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Science curriculum in Nordic countries and PISA

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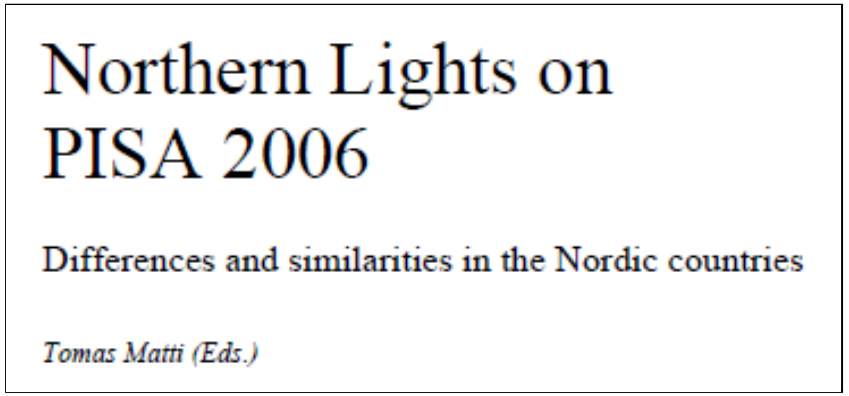
The content of the presentation

- PISA 2006 Scientific Literacy Assessment:
  Some examples of the data

- Analysis of *science curricula for compulsory schools* in the Nordic region from the point of view of the
  PISA 2006 framework.

- The analyses of National level curriculum were done by one expert in each Nordic country based on the agreed guiding questions.



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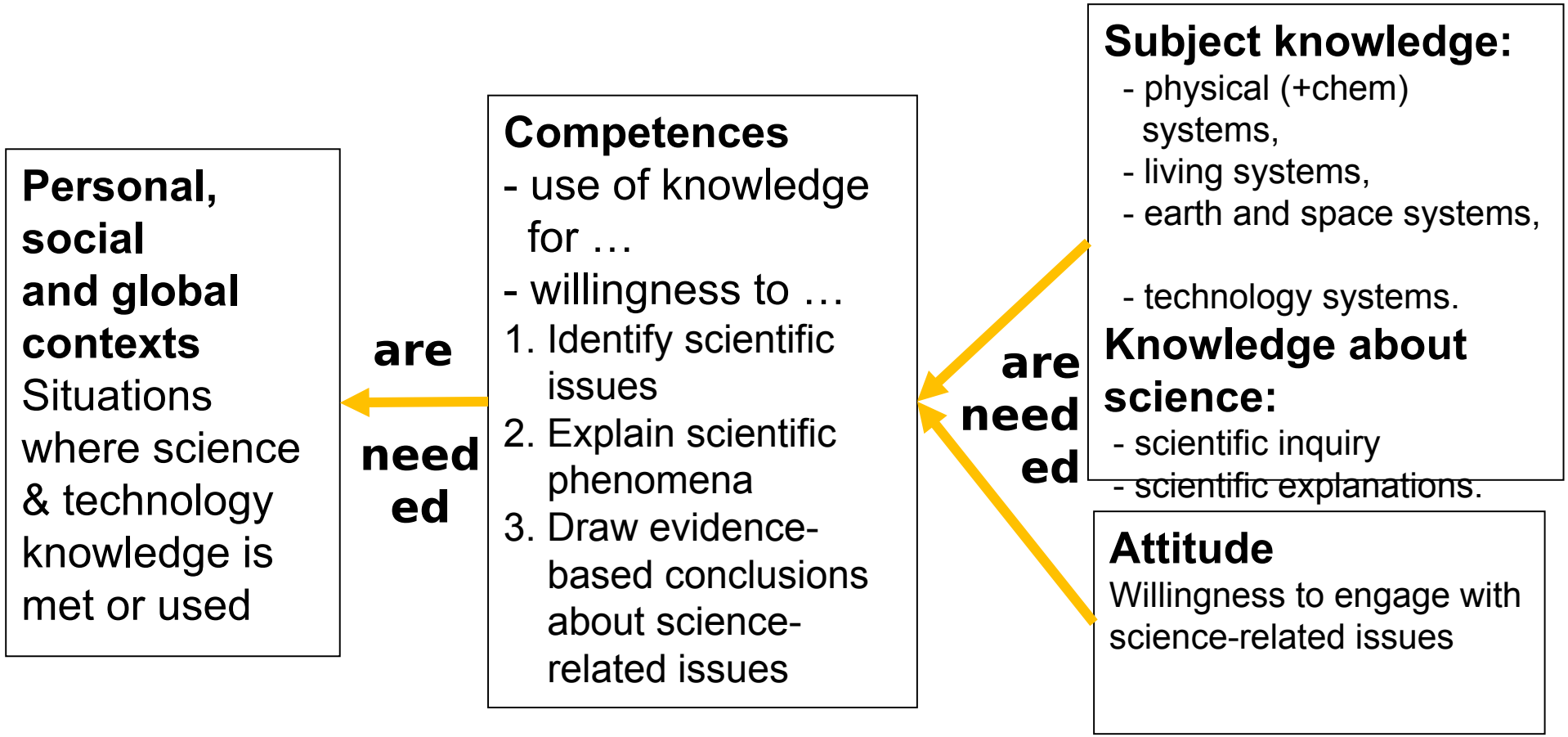
PISA 2006 Scientific Literacy Assessment: Some Examples of the Data

PISA Science Literacy, According to PISA framework

(What citizens should know ? - life-long-learning capacity – Asking not, what we should teach)



Frame for PISA 2015?

