The Development of Scientific Literacy, the Present and Future Challenges in Finland

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1. A little big country and an equal educational system

The country of thousands of lakes and large forests is the home of 5.3 million people. Due to the large land area and small population, the average population density in Finland is low (16 inh. per km^2). In reality, most of the population lives in the large cities of southern Finland, while northern Lapland is very sparsely populated. Over the centuries, the small population of Finland has learned to adapt. The beautiful but raw nature and harsh climate, together with a location on the border of two different cultures (Swedish and Russian) have led to the development of useful survival skills (FinnSight 2015, 2006). The Finnish language and culture are strong. The dominant language in Finland is Finnish, which is spoken in nearly 90% of the families, with Swedish and Sami as the other two domestic languages.

World War II and the large war indemnities to the Soviet Union contributed to the fact that the most significant reforms in the educational system did not take place until the 1970's. First, teacher training was moved to the universities and all teachers began to do master's degree (Arinen and Karjalainen, 2007). Another significant reform was the development of a uniform basic school. The nine-grade basic school became open to all, and obtaining a basic education became compulsory to everyone. These two major reforms have enabled the development of the present-day high-quality educational system. The parents of the children who participated in the 2006 PISA survey have all received a uniform basic education, which may have influenced the good results (Arinen and Karjalainen, 2007).

A uniform and free (from basic school to university) educational system guarantees an equal education for everyone regardless of place of residence, wealth and native language (Arinen and Karjalainen, 2007). This can also be seen in the results of the 2006 PISA survey: The level of education of 15-year old Finns was solid, and there were top results in the schools of northern Lapland as well as in the schools in the greater Helsinki area (Figures 1 and 2). Swedish-language schools have produced equally good results. A good or top level education can be reached by every child, regardless of school.

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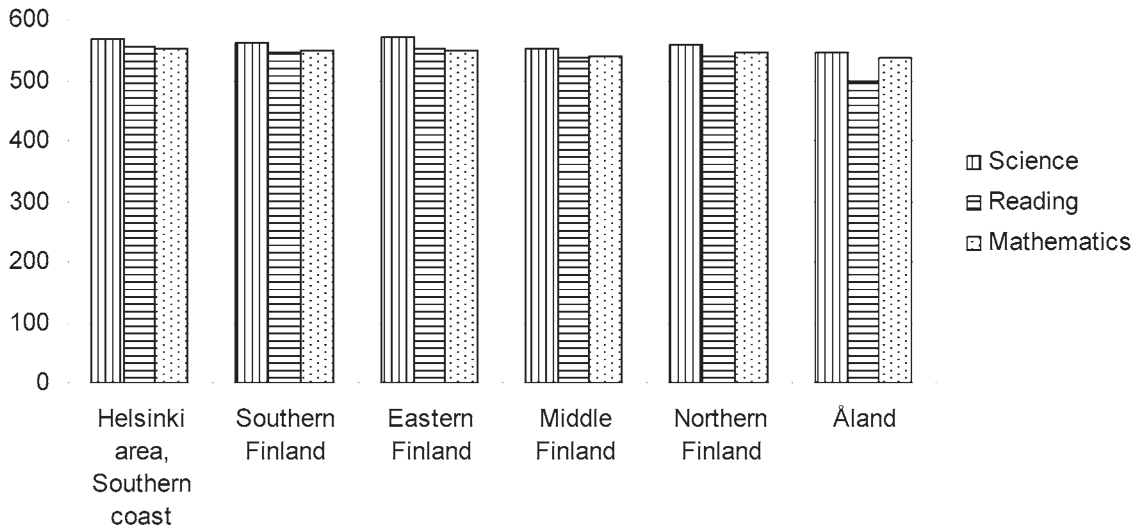

Figure 1. PISA2006 average results in scientific literacy, reading literacy and mathematical literacy in different geographical areas of Finland (Arinen and Karjalainen, 2007)

