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Reasons behind Finnish students' success in the PISA Scientific Literacy Assessment

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Structure of the presentation

1. Some PISA 2006 Scientific Literacy Assessment data
2. Education policy in Finland
3. Finnish comprehensive school
   - Structure of the comprehensive school
   - Goals for science education
   - Science teacher education
   - How science is taught in Finland (evaluated by the students)
4. Summary and comparison of Finnish approach to some other approaches in Europe

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PISA 2006 Scientific Literacy Assessment

Framework for PISA 2006 Scientific Literacy Assessment

- The PISA 2006 assessment emphasizes 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**
  - Understanding of science as a form of human knowledge and enquiry
  - Awareness of how science and technology shape our material, intellectual and cultural environments
  - Willingness to engage with science-related issues
- A large proportion of complex open-ended tasks which can be classified in several ways.

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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

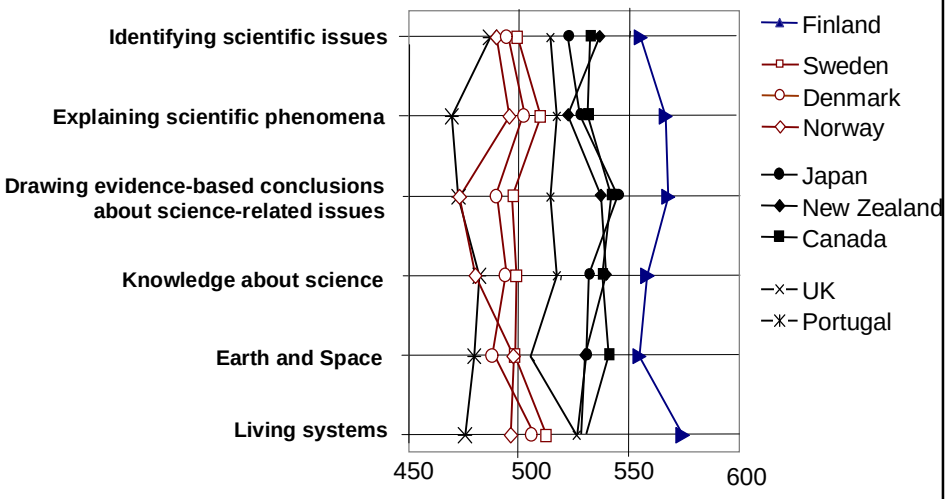
In 1980, the original statues were transferred inside the museum of the Acropolis and were replaced by replicas. The original statues were being eaten away by acid rain.
Normal rain is slightly acidic because it has absorbed some carbon dioxide from the air. Acid rain is more acidic than normal rain 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?

_____

_____

5

Students' PISA scores in different competence categories and knowledge areas



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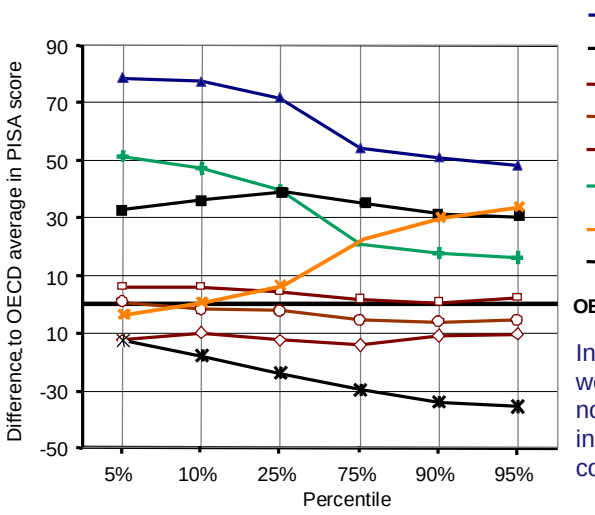
Country percentile scores compared to the OECD average percentile scores in PISA 2006 science scale



