

TEACHING SCIENCES IN THE FINNISH COMPULSORY SCHOOL (PHYSICS, CHEMISTRY, BIOLOGY AND GEOGRAPHY)

Brief description of the Finnish Educational system

The Educational policy of education in Finland stresses quality, efficiency, equity and internationalism. The Government and the Ministry of Education and Culture, as part of it, are responsible for preparing and implementing education in both state languages, financed from the state budget. During the last 10 years there were several budget cuts. As an example, we can compare the budget of the year 2008 and this year's (2011) budget. Year 2008 the budget was 10 900 000 000 € and now it is 6 809 136 000€ [1].

The public authorities must secure equal opportunities for every resident in Finland to get education also after compulsory schooling and right to pre-primary and basic education according to the Basic Education Act (1998).[2]

The Finnish government underlines that the Finnish educational system is geared to promote the competitiveness of the Finnish welfare society. Finland, as a member of EU, support the overall lines of Finnish education and science policy with the EU Lisbon strategy.

Nowadays the Finnish Educational system is the result of several changes and reforms. The content of curriculum and the goals in education changes approximately every 10 years, but the Finnish Educational system remains traditional (see figure 1).

The Basic Education Act contains the main goal with the Compulsory Education in Finland:

“The objective of basic education is to support pupils' growth towards humanity and ethically responsible membership of society, and to provide them with the knowledge and skills necessary in life. The instruction shall promote equality in society and the pupils' abilities to participate in education and to otherwise develop themselves during their lives”

(Basic Education Act, 1998).

Basic education in Finland is provided for children between the ages of 7 to 16. The basic education is compulsory and free of charge, what is more it is forbidden to charge students. All students during their compulsory studies receive books, notebooks, pencils and all needed material so that their studies remains free, it is even an obligation for the school to provide students with study materials. As a rule, all children are to be educated in the school closest to where they live, but

parents may choose other schools if possible. Schools must provide the students with transportation if the school journey exceeds 5 kilometers.

It is also possible to fulfill one's compulsory education without attending school, but this occurs rarely. There are also private schools in Finland but very few students attend them (approximately 1%). The Academic year consists of 190 working days.

Pre-primary school in Finland is not a compulsory part of basic education, but it is offered as an option. Pre-school classes are usually organized at the day care centers or at the comprehensive schools. The groups are organized for six-years-old children who are going to start their compulsory education next year.

The compulsory basic education consists of two parts : Elementary school (from grades 1 to 6) and Lower Secondary School (from grades 7 to 9).

Children begin the Elementary School during the autumn (in August) of the year when they become seven years old; the pupils remain in elementary school for six years. Instructions are usually given by a class teacher who teaches all (or nearly all) of the subjects. Teachers training is carried out by the Finnish universities and the educational programme to become an elementary school teacher lasts 3 years. There are two official national languages in Finland – Finnish and Swedish, which means that there are two types of schools, schools with the Finnish-language of instruction and schools with the Swedish-language of instruction. Curriculum of the Elementary school contains the following subjects: The “mother tongue” (Finnish or Swedish), Mathematics, Foreign language (usually starts from grade 3 and onwards), Nature (from the 5th grade this subject contains basic Physics and Chemistry), History, Geography, Religion (or Ethics), Visual Arts, Physical education, Music and Craft. There are no examinations in elementary school. Students are introduced to the mark-system at the fifth grade (age 12-13). In order to assess the students' level of knowledge in different subjects, teachers themselves prepare the tests. These tests assess the students in the material which teachers choose to teach to the students during class as well as material which are obligatory according to the National curriculum. Teachers' freedom to teach what they want is the main cause for students with different background have a different level of knowledge when they arrive to the Lower Secondary School.

The Lower Secondary School usually lasts three years (grade 7 to 9). However there is one voluntary additional year (grade 10) for students who wish to improve their marks. Good marks are needed to fulfill the requirements to attend the Upper Secondary schools. The final average mark of Lower Secondary School subjects must be at least 8 in order to attend Upper Secondary school. The assessment scale ranges from 4 (poor) to 10 (excellent).