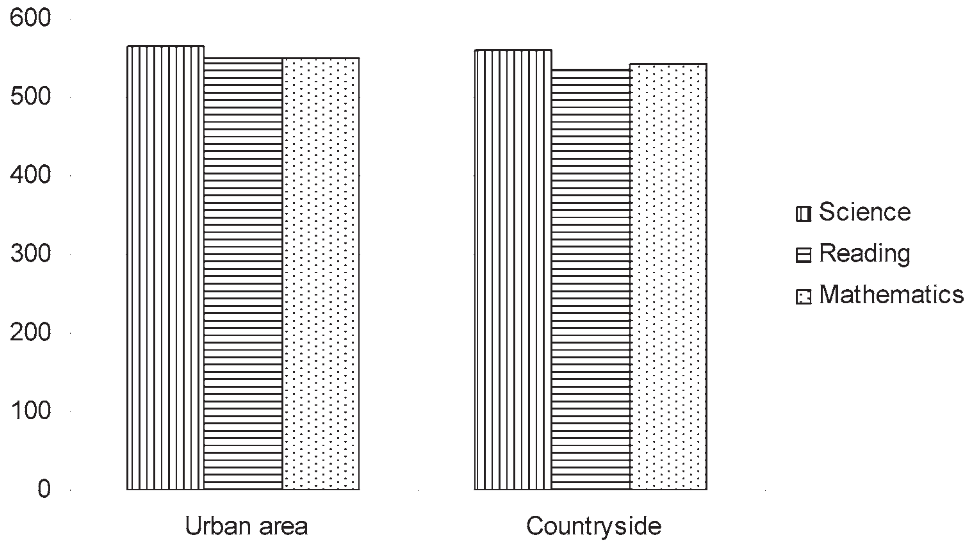

Figure 2. PISA2006 average results in scientific literacy, reading literacy and mathematical literacy in urban area and countryside of Finland (Arinen and Karjalainen, 2007)

A broadly accepted vision of information society, educational equality, trust and the delegation of responsibility and decision-making to a local level are the cornerstones of Finnish educational policy (Lavonen, 2008).

2. All-round education and scientific literacy

An even more diverse all-round education is needed both now and in the future. An individual needs the kinds of information, skills and values that enable them to form their own world view and to get along in a global society. Education has to be able to respond to this challenge.

Scientific and technological literacy is an important part of all-round education. On the other hand, the increased freedom of choice has made decision-making more difficult. Many things in everyday life require scientific literacy. Issues related to things like health, energy consumption and the environment can be encountered, for example, during grocery shopping.

Good scientific literacy is obtained through diverse science education. In a broad sense, science education encompasses the absorption of scientific information, and the adoption of critical and rational thinking and skills for future development in all subjects. It can be considered to be a precondition for full life and good all-round education. On the other hand, science education includes the absorption of basic facts in science, mathematics and information technology, which forms the so-called narrow concept of science education. It is the narrow concept of science education that forms the basis for scientific literacy: Reading and understanding is difficult without knowledge of the alphabet.

How a student learns and absorbs science in the classroom depends on many different factors. On the one hand, international trends and trends in economic life influence national educational policy and form a basis for the national core curriculum. The national core curriculum has a direct influence on local curriculum, teacher training and the production of learning and teaching materials. This forms a basis for science teaching. On the other hand, the learning process is also affected by support from outside the school. In some cases, the way the parents support their children, or the nature of the school culture, hobbies, evening schools or other forms of optional activity can be much more significant. The evaluation of learning results provides direct feedback for science teaching on a national level. Broader national evaluation, such as the PISA survey, can also influence international trends (Figure 3).