In Finland the weak pupils are not so weak than in other OECD countries

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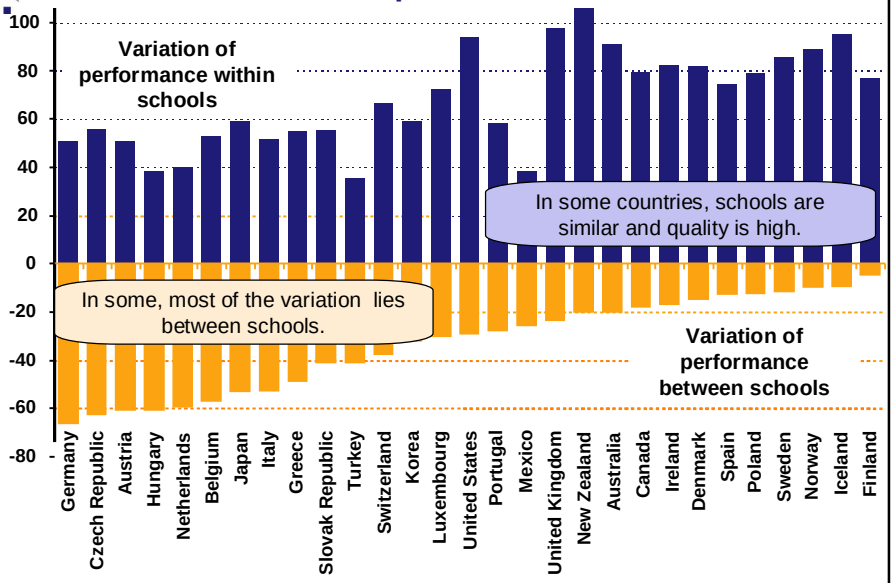
Variation in student performance in Science



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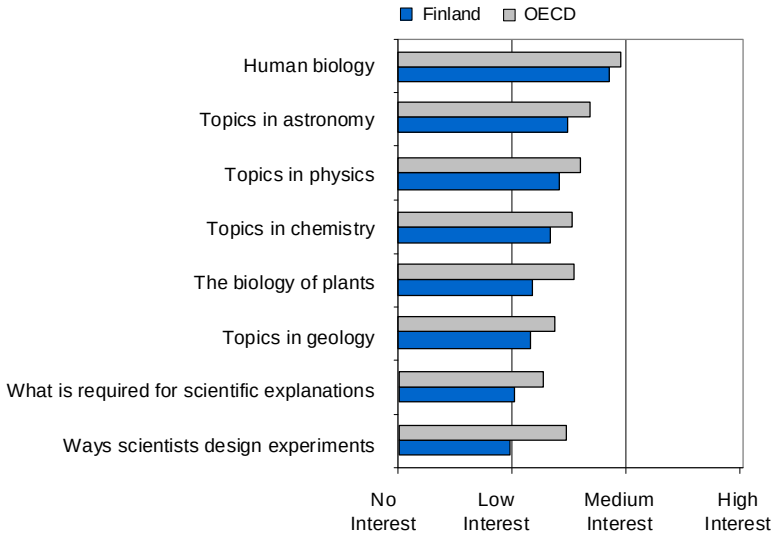
Students interest to learn about science topics.



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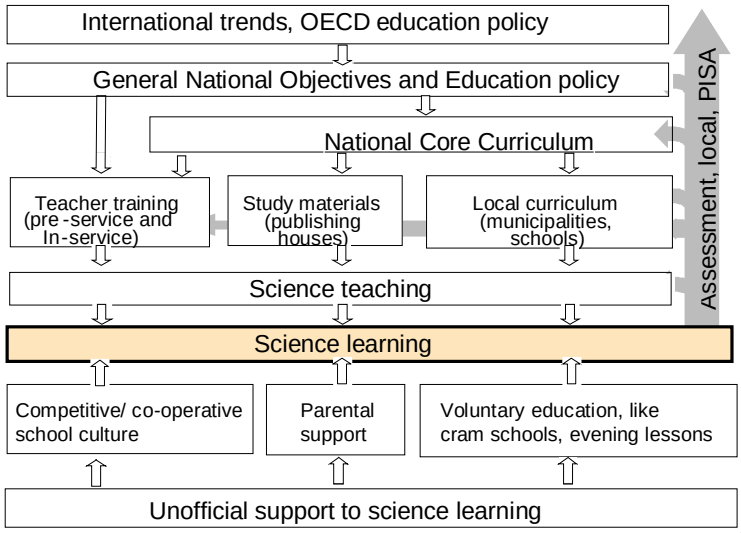
Education policy in Finland

Finnish Education Policy



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Main cornerstones of the education policy (can be found in policy documents)

1. Common, consistent and long-term policy
2. A broad commitment to a vision of a knowledge-based-society (parents, employers' and labour organisations)
3. Educational equality (comprehensive school free of charge to all, including books, meals, transport and health care; well-organized and effective special education).