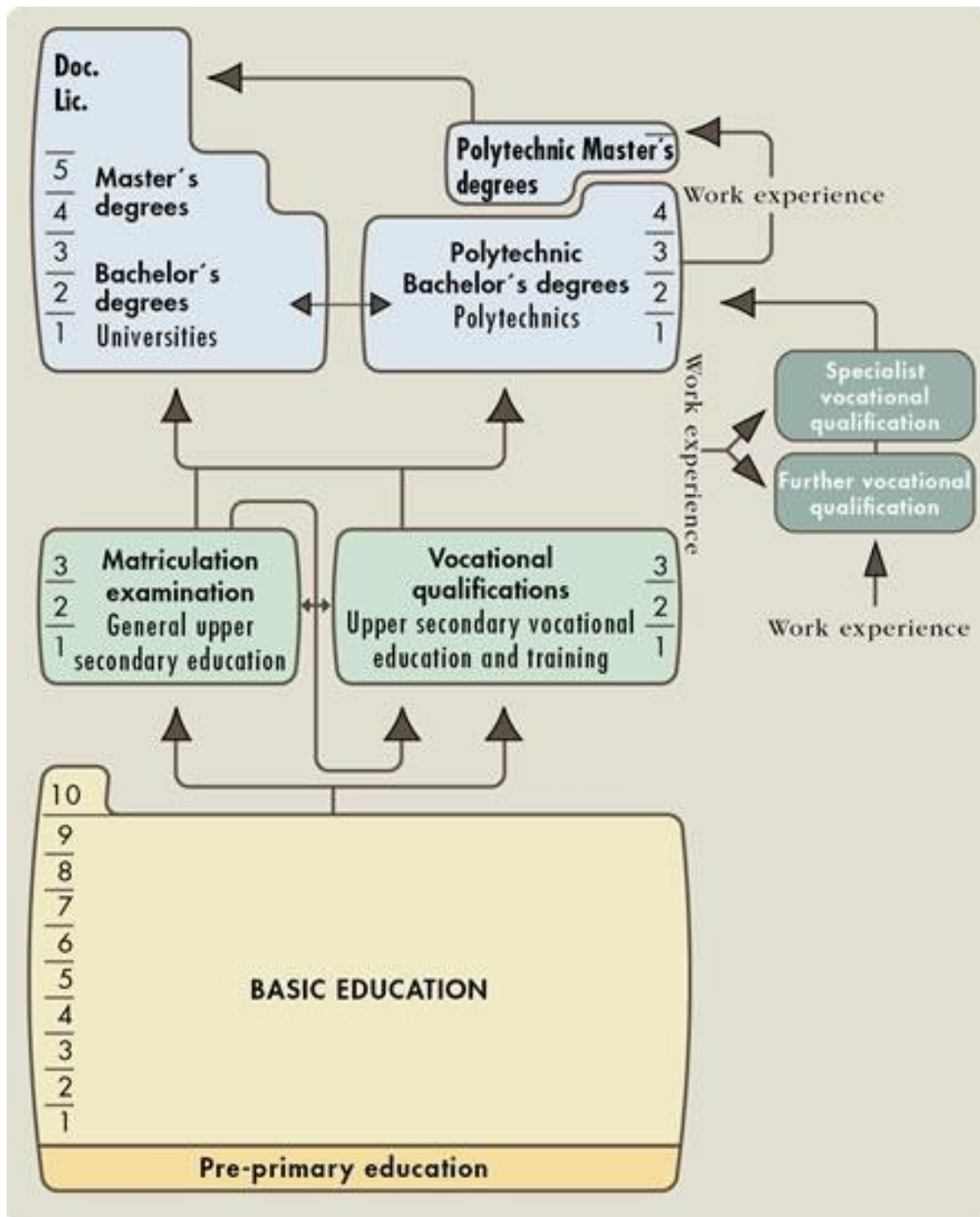


Figure 1: The structure of the Finnish Educational system

At the Lower Secondary school all lessons are held by subject teachers. Teacher training of subject teachers takes 5 years and is carried out by universities and as additional training to obligatory specialization. After this training teachers receive a Master Degree in their main subject and a Teacher Certificate. For example, a teacher may have a Master Degree in Mathematics and Certificate of Teacher in Mathematics at Lower Secondary and Upper Secondary Schools. In order to

receive this certificate candidates must have 60 credits in Pedagogy Studies and Practice.

At the Lower Secondary School, the Curriculum (Figure 2) consists of with (even more) languages, Environmental studies, Civics, Religion or Ethics, Physics, Chemistry, Home Economics and several optional subjects (Figure 3).

Subject:	Grade 7	Grade 8	Grade 9
Native language and literature	4	3	3
Second official language (Finnish)	2	3	3
English or German as A-language	2	3	3
Mathematics	3	3	4
*) Biology/ geography	2	3	2
*) Physics/ Chemistry	2	3	2
Health Literacy	1	1	1
Religion /Secular Ethics	1	1	1
History	2	2	0
Social science	0	0	3
Music	1		
Art	2		
Handicraft	3		
Physical education	2	2	2
Home economics	3		
Student Guidance	1	0	1
Multimedia	1	0	0
	32	24	25
**) Optional (3) at Grade 8 and 9: 2h/week	0	6	6
Σ	32	30	31

Figure 2: The distribution of teaching hours for different subjects per week

- Art
- Music
- Technical Craft
- Textiles
- Home economics
- Ball games
- English
- German
- French
- Economics and Enterprise
- Computer science
- Science