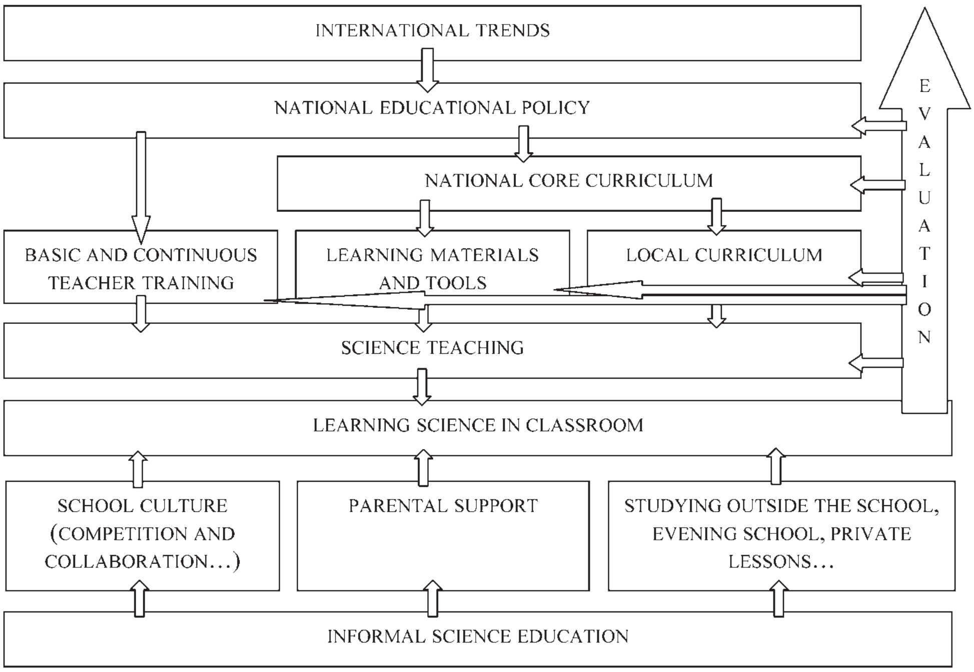

Figure 3. The factors that influences science learning in classroom (Lavonen, 2008:30).

A student's hobbies have an undeniable influence on the student's learning in the classroom. Science clubs and camps and other types of science hobbies make learning more meaningful and provide an opportunity to succeed or fail without fear of getting poor grades. Especially in sparsely populated areas, the school is often the only place where students can engage in hobbies in a safe environment under the guidance of a competent adult. Because of this, the aims of club activity have also been defined in the national core curriculum. Clubs can deepen and inspire interest in science - clubs are a good means of differentiating science teaching. Science clubs offer an opportunity to concentrate on genuine interdisciplinary questions and to solve problems across subject boundaries.

In addition to club activity, science centres and collaboration with universities and other institutions of higher education as well as businesses enrich both teaching and learning.

3. Natural sciences as a focus of interest

Finnish youths have had good results in science skills, but the general value given to individual subjects is low. The enjoyment of science and the self-concept of science are on the average level of the OECD countries (Arinen and Karjalainen, 2007). Other research results show that the general interest in science is quite high. This leads to the conclusion that studying science in a classroom is different from learning outside the class. The classroom rarely offers opportunities to study and learn genuinely interesting things - learning the basics is seen as dull. Knowledge of the basics has to be good and learning them requires effort and hard work.

As many as 80% of the Finnish people trust in scientific research and believe that science can lead to solutions to many problems, such as overcoming diseases or improving the quality of life (Kiljunen, 2007). The value of universities and institutions of higher education is also very high. In the upper secondary school students Top 10 list of professions (Figure 4), however, researcher is only in the 8th place.

1.	Business man/woman
2.	Solicitor
3.	Journalist
4.	Doctor
5.	Athlete
6.	Engineer
7.	Artist
8.	Scientist (researcher)
9.	Judge
10.	Politician

Figure 4. Finnish upper secondary school students' Top 10 list of professions (Lehtoranta *et al.*, 2007:48).

Even though the results of a researcher's work are valued, the message sent by a researcher's low salary and the difficulties in getting funding has a significant effect on young people's attitudes and willingness to become researchers.

4. Science curriculum - the key to success?

Science is taught in Finnish schools on all forms all the way to the upper secondary school. The curriculum always includes compulsory courses and a varying number of optional courses. Electivity is broader on forms 7-9 and in the upper secondary school.

The Finnish national core curriculum is revised every ten years. Developing the national core curriculum is a long process, and in practice, the planning of the new curriculum begins when the previous one takes effect. Expert groups comprised of researchers, civil servants, teachers and representatives of economic life are formed for the planning of subject-specific curriculum.

After the major reforms of the 1970's, the next major change in the Finnish school system took place in 1994. The Finnish curriculum was revised significantly: The national core curriculum was designed to be very general, and the task of creating a more detailed curriculum was transferred to the local level - to the municipality and the school (Figure 5) (Meisalo and Lavonen, 1994). Thereby the responsibility of teachers in the planning and evaluation of teaching increased significantly, and collaboration between teacher groups was intensified. The multi-step preparation of the curriculum guarantees that local resources and the competence of teachers are utilized in the most effective fashion. Students develop their subject-specific skills, linking them to their everyday life. The teachers therefore have a large responsibility, but this also guarantees a fruitful teaching process.