According to *PISA School Questionnaire data*

- 97.1% of the schools are public schools (OECD: 82.7%).
- More than 97.5 % of the schools reported that more than 99% of the funding came from the government.
- 64.3% (33.3%) of the schools reported that students were not grouped by ability into different classes in any subject

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Main cornerstones of the education policy

5. Devolution of decision power and responsibility at the local level (local authority can levy taxes, plan local curriculum; organise general assessment and use this data for evaluating educational policy).
6. The culture of trust (no inspectors, no national exams …)

According to *PISA School Questionnaire data*

- in 65.3% of the schools a principal teacher formulates the school budget (53.2%)
- in 96.0% of the school, principal teacher and teachers are responsible for disciplinary policy (80.5%)
- in 97.0% of the school, principal teacher and teachers are responsible for assessment policy (76.9%)

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Comprehensive school in Finland

The Finnish education system

- The Finnish education system consists of
  - comprehensive school (grade 1 – 9),
  - upper secondary school or vocational school (grade 10 – 12),
  - higher education (3 + 2 years) and
  - adult education.

- In 2006, there were 3393 comprehensive schools and 578 918 students in those schools (Tilastokeskus, 2007).
- 53.3% of the students continued their studies in upper secondary school and 41.8% in vocational schools
- According to *PISA 2006 School Questionnaire data*, there were in 49.9% of the classes less than 20 students and in 47.4% of the classes there were 21 – 25 students.

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Allocation of science subjects to grades in comprehensive school

Grade	1	2	3	4	5	6	7	8	9	10	11	12
Students' age	7	8	9	10	11	12	13	14	15	16	17	18
Level	primary school						lower secondary school			upper secondary school, high school		
	Comprehensive school, Basic education											
Science subjects	*Integrated* environmental and natural studies *Altogether 9 hours/week/4year = 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*			*Separate*: Biology *2+3 courses* Geography *2+2 courses* Physics *1+7 courses* Chemistry*1+4 courses* Health education		
Compulsory/ Optional	C									C+O	O	

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

- The starting points for science instruction are the students' prior knowledge, skills, and experiences, and their observations and investigations …
- … From these, the instruction progresses towards the concepts and models (Not a discovery approach!)
- 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.

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Examples of goals for learning scientific method:

The pupils will learn in physics and chemistry:

- scientific skills, such as the formulation of questions … ,
- to make observations and measurements,
- to look for information on the subject of study,
- to make, compare, and classify observations, measurements, and conclusions;
- to present and test a hypothesis,
- to process, present and interpret results,
- to formulate simple models, to use them in explaining …,
- to make conclusions about their observations and measurements and recognize the causal relationships associated with the properties of natural phenomena
- to carry out simple scientific experiments clarifying the properties of phenomena.

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Examples of contents of physical systems:

- producing heat, light (grades 5 – 6),
- motion and equilibrium due to forces (grades 5 – 6),
- natural structures and proportions (grades 7 – 9),
- motion and forces, models of uniform and uniformly accelerating motion (grades 7 – 9) ,
- various basic phenomena of vibrations and wave motion; production, detection, observation, reflection, and refraction of wave motion (grades 7 – 9),
- interpretation of chemical reaction equations and the balancing of simple reaction equations (grades 7 – 9),
- composition of air; the atmosphere (grades 7 – 9),
- properties of water and its importance as a solvent; investigation of natural waters; water purification (grades 7-9).

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PISA 2006 framework for scientific literacy

- … 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 the changes made to it through human activity. …
- The OECD definition of scientific literacy fits well with the goals for science education in Finland