Personal, social and global contexts
Situations where science & technology knowledge is met or used

working life
(focus: STEM)

are needed

Competences
- use of knowledge for …
- willingness to …

1. Identify scientific issues (recognise , identify problems)
2. Explain scientific phenomena (argumentation)
3. Use of scientific knowledge for explaining (**problem-solving**: combine already known (concepts and) ideas to create something new, (decssion making)

are needed

Subject knowledge:
- physical **(+chem)** systems,
- living systems,
- earth and space systems,
- technology systems.

Knowledge about science:
- scientific inquiry
- scientific explanations
- SSI issues

Interest (situational)
Motivation (fulfillment of basic psychological needs in an activity)
Efficacy

Critical and creative thinking

Communication and collaboration

ACID RAIN - Question 2 (S485Q02)

Below is a photo of statues called Caryatids that were built on the Acropolis in Athens more than 2500 years ago. The statues are made of a type of rock called marble. Marble is composed of calcium carbonate

In 1980, the original statues were transferred inside the museum of the Acropolis and were replaced by replicas. The original statues were being eaten away by acid rain.

Normal rain is slightly acidic because it has absorbed some carbon dioxide from the air. Acid rain is more acidic than normal rain because it has absorbed gases like sulphur oxides and nitrogen oxides as well.

Where do these sulphur oxides and nitrogen oxides in the air come from?

