worlds, worldviews or practical experiences and that there is a need to dismantle barriers between students and school science (Layton *et al.*, 1993; Costa, 1995; Cobern, 1996). Aikenhead (1996) argues that a cultural perspective in science education recognises conventional science teaching as an attempt at enculturation or assimilation; that is, cultural transmission that supports or replaces a person's life-world subcultures. A cultural perspective, in contrast, considers students' experiences with school science in terms of students crossing borders from the subcultures associated with their peers, family, the media and the school into the subcultures of science and school science. Science instruction becomes a cross-cultural event for many students.

Aikenhead (1996) argues that if students are going to cross the border between everyday subcultures and the subculture of school science, border crossings must be explicit and students need some way of signifying to themselves and others which subculture they are engaging with at any given moment. A legitimate question posed in a science classroom would be, 'What subculture are you talking now?' Aikenhead suggests a technique whereby the student divides a page in the notebook in half, labelling the left-hand column 'my idea' (personal knowledge of an event or explanation from the point of view of one of the student's life-world subcultures, and using the language of this culture) and the right-hand column 'subculture of science' (canonical knowledge using appropriate scientific language).

The empirical results presented here underline the relevance of a cultural approach to science education in the Nordic countries. The results show that the question as to how to motivate and meet the needs of students from families with lower levels of cultural and social capital is important. In a country such as Norway this is of special consequence in relation to the process dimension of scientific literacy. The results also show that it is important to focus on developing these students' repertoire of learning strategies since they are critical to the future development of students' scientific literacy, both in further education and in a lifelong perspective beyond formal schooling. For several years, there has been a strong focus in science education research on how to motivate girls to learn science, not least in the Nordic countries. The results presented in this article show that there is also a need for a special focus on students from lower socio-economic backgrounds. In scientific literacy, differences in achievement between students with high and low cultural and social capital are much larger than they are between the genders.

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