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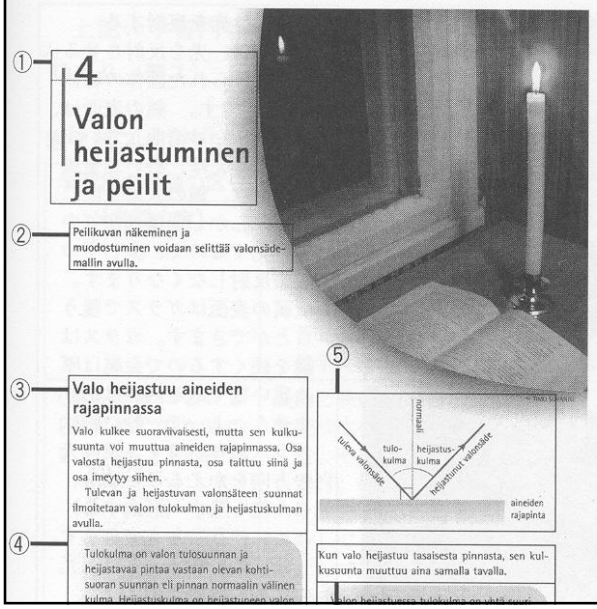
Textbooks?

写真 2 ■物理教科書「光の反射と鏡」（1）



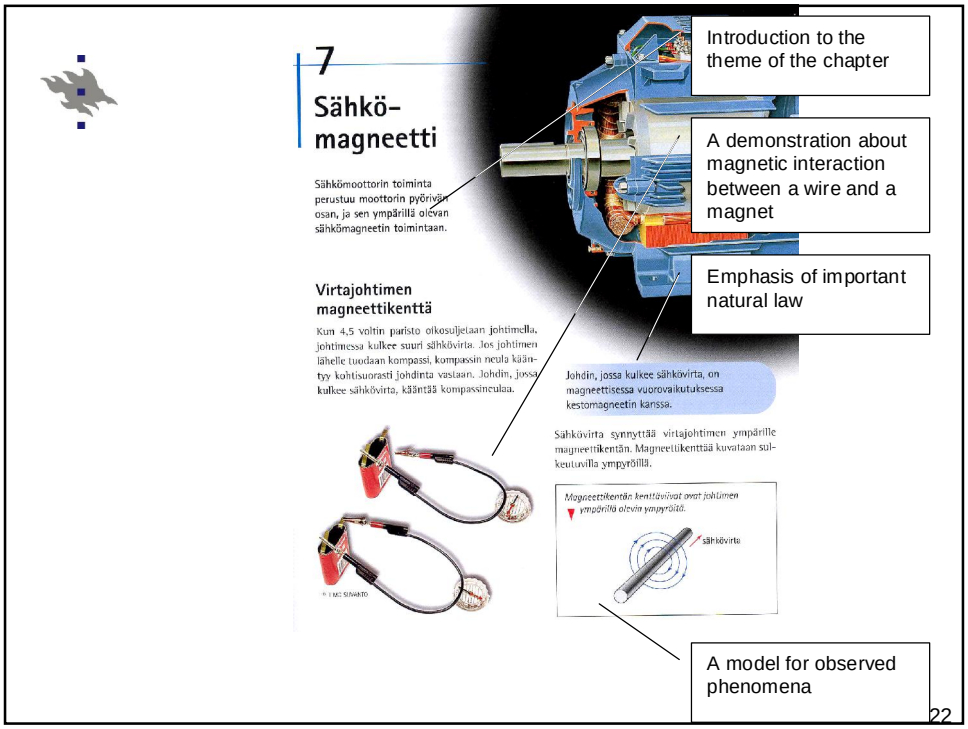
■日本語訳

① 4 光の反射と鏡

② 鏡に映った像を目で見ることや、それがどこかに実際投影されて見えるという現象は、光の反射によって説明することができます。

③ 光は物質の境界面で反射します。
光は直進しますが、その光の進む方向は、物体の境界面によってかえることができます。 光線の一部は、その表面で反射し、一部は屈折し一部は吸収されます。入射また反射する光線の方向は、それらの入射角と反射角によって知ることができます。

④ 入射角は、入射光とその光が反射する表面に垂直



Introduction to the theme of the chapter

A demonstration about magnetic interaction between a wire and a magnet

Emphasis of important natural law

A model for observed phenomena

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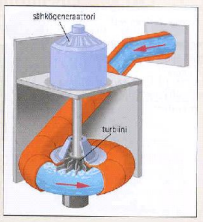
EXTRA

Vedestä energiaa

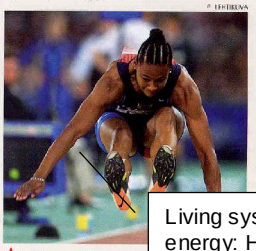
Korkealla vuoristojärvessä oleva vesi on ihmiselle hyödyllisempää kuin sama määrä vettä merenpinnan tasolla. Vuoristossa sijaitsevan järven vedellä on runsaasti potentiaalienergiaa, jos vertailutasona on merenpinta. Potentiaalienergia muuttuu veden liike-energiaksi, kun vesi virtaa alas vuoristosta. Veden liike-energialla voidaan pyörittää turbiinia ja siihen yhdistettyä generaattoria. Generaattori synnyttää sähköä.