Students' PISA scores in different competence categories and knowledge areas

Identifying scientific issues

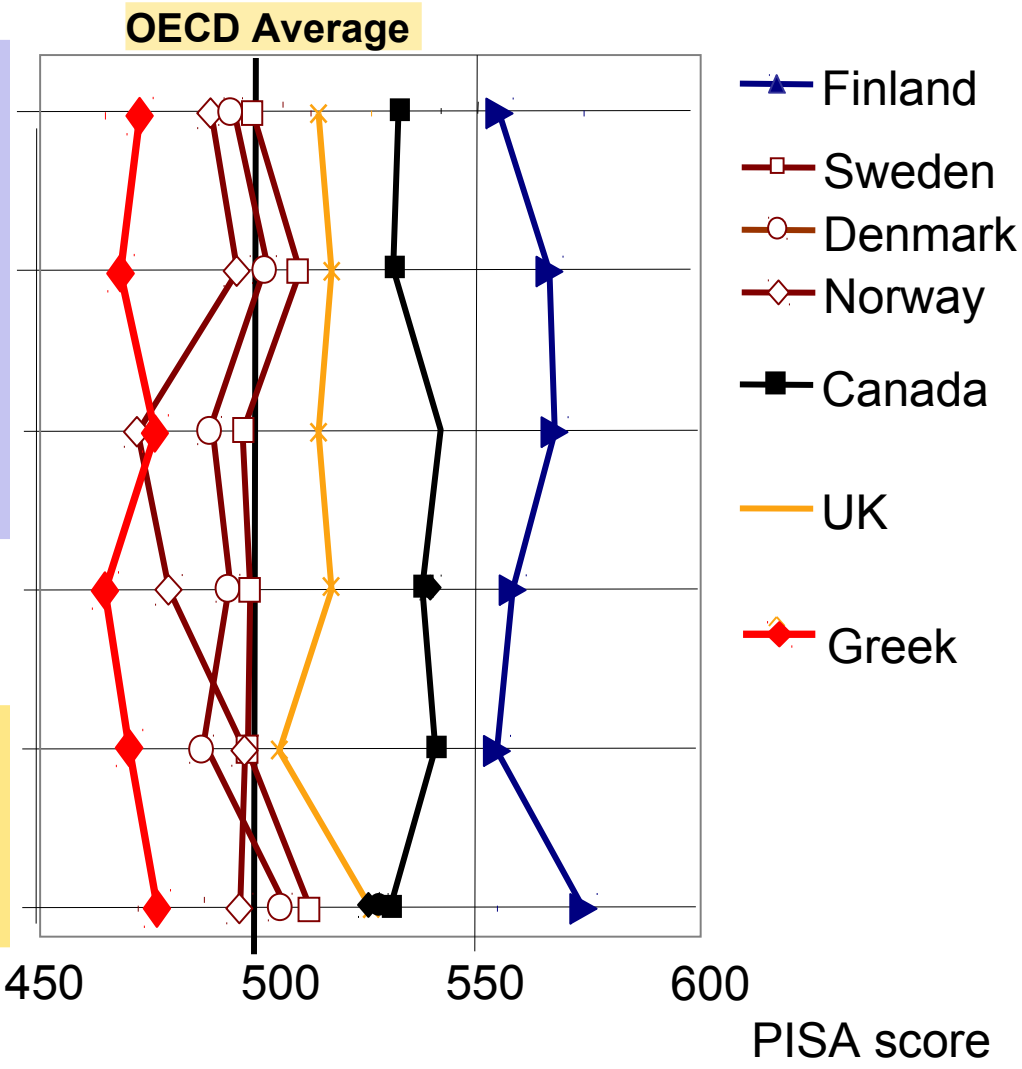
Explaining scientific phenomena

Drawing evidence-based conclusions about science-related issues

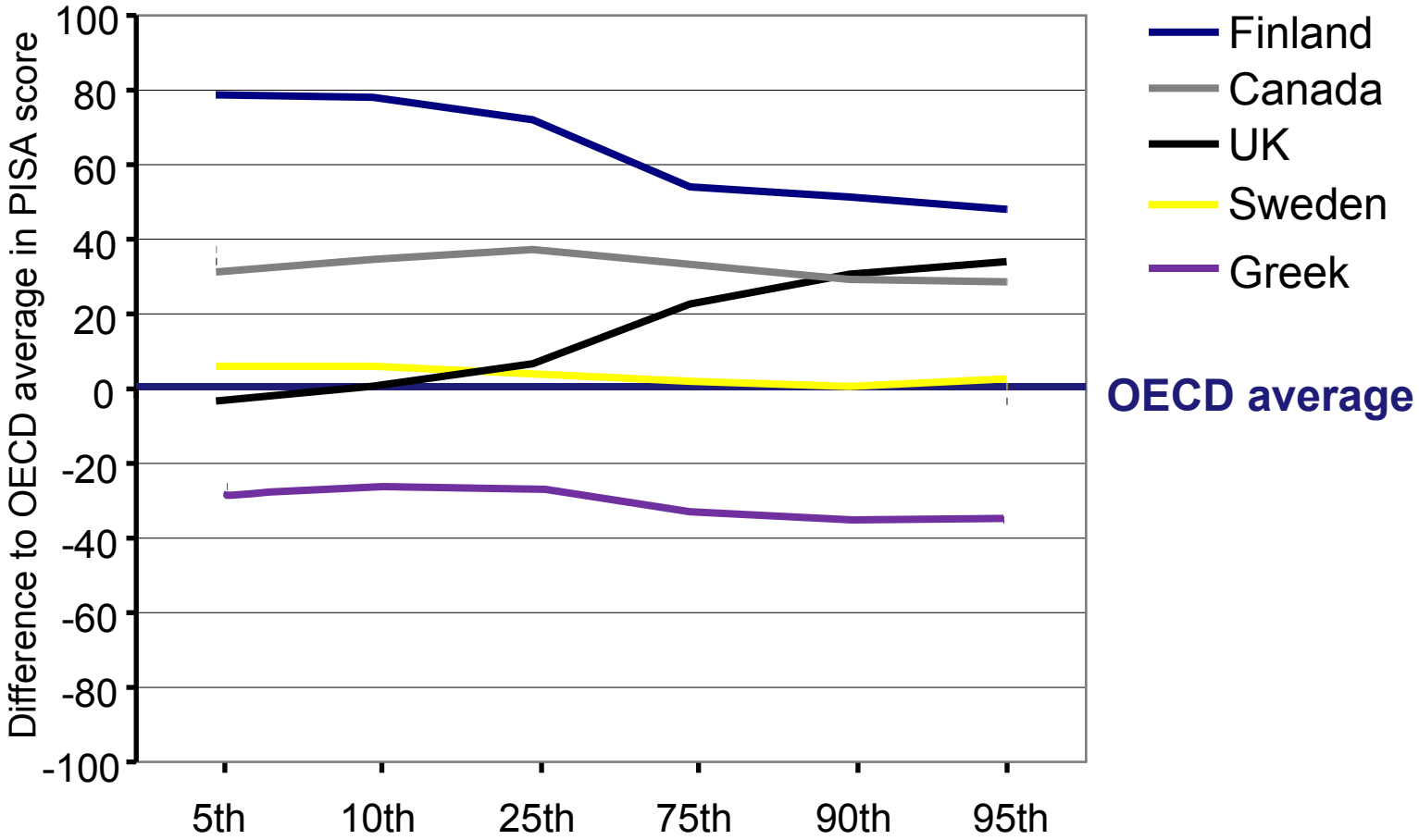
Knowledge about science