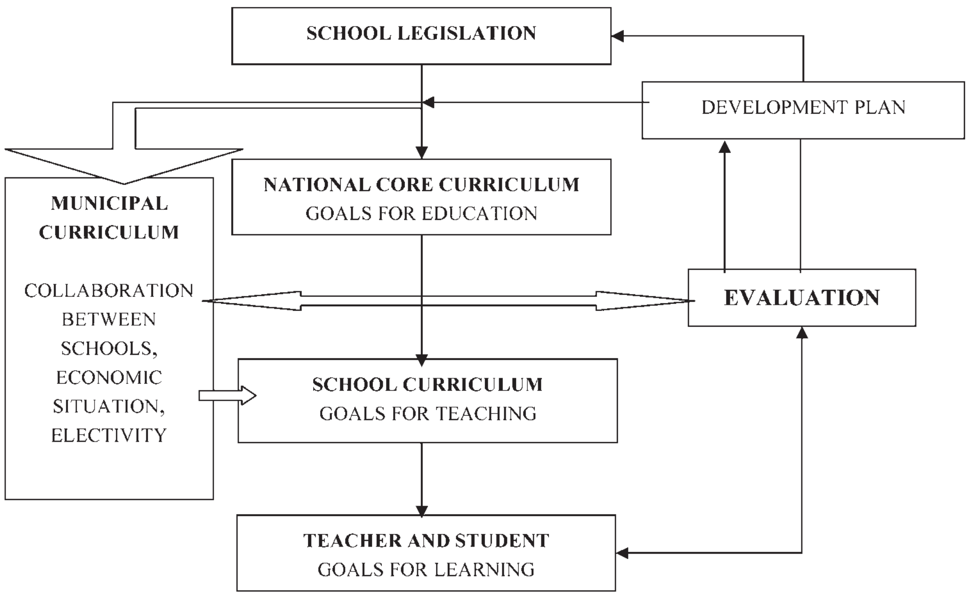

Figure 5. Main process of developing the national core curriculum in Finland (Meisalo and Lavonen, 1994:19).

The current core curriculum was finished in 2004. The schools were given a two-year transitional period, and since 2006, all Finnish schools have been using the new curriculum. A review of the results of the PISA surveys from 2000, 2003 and 2006 (Figure 6) shows that the results have improved in 2006, but it is hard to say how much effect the new curriculum has really had on them. If Finland also participates in the next PISA survey, we can say with more certainty what kind of effect the curriculum has on the results. It can be seen, however, that there are many criteria in the current national core curriculum that support the skills measured in the PISA survey (Lavonen, 2008). Based on this, we can at least assume that the results are not going to be significantly worse.