Virtaavan veden liike-energiaa käytetään hyödyksi sähkön tuotannossa: virtaava vesi pyörittää turbiinia, joka puolestaan pyörittää generaattoria.

Urheilijat hyödyntävä

Korkeushyppääjät ottavat pi
voisi kuvitella, että vauhti e
seen. Syy vauhdinottoon on
voi muuttaa sekä vauhdinot
energian että ponnistuksessa
gian potentiaalienergiaksi. Pi
vät samoin, ja moni pikajuoksija pitkästä toisesta
lajinaan pituushyppyä.



*Mitä suurempi nopeus, sitä
energia ja pitempi hyppy.*

Kemiallinen energia ja ihminen

Elintoiminnot perustuvat soluissa tapahtuviin energia-aa vapauttaviin prosesseihin. Kasvit sitovat Auringon energiaa yhteyttämisessä valmistamaansa sokeriin. Eläimet eivät sen sijaan pysty sitomaan suoraan Auringon energiaa, joten niiden on hankittava rakennusaineensa ja energiansa joko syömällä kasveja tai toisia eläimiä.

Lähes kaikkien solujen energiahuollon perustana on sokeri, glukoosi, josta energia sii
aa sitoviin molekyyleihin. Näiss
neena kemiallisiin sidoksiin ja he
tarpeen tullen vapautettavissa.

Ihminen tarvitsee energiaa aineenvaihduntaan, liikkumiseen, uusien yhdisteiden valmistamiseen sekä vanhenevien ja tuhoutuneiden solujen korvaamiseen uusilla. Osa energiasta vapautuu lämpöenergiana.

Role of science-based technology: How electricity is produced in a water power station

Living systems and energy: How kinetic energy is transferred.

Chemical energy and human being

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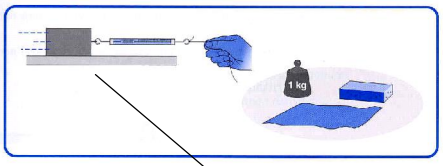
3. Liukukitkatutkimuksia

Välineet

- jousivaaka
- kitkakappale
- punnuksia
- hiekkapaperia
- pyyhe tai talouspaperia



- *Laadi lista seikoista, jotka voisivat vaikuttaa kappaleen ja pöydän välisen kitkan suuruuteen.*

Some ideas how the phenomena will be investigated

Students are asked to think about possible reasons for friction.

Suunnittele, miten tutkisit näitä seikkoja, ja toteuta tutkimukset.

- *Tutkimusten perusteella kitkaan vaikuttavat seuraavat asiat:*

Students are asked to make conclusions based on their investigations.

Students are asked to compare their conclusions and hypothesis.

- *Vertaa ennusteitasi ja tutkimustuloksiasi. Pitikö ennusteesi paikkansa?*

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Science teacher education in Finland

A subject teacher

- typically teaches at grades 7 to 12 (ages 13 to 19)
- is qualified for teaching positions in all kinds of schools in his or her major or minor subject
- teaches typically one major and one minor subjects (e.g. math and physics)