Earth and Space

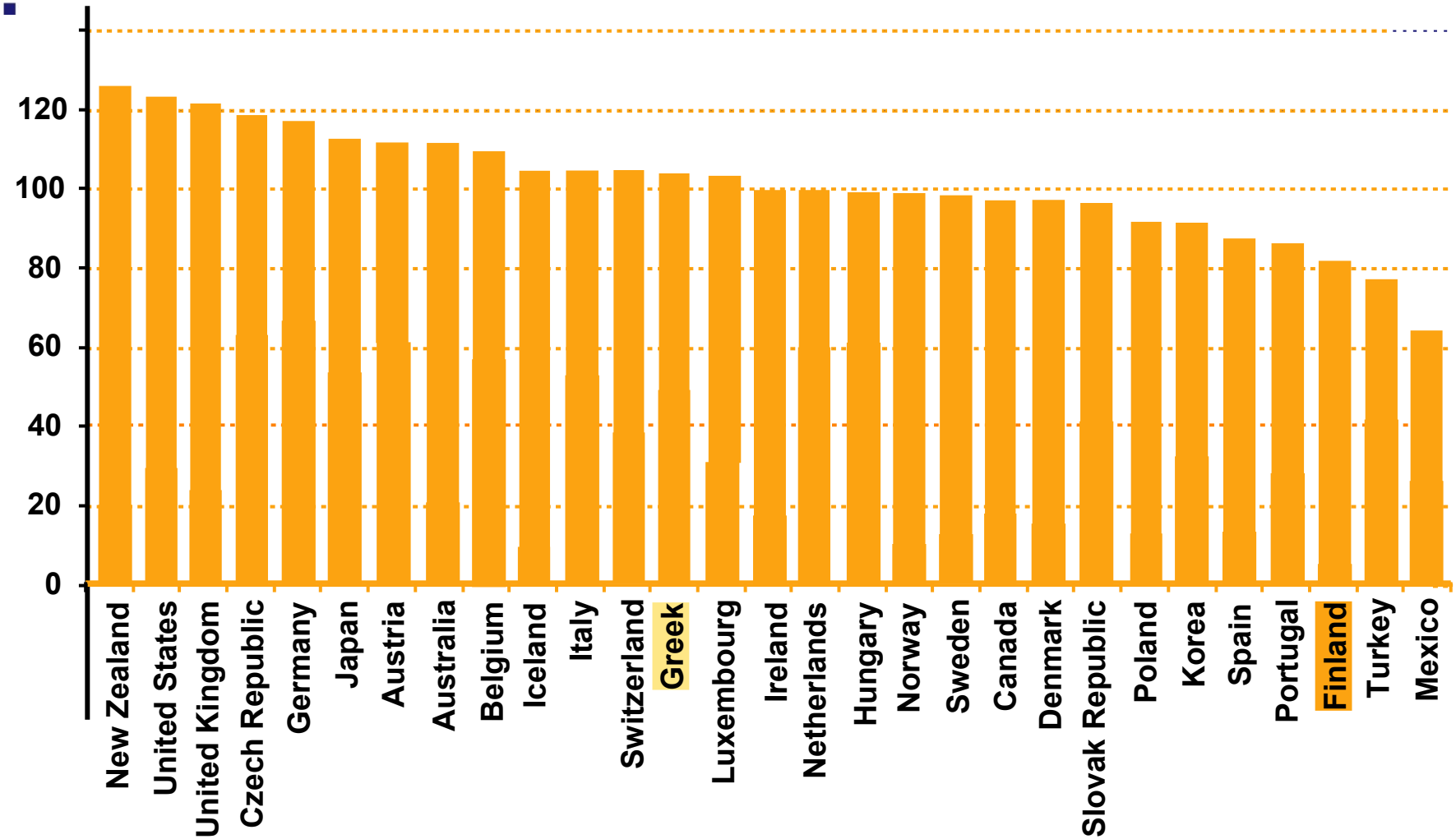
Living systems



Country percentile scores compared to the OECD average percentile scores in PISA 2006 science scale



Variation in student performance in Science



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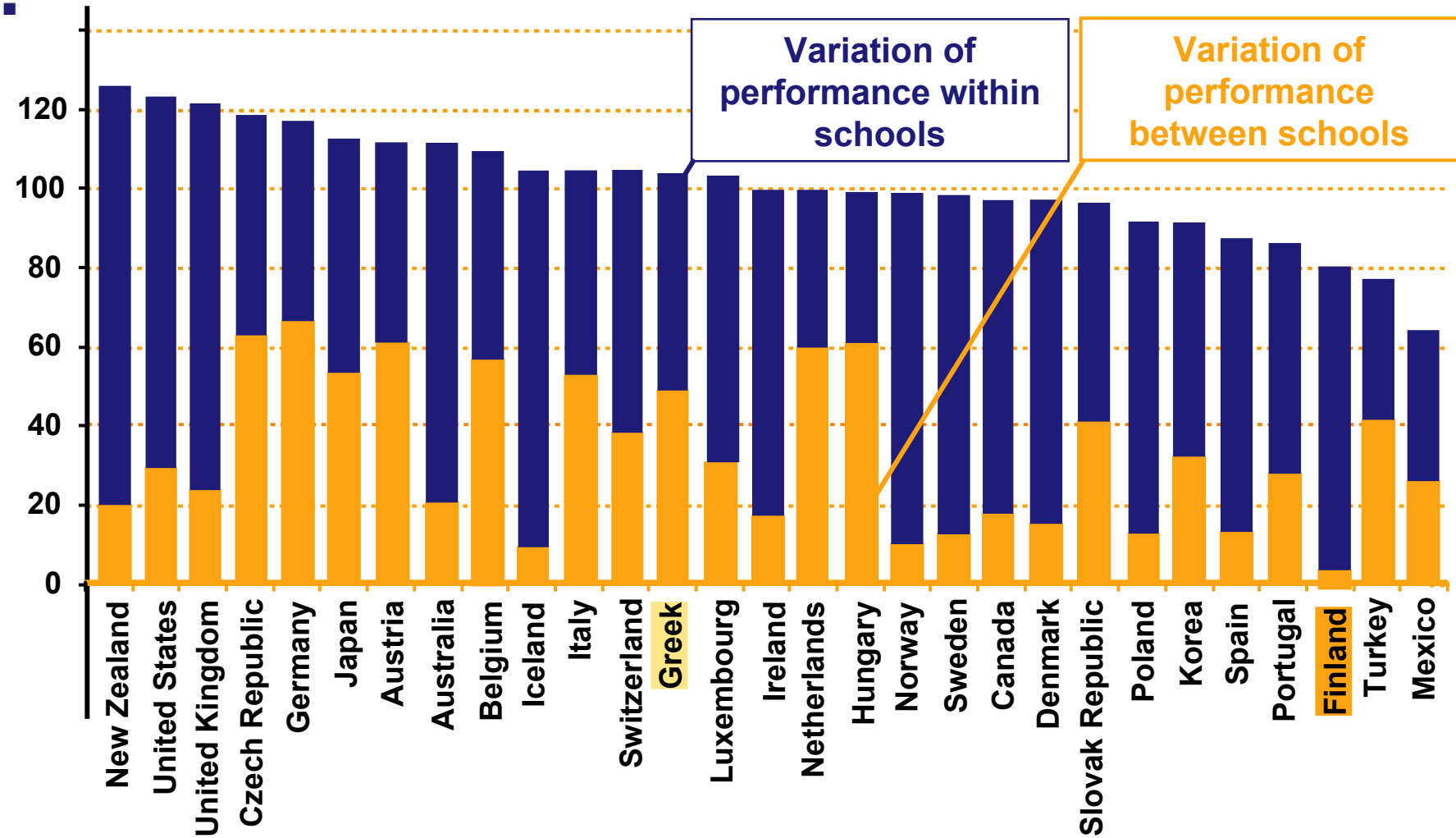