Figure 3: The optional courses at Botby Junior High-school, Helsinki, Finland

In order to assess students' knowledge in the different subjects, teachers organize

“competency test”. Competency tests may take place several times during the academic year. Every subject teacher has a responsibility for test content. The syllabus is defined by the National curriculum for every individual subject. In this document there is no assessment scale, it only contains a description of required knowledge and skills earning mark 8 (good). It is up to every school (and teacher) to specify the assessment criteria for other marks, which is derived from the mark 8 description. There are no examinations for students, during the Lower Secondary school period. In order to measure students' knowledge level in different subjects, every teacher has the possibility and right to order the National test, but this test is not compulsory. Generally teachers assess students according to the following procedure. Teacher gives points for every question in the competency test, then draws the coordinate system and places the points on a drawn y-axis. After that teacher places the best and worst points in to the coordinate system and determine the ordinates for best point and worse point, then teacher divide intervals between ordinates in three equal intervals. First $\frac{1}{3}$ of the interval equals mark 4 and following $\frac{2}{3}$ of interval equals to mark from 5 to 10. This $\frac{2}{3}$ interval divides into 5 equal intervals which represents assessment scale. Teacher generally follow the same procedure for every test in different classes. It means that if hypothetical student A and student B were to receive the same mark 10, their level of knowledge may not be at the same level. This causes students to be at different knowledge level after their compulsory education.

The Upper Secondary school is a three-years program which ends with the national matriculation exams – it consists of an compulsory exam and 3 or more are elective exams. Students must have at least 4 subjects on their matriculation certificate. Approximately 70% of a finished students courses were compulsory, while the rest were optional or electives. Passing the matriculation exams makes student eligible for higher education in principle, but most universities and polytechnics hold also entrance examinations, interviews, aptitude tests or such.

Where does the Sciences stand with regards to the other subjects in the Finnish Curriculum?

The Sciences in the Finnish Curriculum are not stressed. The reasons for the lack of stress in Science Education is explained in a document about the core curricula for basic education. The Sciences are first taught in the grades 1-4 under the official name of “Environmental and Natural Studies”. This subject is an integrated subject which contains basic biology, geography, physics, chemistry and health education. The main point of the “course” is sustainable development. The main

goals of the studies are “to familiarize with and understand nature as well as the built environment, themselves and other people, human diversity, and health and disease” [2]. It is recommended to teach students according an investigative and problem-centered approach. The starting point is the students' existing knowledge, skills and experiences such as things, phenomena, events which are connected to the students' environment and the students themselves. Generally this course is presented as separate modules and the main goal with all modules is to help students to understand their own environment and understand the interaction between “the individual and the environment” [2, p.170]. Because of these modules there is no possibility to gain knowledge in one holistic structure and there is no such goal with other subject to build one. The definition of scientific world view is missing. There is no assessment of students in those grades.

The next level of education in Sciences starts on grades 5 – 6. There are 4 different subjects which all are lectured with 1 hour per week. Science as a whole is taught in well separated subjects such as Biology, Geography, Physics and Chemistry. The subjects could be unified with the definition about scientific world view, however only object of investigation is clearly mentioned. In Biology it is life and its phenomena. In Geography it is the world and its various regions. In Physics and Chemistry it is observation and investigation of natural phenomena. In the end of the students' studies in grade 6, teachers mark students according to the assessment criteria in the National Curriculum. Only Biology teaching is required to be inquiry-based, which implies project-based education.

The next level of education in the Sciences starts in the Lower Secondary school, grades 7 – 9. The separation between Physics, Chemistry, Biology and Geography turns to be more distinguished. For a half academic year the subjects are taught 2 hours per week in grade 7. For example, if students in grade 7 starts with Physics it means that students have 2 h per week one half of the academic year and then other half of the academic year students have Chemistry. The courses in grade 8 are organized accordingly but with 3 h per week. The courses in grade 9 are structured like in grade 7. Biology and Geography courses are alternating like the Physics and Chemistry courses. There are no required methods of instructions (teaching), teacher may decide their own teaching method which is the main advantage of the Finnish School system. Science subjects and mathematics may be taught 2 additional hours per week, as optional subjects. The content of all subjects is represented in form of modules as well; each module contains description of the main topics. This structure requires special teaching system which is common for all Lower Secondary schools. This teaching structure or model is based on a mixture of structuralistic and pragmatistical models. According to

this model the teacher invites students to participate in the lesson, which contains structured facts (sometimes with examples from different scientific areas), asks questions and tries to get desired answers from these questions, and offers on frontal laborations which have already been planned for and have ready made instructions of the task and the method. When a “cycle” is completed the class moves on to the next “cycle”. This system or model can be named as Traditional Cyclic System (TCS).