A primary school teacher

- teaches at grades 1 to 6 (ages 7 to 13)
- teaches typically all 13 subjects

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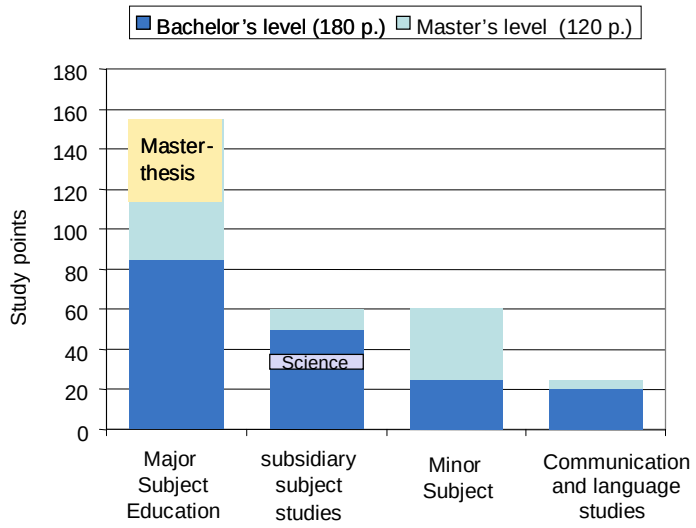
Structure of the master degree of a primary teacher: 3 + 2 years



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Subject teacher's Master's degree

- Master's degree: 3 + 2 years (180 + 120 credits)
- Major subject (e.g. physics) 120 credits
  1. minor subject (e.g. chemistry) 60 credits
  2. minor subject (pedagogical studies) 60 credits

  Language and communication studies
- Competent to continue postgraduate studies

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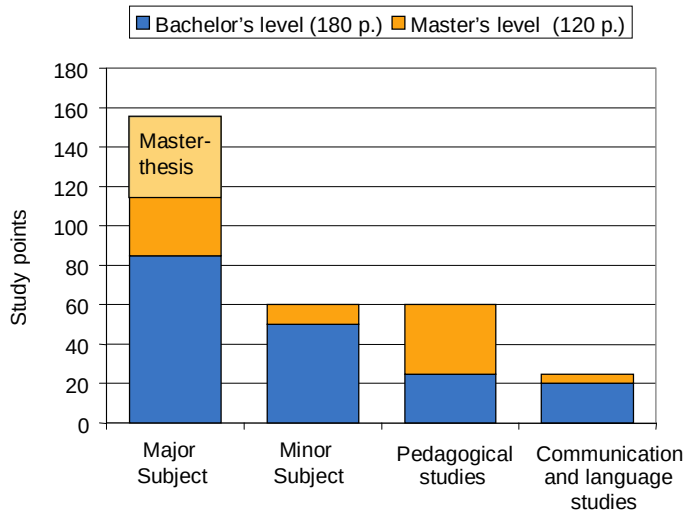
Structure of the master degree of a subject teacher: 3 + 2 years



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Basic strategies guiding planning of the teacher education

- Research-based teacher education (*University's strategy*)
- Wide pedagogical competence through teacher education: from primary schools to polytechnics (*Ministry of Education*)
- …

- Based on national and local strategies science teacher education have been developed in Finnish universities locally

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Teacher Education Development Programme (2002): The teacher education programmes should help students to acquire:

- high-level subject knowledge and pedagogical content knowledge, and knowledge about nature of knowledge,
- academic skills, like research skills; skills to use pedagogically Information and Communication Technology, skills needed in processes of developing a curricula,
- social skills, like communication skills; skill to cooperate with other teachers,
- knowledge about school as an institute and its connections to the society (school community and partners, local contexts and stakeholders),
- moral knowledge and skills, like social and moral code of the teaching profession,
- skills needed in developing one's own teaching and the teaching profession.

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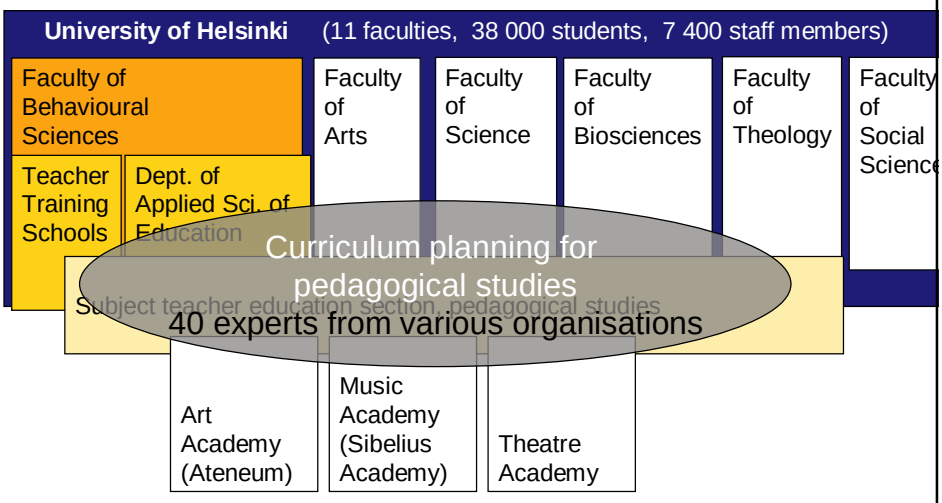
Subject teacher education at the University of Helsinki