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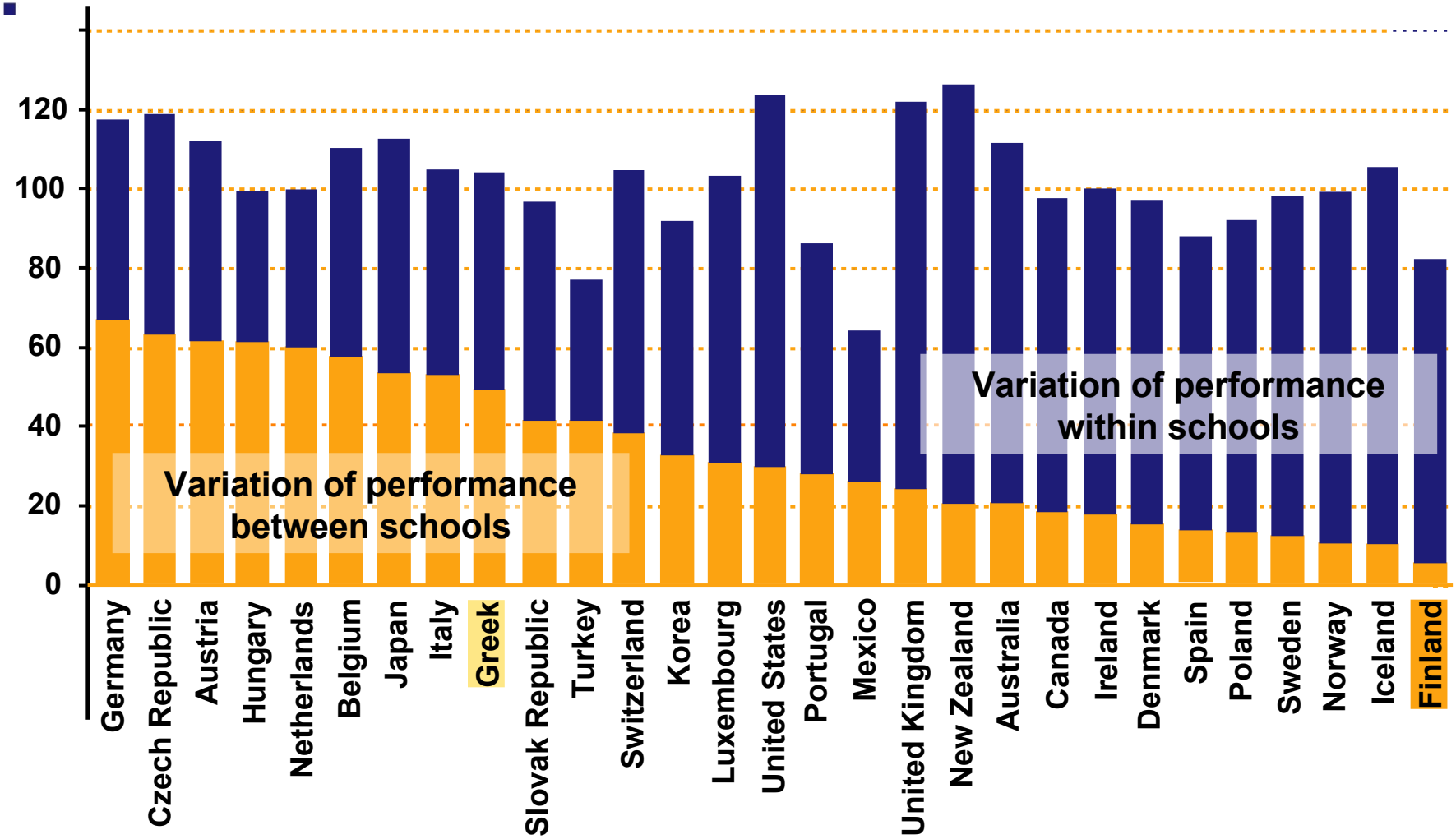