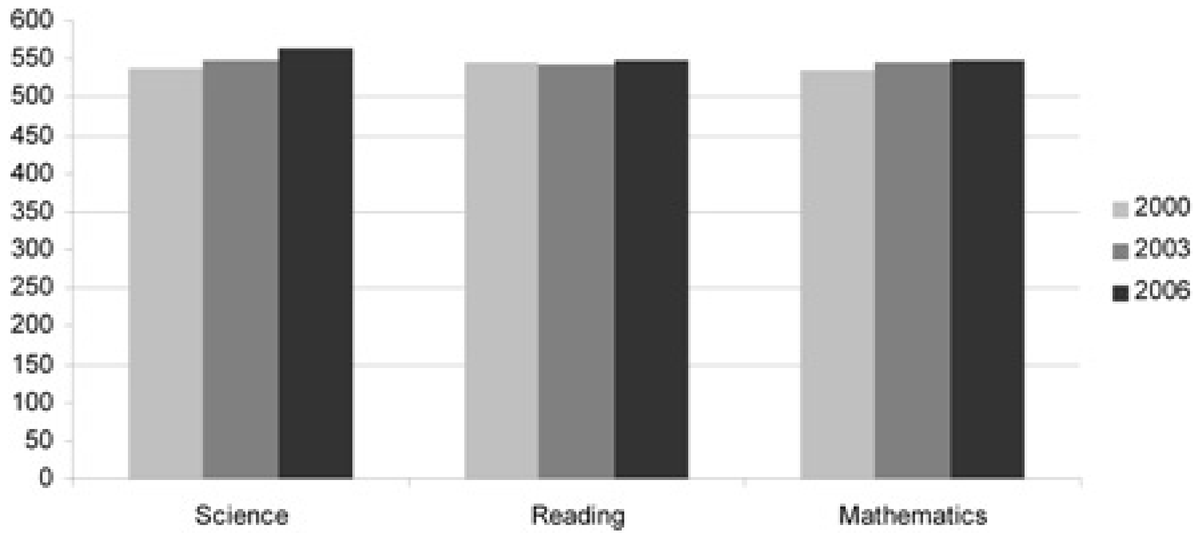

Figure 6 . PISA results from 2000, 2003 and 2006 in Finland (Arinen and Karjalainen, 2007).

The developing process of the 2004 curriculum was largely modelled on the previous curriculum - the role of the local level and the school in creating a detailed curriculum is important. However, on the national level, there were several changes in the core curriculum that are significant for science teaching. Up until 2004, physics, chemistry, biology, geography and health education on forms 1-6 had been integrated into one subject - environmental and natural science. Since 2006, environmental and natural science is only taught in forms 1-4, with physics, chemistry, biology and geography as their own, separate subjects up form 5.

The most significant change in forms 7-9 is the increase in the number of classes (Table 1).

Table 1. Number of classes in natural sciences in Finnish basic school (NCCBE, 2004). Numbers in rows means how many 45 minutes long lessons students have in week.

FORM	1	2	3	4	5	6	7	8	9
AGE	7	8	9	10	11	12	13	14	15
ENVIRONMENTAL AND NATURAL SCIENCE (INTEGRATED HEALTH EDUCATION)	2.5	2.5	2.5	2.5					
BIOLOGY AND GEOGRAPHY					1.5	1.5			
PHYSICS AND CHEMISTRY (INTEGRATED HEALTH EDUCATION)					1	1			
BIOLOGY							1.2	1.2	1.2
GEOGRAPHY							1.2	1.2	1.2
PHYSICS							1.2	1.2	1.2
CHEMISTRY							1.2	1.2	1.2
HEALTH EDUCATION							1	1	1

The new curriculum further emphasize the role of experimental methods and field education, and the aim is to make experimentation a natural part of teaching in every subject. For example, in Figure 7 we see how the teaching contents of chemistry are organized in national core curriculum. In basic school on all forms subject chemistry has five general areas and in all this areas teachers use four generals methodologies. Learning begins with observations in students everyday life and knowledge will deeper on every next form.

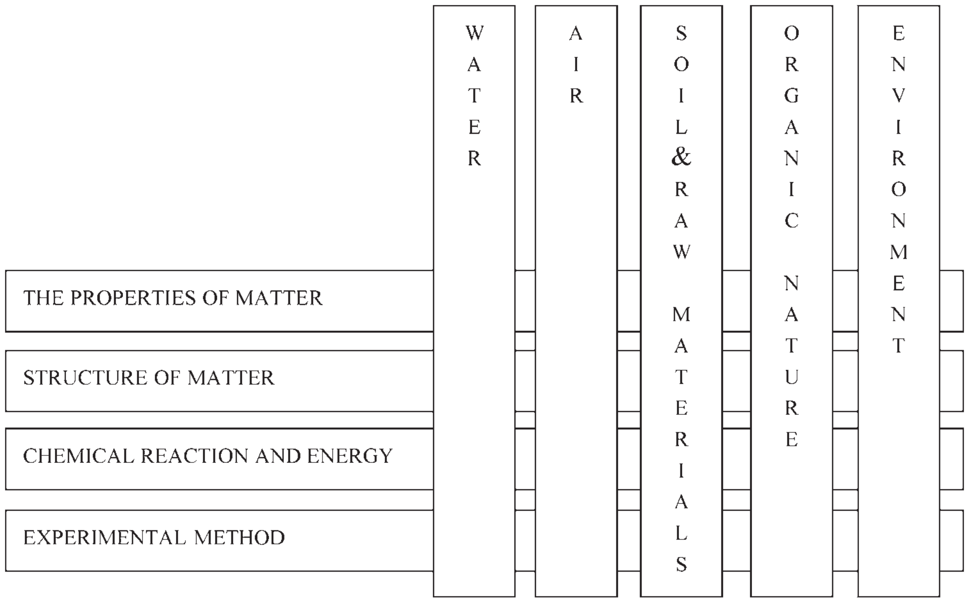

Figure 7. Organizing the teaching contents of chemistry in Finnish national core curriculum (NCCBE, 2004)

Long and thorough curriculum planning requires far-sightedness. The curriculum has to respond flexibly to changes in society. Science and technology develop fast, and the amount of new information increases. Once again, the role of the teacher is emphasized - only a teacher who actively participates in curriculum planning is able to develop their teaching to keep up with current developments in society.