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Expertise needed in the profession of a science teacher

Agreed together with university teachers working in science teacher education in the University of Helsinki

1. Subject knowledge and skills:

- well organised knowledge structure (expert)
- understanding nature of knowledge and how knowledge is acquired in the subject (e.g. nature of experiments),

2. Pedagogical knowledge and skills:

- an expert teacher can **plan, implement and evaluate** learning activities and learning (psychological, philosophical, historical and sociological background)
- competence to choose a variety of teaching and motivation methods

3. Competence for continuous professional development:

- readiness to learn new subject and pedagogical knowledge and skills (teacher as a researcher)
- skills for reflective thinking and collaborative working

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How science is taught in Finland (evaluated by the students)

Teaching method

- "Teaching method" is used here as a synonym for a
  - learning or instructional method/model/strategy,
  - student activity or classroom practice.
- Teaching methods are
  - goal-oriented and
  - emphasise social interaction among students and between students and the teacher.

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Teaching Methods in Science Education in Finland

- There is little research which describes what really happens in Finnish science classrooms.
- Norris et al. (1996) observed science lessons and interviewed teachers and students in 50 lower and upper secondary schools. They conclude that teachers were pedagogically conservative, and the teaching and learning traditional, mainly involving frontal teaching of the whole group of students. However, during science lessons there were a lot of practical work.
- Simola (2005) explains that this kind of behaviour of a teacher is supported by social trust and teachers' high professional academic status. It is possible to teach in the "traditional" way in Finland because teachers believe in their "traditional" role and pupils accept their "traditional" position.

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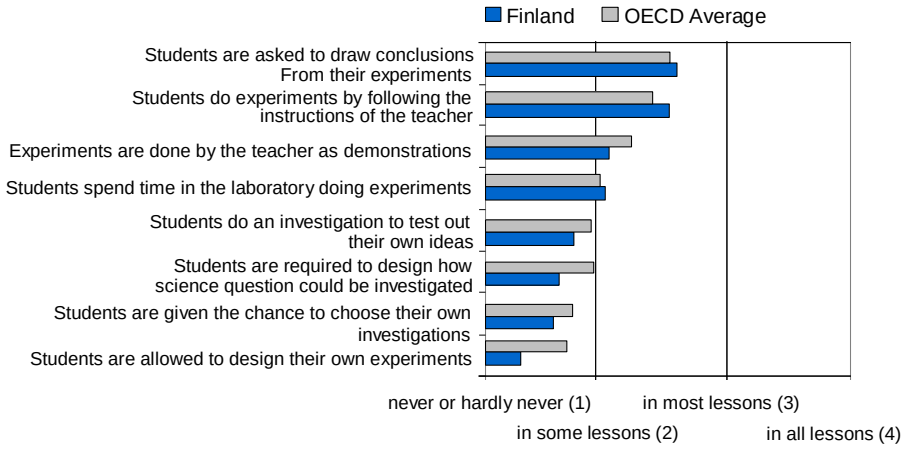
According to PISA 2006 Student questionnaire:
Activities dealing with practical work



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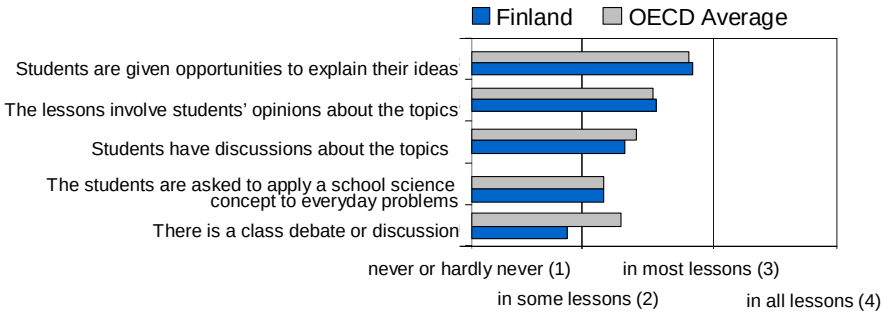
According to PISA 2006 Student questionnaire:
Activities dealing with student talk