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Comparison of Science curriculum in Nordic countries

Curricular terms

- There are differences in terms used in curric. documents

  -> the translation of the meaning of concepts is not simple
- **Goals** describe the overall purpose of a subject or a course, are typically broad and abstract. They indicate general intentions and are not easily validated.
- **Aims** (objectives) break down goals into measurable behaviors that demonstrate competency.
- **Objectives** are stated in narrower, precise, concrete and measurable terms and are always stated in terms of what the learner should know or be able to do.
- **Learning outcomes** are statement of what a learner is expected to know, understand or be able to do at the end of a learning sequence
- **A syllabus** means a description of the topics or main content of a subject or a course.
- **Standards** are statements of what students are expected to know and be able to do or have attained by the end of a course or compulsory school.

Different approaches to the quality of teaching and learning

”Outcome based” –approach

- Quality control in industry (behavioristic, Mager, 1984)
- Focus on product
- National level assessment

- ”Learning outcomes” descriptions (+):

- enable learners to have an active role in the learning process alongside their teachers
- easy to construct items for assessment

- Problems (-):

- competitive school culture, ranking
- ”teaching to the test”
- all aims are not taken into account (inquiry) (Sturman, 2003)

- UK ,US (EU is emphasising towards learning outcomes)

”Aims” –approach

- “Didactical” model (constructivistic)

- Focus on process and product
- Assessment in the level of school and classroom (teacher)
- Aims, goals:

- a teacher and students are perceiving what they should teach/learn
- all aims are taken into account (+)
- a teacher is actively using assessment data in guiding the process (+)

- Problematic to discuss about learning outcomes in a national level (comparison, selection) (-)
- Recent research supports this model (Black & Wiliam, 2003; Inbar-Lourie & Donitsa-Schmidt, 2009)

PISA competences

- PISA 2006 emphasises science competencies, defined in terms of an individual's Scientific knowledge and *use* of that knowledge to…
  - … **identify scientific issues,**
  - … **explain scientific phenomena, and**
  - … **draw evidence-based conclusions about science-related issues**

≈ competences essential for future life

National level curriculum in Nordic region

- General part:
  - goals for education in compulsory school, like growth to ethically responsible membership in society
  - values curriculum is based on
  - knowledge and skills necessary in life and for life-long learning (PISA)

- National level guidelines for each school subject
  - goals/aims of the subjects
  - short description of subjects

General Goals for Learning in the Finnish Core Curriculum

- *… learning depends on the learner's previously constructed knowledge, motivation, and…*

  … learning is an active and goal-oriented process

  … collective problem-solving

  … Learning is situational,

  …

National level and local curricula

- In all countries local municipalities (FI, DK) or individual schools (DK, IS, NO, SE) establish a local curriculum based on national level guidelines (framework curriculum).
- Students have the option of choosing courses or school subjects, especially during the last years of compulsory schooling.
- However, there are differences in Nordic region

- In Iceland the 1999 national curriculum allowed up to 30% of the school week to be devoted to optional subjects in grades 9 and 10.