5. Good teacher training is the basis of everything

The work of teachers is highly respected and the competition for training is fierce. Although the teachers' salary level is low compared to other salaries in Finland, teaching provides a secure job and an opportunity for constantly developing oneself.

Although much of the learning takes place outside the classroom and the role of self-guided teaching has increased, Finnish children like teacher-led studying. The blackboard and chalk are still important tools for the teacher (Lavonen, 2008).

Teacher training in Finland provides working life skills for class teachers, who provide basic education on forms 1-6, and subject teachers, who teach subjects on forms 7-9 and in the upper secondary school. Both class teachers and subject teachers can train themselves for teaching specific subjects for forms 1-6 or 7-9. The structure of teacher training is based on so-called tripartite collaboration (Figure 8). Collaborating between behavioural sciences faculty, subject departments and teacher training schools gives opportunity to use up-to-date research materials and improvements possibly soon assuring quality and up-to-datedness with it.

Figure 9. The structure of teacher training in Finland.

The tripartite is comprised of subject departments, behavioural sciences faculties and teacher training schools. This collaboration guarantees that the quality of teaching and the development of professional skills are top quality. In light of the PISA results, the class teacher's work is particularly valuable. The 15-year old subject of the survey has spent six years under the guidance of a class teacher and two years under a subject teacher. We may conclude that a good level of elementary teaching significantly affects the student's future studies and results.

The curriculum reform of 1994 also presented new challenges to teacher training. Mastery of the subject alone is no longer sufficient for responsible teaching work. For example, because of curriculum planning, a physics teacher has to consider questions such as the following (Meisalo and Lavonen, 1994:31):

- *How is physics a part of the school's activity on the whole?*
- *How does physics teaching take into account the different interests of the genders?*
- *How does physics support the student's growth into an independent and good person?*
- *What is all-round science education and what is its share of all-round basic education?*
- *How does physics teaching develop the student's abilities for further studies?*

Teacher training must therefore prepare the teacher for many forms of expertise (Lavonen *et al*, 2007):

1) Expertise in their own subject, which encompasses excellent knowledge of the field, an understanding of information and the nature of the field of information and an understanding of how new information is obtained.
2) Pedagogical expertise, which encompasses planning the teaching, the ability to take into account different types of learners, good assessment skills, command of good working practices, the ability to control the psychological, social and philosophical conditions, etc.
3) The development their own profession, which includes the ability to constantly develop

oneself and to learn new information about the subject as well as pedagogical knowledge, and the ability to assess one's own competence.

6. Future challenges for scientific literacy

In order to examine the future challenges for science teaching, we must also take a more general look at the challenges future brings for scientific literacy and all-round education in a broader sense.

Even today, we can see that anything that happens on a local level has repercussions on the global level, and anything that happens on the global level also has repercussions locally. Welfare and economic life go hand in hand. How is economic life going to change? The nature of work is changing due to changes in people's mental resources and the cultural environment (FinnSight 2015, 2006). The workforce meets increasing expectations for innovativeness and cost efficiency. There is an increasing need for people with top scientific literacy and good manual skills.

The population in Finland is aging rapidly. Ten years from now, there will already be more people retiring than young people entering working life. This leads to changes in consumer needs and an increase in the consumption of welfare technology. Scientific and technological knowledge are strongly combined particularly in welfare technology (FinnSight 2015, 2006).

Global and local environmental issues must be understood, and solutions must be found to things like water, waste and energy problems. Faster adaptation to environmental changes is also necessary.

Most Finns consider the television and radio (93%) and the newspapers (82%) to be the most important sources of information (Kiljunen, 2007). For an increasing number of people, the Internet is the most important means of obtaining information. Critical analysis of information in particular must be learned at an early age. The increasing amount of information makes both learning and teaching more and more interdisciplinary.