The TCS is based on a behaviorist approach. The next level of education in Sciences continues at the Upper Secondary school. At this level students do not attend subjects but they chose modules in Sciences which are independent from each other and presented as a complete unit. For example, Physics is represented by 8 different modules and only one module is compulsory for all students, while the other 7 modules are electives. The situation in Chemistry is the same – 1 compulsory module with 5 elective modules; Biology – 2 compulsory modules with 2 elective modules; Geography – 2 compulsory modules with 2 elective. Interesting is that the only technology oriented subject is Computer Training with optional 1 module. However, in order to receive the Matriculation Certificate students need have passed only the compulsory modules: 1 in Physics, 1 in Chemistry, 2 in Biology, 2 in Geography (total 5). Remarkable is also that Religion consists of 3 compulsory modules. The duration of one module is five weeks.

Gaps in the Physics curriculum

The main goal with the National Curriculum in Physics is defined as “... to broaden the pupils' knowledge of physics and their conception of the nature of physics, and to strengthen skills in the experimental acquisition of information”. This means that the content of the syllabus is concentrated on Physics as one disjoint part of the natural sciences. In order to achieve this goal the curriculum recommends the method of induction – to start with students' prior knowledge and develop it towards general laws and fundamental principals. This method has advantages and disadvantages. One advantage is apparent in the phrase “prior knowledge of students”, it is a good starting point to develop discussions about different phenomena in nature based on the students' own experiences. In order to show the impossibility to implement this transition from the “simple” to the “complex” one may use the principle of scientific topicality to be applied. According the principle of scientific topicality a developed theory is the key to understand and explain all problems and flaws with predecessor-theories. Undeveloped theories are incapable to explain the developed theory. Transition from the “simple” toward the

“complex “ is in contradiction with the principle of scientific topicality, because the “complex” cannot be explained by the “simple”. The Physics National curriculum is created on the principle of simplicity, in the beginning of a teaching process it starts with classical Physics and then after several transitions it arrives to the complex theory of Quantum Physics. During the teaching process some of the students' knowledge becomes obsolete. However, understanding some obsolete knowledge led to the creation of new topics which are not connected to each other. The Physics National curriculum points to “... (guide) the pupils in thinking in manner characteristic of science...” which is advantage, but what means under “...in manner characteristic of science...” is not clear.

The next task of Physics studies is the development of “... his or her personality and forming a modern world view.” The quote appears to be about a personal worldview. However, the personal worldview is not the same as the scientific picture of nature or simply the scientific worldview. In order to understand and use the scientific worldview the national curriculum must open the borders of Physics, which means that it has to create connections with other sciences in general. This could be done by establishing interdisciplinary relations.

The objectives of the National curriculum contains many good ideas. These objectives, however, must be analyzed together with the official Physics textbook. The Physics National curriculum states that “The pupils will learn scientific skills, such as the formulation of questions and the perception of problems... to present and test a hypothesis;...” but the Physics textbooks and the description of laborations contains already defined hypothesis and instructions on how to conduct ready made experiments. The double standards of the curriculum is clearly apparent in the final-assessment criteria, “The pupils will know how... to follow directions..., how to perform a science investigation according to the instructions given...”. It should be noted that the usage of mathematics in Physics is somewhat limited because of the students' undeveloped math skills. For example, solving of linear equations is the last topic in grade 8 and definition of the function is introduced as late as in grade 9. It is interesting to analyze the concept of phenomena. The Physics National curriculum emphasize the classification of observations which belongs only to Physics. Students learn which phenomenons belongs to Physics and which do not, they learn to “... understand casual relations between phenomena”. It should be noted that the categorization of different physical phenomena contains contradictions, for example, Motion and Vibration are considered to be different phenomena. The same confusion arises with general properties of waves – reflection, refraction are properties of light. Very often the word “phenomena” is used as a synonym for the word “property”. It is

good that the syllabus emphasizes applications of Physics.

The listed contradictions of the Physics National curriculum creates problems in teaching physics. The teachers have to develop their own educational programs creating a society of people with a high variance in their Science knowledge level. The Physics National curriculum does not necessarily create the opportunities for students to "...know that physics is a basic science, and that physical knowledge and experimental methods of information acquisition are used in other sciences, and in technology", it depends on the creativity of a subject teacher.

The same tendency occurs in the Chemistry and Biology curriculum. For example, in the introductory part of the Biology National curriculum states that "In biology instruction, life and its phenomena and prerequisites come under investigation." Again, the content of the syllabus is concentrated on Biology as one disjoint part of the natural sciences.

References.

1. <http://www.eduskunta.fi>
2. Finnish National Board of Education, National Core Curriculum for Basic Education 2004,
http://www.oph.fi/instancedata/prime_product_julkaisu/oph/embeds/47672_core_curricula_basic_education_3.pdf