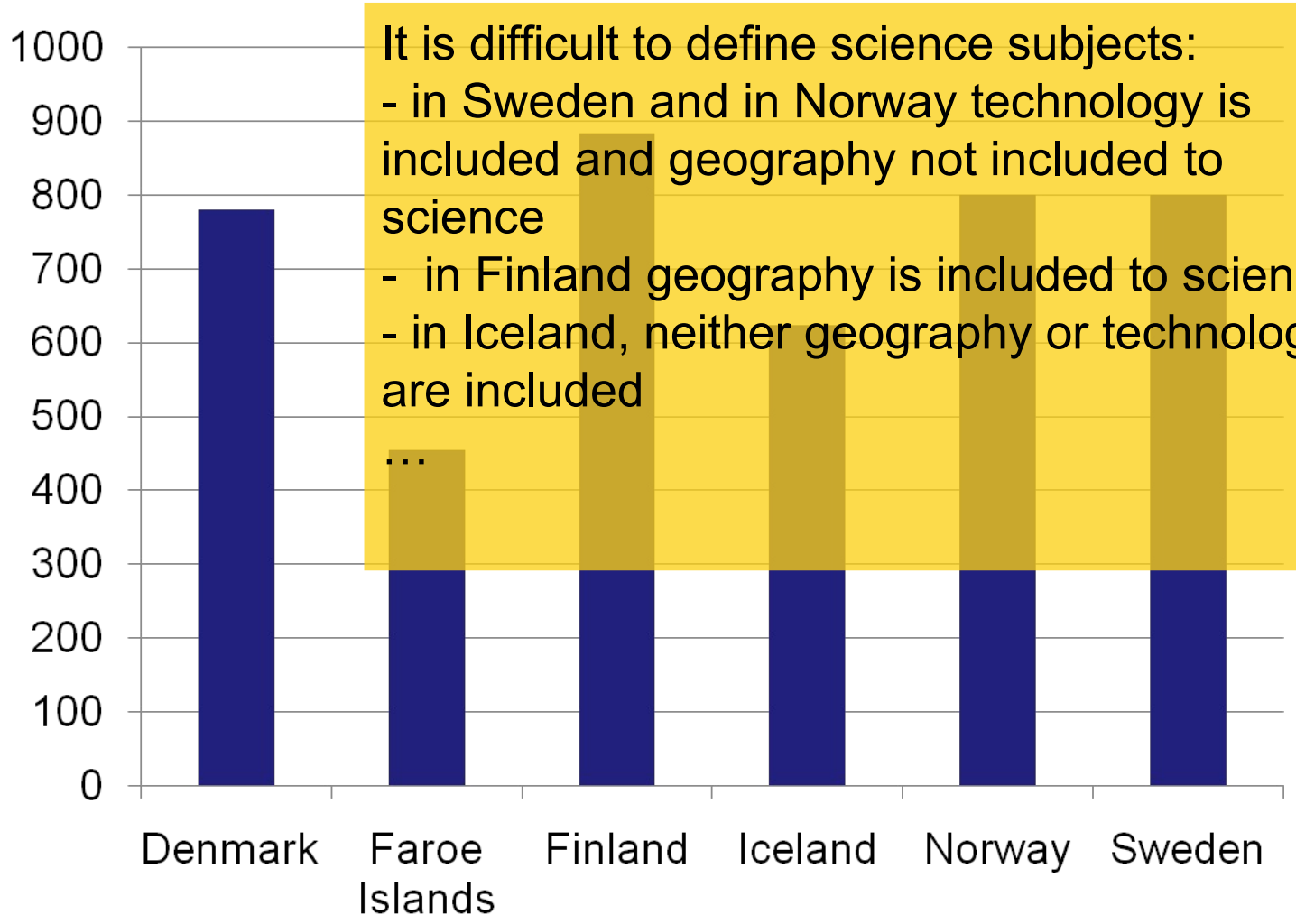
Teacher competences

- In Finland a teacher has completed undergraduate studies in the particular subject (e.g. physics).

- In other countries, the student teachers take fewer courses in subjects they are teaching.
  - In Iceland fewer than 40% of those teaching science have been trained as science teachers.
  - In Norway the teachers of science have little specific education within science.

  - Teachers tend to spend little time on science subject matter in their instruction.

Hours of science subjects in compulsory school



It is difficult to define science subjects:
- in Sweden and in Norway technology is included and geography not included to science
- in Finland geography is included to science
- in Iceland, neither geography or technology are included
…

Allocation of science subjects to grades in comprehensive school in Finland

Grade	1	2	3	4	5	6	7	8	9
Student's age	7	8	9	10	11	12	13	14	15
Level	primary school						lower secondary school		
Comprehensive school, Basic education									
Science subjects	*Integrated* environmental and natural studies *Altogether 9 hours/week/4years = 2.25 hours/week/year*				*Integrated* Biology and geography *1.5 hours/week /year* *Integrated* Physics and chemistry *1 hours/week/ year*		*Separate* Biology *1.2 hours* Geography *1.2 hours* Physics *1.2 hours* Chemistry *1.2 hours* */week/year* Health education *1 hours/week/year*		
Compulsory/ Optional	C								

Integrated science or seprate science subjects?

- In Finland
  - science subjects are separated at grades 7 – 9;
  - even at grade 5 and 6, separate *physics and chemistry* and *biology and geography*
- In Denmark and in Faroe Islands science subjects are partly separated at grades 7-9
  - goals for physics and chemistry are combined
  - biology and geography are taught separately.
- In Sweden a school can decide: seprate or integrated (The majority teach science subject separately)
- In Norway, all schools teach integrated science.
- In Iceland science is divided into earth sciences, life sciences and physical sciences

Goals for science

- In Finland
  - goals and content of the subjects (syllabus) are structured in clusters of grades (1-4, 5-6 and 7-9).
  - descriptions of students' achievements (standards) at the end of the 4th, 6th and 9th grade.
- The Swedish curriculum list two types of aims: the aims that guide school operations towards achieving the goals of compulsory education ("the goals to strive towards"), and the aims that define the minimal expected outcomes upon completion of the compulsory segment, expressed as the knowledge, skills, values and attitudes students are expected to have developed ("goals to be attained").
- Danish, Faroese, Icelandic and Norwegian national level curricula give a summary description of science, indicating the goals and common structural elements of science for the whole of compulsory education and the goals for individual educational cycles, for example, grades 1-4, 5-7, 8-10 in Norway and Iceland, expressed in terms of outcomes and in Denmark goals for outcomes are described after six, and year nine..