Perhaps the following question will best summarize what we are dealing with in the future in science literacy: "***What will be of crucial importance in the future is the skill to assess the societal context of scientific and technological knowledge, in other words, the capacity to ask: where was the knowledge in question produced, by whom, for what purpose, and, above all, what will be the potential consequences for the surrounding society at large?***" (Lehtoranta ***et al.***, 2007:14.)

7. Future challenges for science teaching

The greatest challenge for science teaching in Finland is maintaining the current good level and the good survey results achieved through it.

On the other hand, the task of Finnish basic education is the creation of good civics, which includes a solid all-round education, basic knowledge of science and technology, the utilization of information and communication technologies and networks, maintaining good health, dialogic interaction skills, communication skills and cultural and social skills (FinnSight 2015, 2006). The basic aim is therefore not the mass production of researchers, but to raise healthy and happy people.

Because of the aging population and low birth rate, the number of immigrants in Finland will increase significantly. Presently approximately 25,000 people move to Finland every year, and foreigners form less than 10% of the population. Students with immigrant backgrounds are found almost exclusively in schools in the greater Helsinki area. If the proportion of immigrant children in schools increases, it brings many different challenges to teacher training, the producers of learning materials as well as curriculum planning in general. Are the teachers and teacher trainers ready to encounter and utilize multiculturalism (FinnSight 2015, 2006)?

Presently 95% of Finnish children and youths get municipal basic education. Highly talented children and ones needing special support both attend same classes in the same schools. There has been a lot of discussion about whether support for the talented should already begin in basic school. The challenge is real, because there is no information about the mental and financial resources required. In addition, a little research has been done to know the real percentile share of the highly talented in the age group. Exceptional success at school is rarely a sign of special talent; it is common for the talented children to get frustrated at school, which leads to low grades. Current teacher training concentrates especially on helping poorly performing students, and in the future, this needs to change.

In Finland, funds for the educational system are used effectively - good results have been achieved even with small resources (Arinen and Karjalainen, 2007). These results have made decision-makers think that the allocated funds can be reduced further. After the previous good PISA results, there was a push to make the resourcing of teacher training more efficient and to save money. We must truly hope that the funding for education will not be cut further. The adequacy of research funding is also problematic, and probably the most important reason why talented young researchers choose not to stay in Finland (Kiljunen, 2007). Therefore the challenge is not only finding the most talented students in an average class, but also getting them to stay in Finland.

References

Arinen, P. and Karjalainen, T. (2007). PISA 2006 ensituloksia. *Opetusministerion julkaisuja 2007:38* [Finnish First Results of the PISA Study 2006. *Ministry of Education , Finland*]

FinnSight 2015. (2006) *Suomen Akatemia, Tekes*. [Academy of Finland, Tekes: Finnish Funding Agency for Technology and Innovation]. Available online at: www.finnsight2015.fi (accessed 1 December 2007)

Kiljunen, P. (2007). Tidebarometri. *Tieteen tiedotus ry*. Helsinki: Yliopistopaino [Finnish Science Barometer]

Lavonen, J. (2008). PISA 2006 -tutkimuksen tuloksia: luonnontieteiden osaaminen ja kiinnostavuus. [Results of the PISA 2006 Study: Science literacy and interest in science] *Dimensio*, 1/2008, 22-31.

Lavonen, J., Krzywacki-Vainio, H., Aksela, M., Krokfors, L., Oikkonen, J. & Saarikko. H. (2007). Pre-service teacher education in chemistry, mathematics and physics. In E. Pehkonen, M. Ahtee & J. Lavonen (Eds.), *How Finns Learn Mathematics and Science* (pp. 49-68). Rotterdam: Sense Publisher

Lehtoranta, O., Pesonen, P., Ahlqvist, T., Montonen, E. and Loikkanen, T. (2007). Technology Barometer 2007. Instrument for measuring citizens' attitudes and the nation's orientation towards a knowledge-based society. *The Finnish Association of Graduate Engineers TEK*. Helsinki: Painotalo Miktor

Meisalo, V. and Lavonen, J. (1994). Fysiikka ja kemia opetussuunnitelmassa. [Physics and chemistry in National Core Curriculum] Helsinki: *OPH* [State Printing Press and National Board of Education]

NCCBE (2004). *National Core Curriculum for Basic Education 2004*. Helsinki: National Board of Education.