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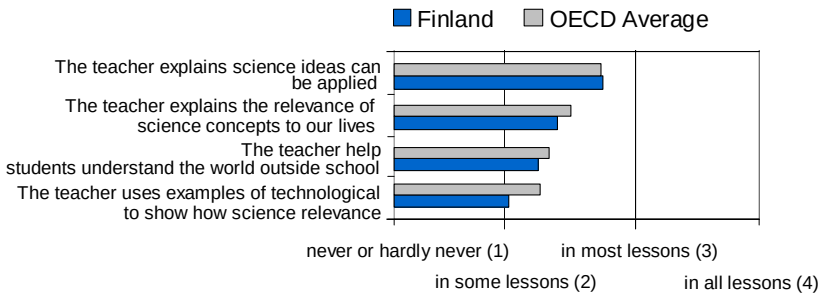
According to PISA 2006 Student questionnaire:
Activities dealing with teacher talk



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Summary

Explanations Made Based on PISA 2000 and 2003 Results by Jyväskylä group

- Finnish students' success in PISA was explained with comprehensive school pedagogy, students' own interests and leisure activities, the structure of the education system, teacher education, school practices, and Finnish culture – shortly pedagogical philosophy and practice (Välijärvi, Linnakylä, Kupari, Reinikainen & Arffman, 2002)
- On the basis of the multilevel modelling procedure affective factors particularly students' self-concept related to mathematics were the strongest predictors of performance variation in mathematical literacy. (Välijärvi, Kupari, Linnakylä, Reinikainen, Sulkunen, Törnroos & Arffman, 2007).

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Conclusions Made Based on the Book "How Finns Learn Mathematics and Science?"

- Editors (Pehkonen, Ahtee & Lavonen, 2007) suggest based on 40 Finnish mathematics, physics and chemistry teachers' educators and researchers several reasons for the success:
  - the general education policy and its implementation strategies, especially high quality teacher education and national core curriculum and its realisation through science teaching in the classroom,
  - realisation of the core curriculum through local level decisions making (no inspectors, no national evaluation of learning materials, nor national assessment
  - Finnish teachers are educated to be autonomous and reflective academic experts,
  - Finnish pupils' good understanding in reading.

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Aho, Pitkänen & Sahlberg: *Policy Development and Reform Principles of Basic and Secondary Education in Finland …* (The world bank)

- A stable political environment for education reforms which have been based on long-term vision, hard work, good will and consensus.
- Political, cultural and economical success of the educational system and its interaction with other sectors.
- Education reform has been evolutionary rather than revolutionary.
- Comprehensive school that offers all children the same top quality, publicly financed education.

- Laukkanen (2008) discuss similar issues and presents following reasons: high standards in education, support for special education, qualified teachers, and balancing decentralism and centralism.

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Obvious reason for Finnish students success in PISA 2006 science items based on preliminary analysis of PISA 2006 data

- Finnish culture: trust for education, high status of teachers
- Education policy:
  - Videly accepted vision of a knowledge-based-society
  - Educational equality
  - Devolution of decision power and responsibility at the local level
  - Trust
- Comprehensive school:
  - Goals for science education and textbooks
  - The headmasters work as a pedagogical director
  - School practices: several subjects, lunches, small groups, high quality equipments, special education
- Teacher education

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Comparison of Finnish education policy to the global education movements

(Hargreaves, Earl, Shawn & Manning, 2001, Sahlberg, 2004)

Global Education Reform Movement	Education development in Finland
Standardization Standards for schools, teachers and students to improve the quality of outcomes	**Flexibility and diversity** School-based curriculum development, networking through steering by information and support.
Literacy and numeracy Basic knowledge and skills in reading, writing, mathematics and science (= prime targets of education reform).	**Broad knowledge** Focus on broad learning; equal value to all aspects of individual's growth in personality, moral, creativity, knowledge and skills.
Consequential accountability The school performance is closely tied to the "inspection" and ultimately rewarding or punishing schools and teachers.	**Trust through professionalism** Culture of trust that values teachers' and headmasters' professionalism in judging what is best for students and in reporting on progress of their learning.

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