Nature of a teaching/learning process in Finnish national science curriculum

- The purpose of science education is to help the students
  (i) to perceive the nature of science;
  (ii) to learn new concepts, principles, and models;
  (iii) to develop skills in experimental work and
  (iv) cooperation; and
  (v) to stimulate the students to study science (interest).

- the role of a teacher is emphasised in the process.

Differences with the level of detail in a syllabus

- In Denmark a syllabus does not exist
- In Finland there is a syllabus for each separate science subject, physics, chemistry, biology and geography for grades 5-6 and for grades 7-9.
- In Sweden and Norway important concepts are listed in the syllabus.
- In Iceland an effort was made to develop the complexity of topics or concepts across the three phases.

PISA competencies in science curricula 1

- "*Identify scientific issues*" can be found in various forms:
  - to recognise
  - to observe
  - to formulate a question
  - to acquire knowledge
  - to look for information

PISA competencies in science curricula 2

- "*Explain scientific phenomena*" can be seen in the following expressions:
  - to interpret
  - to apply knowledge
  - to test a hypothesis
  - to use various graphs and algebraic models in explaining

PISA competencies in science curricula 3

- "*Draw evidence-based conclusions*" can be found in various forms:
  - to make conclusions
  - to formulate simple models
  - to make generalisations
  - to provide capabilities for making everyday choices

Science content described in the national level curricula

- In some Nordic countries the contents is presented as goals and in others as lists of important concepts and topics (syllabus).
- Similarities with p*hysical systems* and *living systems*, such as the structure and properties of matter, chemical reactions, waves, electricity, motion and forces, energy and its transformation, basics of astronomy, cells, the human being, animals and plants around us, populations and ecosystems

Science content described in the national level curricula 2

- In addition, there are a number of content areas which are classified as being part of
  - geography in Finland,
  - social science in Sweden,
  - science and geography in Iceland
  - in physical education and food and health in Norway,

  such as energy resources and energy, raw materials and trade, flow, structures of the Earth's systems (lithosphere, atmosphere, hydrosphere), changes in the Earth's systems, and the Earth in space

Technology systems as a content area in PISA 2006

- In Denmark and in Sweden use of technology in science is part of the national curriculum
- In the Icelandic curriculum technology is addressed more as a process than a product, in a separate curriculum on *Information and technology education*.
- In the Finnish and Icelandic curriculum, there is surprisingly little discussion about technology or about science and technology in daily life, one of the key features of the approach used in PISA.
- This means that issues concerning how physics and chemistry knowledge is applied in technology and health care, in solving environmental issues, in everyday life and with regard to sustainability, were not necessarily part of the material being studied by students taking the PISA 2006 test.

Knowledge *about* science in PISA framework

- The PISA framework identifies two categories of knowledge *about* science:
  - "scientific enquiry" and
  - "scientific explanations".
- In Nordic region, there are several examples of goals in both categories. In particular, the asking of scientific questions, models and modelling, taking measurements, observations and investigations belongs to the first category; whereas, presentation of types of scientific explanations (hypothesis, scientific law, model, and theory), formation of knowledge and outcomes of research (new knowledge, new methods, new technologies, new investigations), belong to the second category.

Finland:
Examples of goals for learning scientific method; ontological and epistemological issues :

The pupils will learn in physics and chemistry:

- scientific skills, such as the formulation of questions … ,
- to process, present and interpret results,
- to carry out simple scientific experiments
- …

Examples of contents of "physical systems":

- natural structures and proportions (grades 7 – 9),
- motion and forces, models of uniform and uniformly accelerating motion (grades 7 – 9) ,
- …

The OECD definition of scientific literacy fits well with the goals and contents for science education in Finland

Conclusions

- Diversity in representation of curriculum in Nordic countries
- Main similarities
  - There is compatibility between goals for science education and contents described in the national level curriculum documents in Nordic region and the competencies described in the PISA 2006 framework
  - Number of lesson hours in science
- Main difference between Finland and other Nordic countries:
  - Finnish teachers are educated in 5 year master level programmes
  - Heavy subject orientation in Finland (emphasis also to epistemological and ontological issues)

DeSeCo, …

Categories	Information, Knowledge, Skills, Competencies, Attitudes, Contexts
Information and Knowledge	- Multiple sources of information (text, picture, graph, table, animation, net, nature) - Meanings of concepts and network of concepts, broad literacy - Knowledge, nature of knowledge
Ways of thinking	- Critical and creative thinking and competence to use both in problem-solving and decision making - Use of knowledge and information interactively - Learning to learn, use of metacognition
Ways of working	- Identifying issues (questioning), making conclusions based on information, explaining phenomena, organising information - Creative problem-solving - Communication and collaboration (team work) - Managing and resolving conflicts
Tools for working	- Scientific literacy: knowledge (network of concepts), nature of knowledge, - Broad literacy incl. history and arts, ICT literacy - Research making skills (critical thinking), skills for generating alternatives - Moral and ethical code
Context	Persona, social, global, working life (focus: STEM),
"Attitude"	Willingness to engage; self-efficacy; situational interest, motivation (activity)
Living in the world	Citizenship – local and global; Life and careers; Natural resources – Human resources; Personal and social responsibility;

Thank you!