Finnish Secondary School Teatcher Education in Mathematics, Physics and Chemistry: Assumptions behind the Programme

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ABSTRACT

The article focuses on the case of Mathematics, Physics and Chemistry teacher training system in Finland. It argues for and justifies the need for a master's degree for teachers, on the ground of the expertise required from them to cope with decision making conditions in the schools. It also refers to the role of the universities in teacher training and the reflections and feedback they get from the curriculum. The article then turns to the case of the University of Helsinki in organising teacher training for mathematics and science teachers..

Introduction

The secondary teachers' masters level study programme is divided into two parts in Finland: the subject is studied at the department of the particular subject (e.g. Physics Department) and the pedagogical studies at the Department of Teacher Education. The aim of the pedagogical studies is to help the students to integrate subject knowledge, knowledge about teaching and learning and school practice into their own personal pedagogical theory.

In this paper, we give an overview of planning and organising mathematics, physics and chemistry teacher education programme in Finland. Especially, the underlying principles of the programme are discussed. First, the Finnish

educational context is described through discussing the national guidelines as well as the main organising theme of research-based teacher education. Second, we portray the structure and the goals of the secondary teacher education at the University of Helsinki regarding both the studies in subjects and the pedagogical studies for future teachers. Last, we reflect on challenges that emerge in developing and evaluating the secondary teacher programme.

Finnish Education context

A description of national education policy and its implementation in Finland is outlined from the point of view of teaching and learning in comprehensive school (Figure 1). Education policy is controlled by the Finnish Ministry of Education (ME). The Finnish National Board of Education (FNBE) takes care of the implementation of this policy and is responsible for development of education as well as preparation of the *National Core Curriculum for Basic Education* (FNBE, 2004). The local education providers, municipalities, are responsible for planning and implementing local level school curriculum and, moreover, evaluating the learning outcomes in basic education.

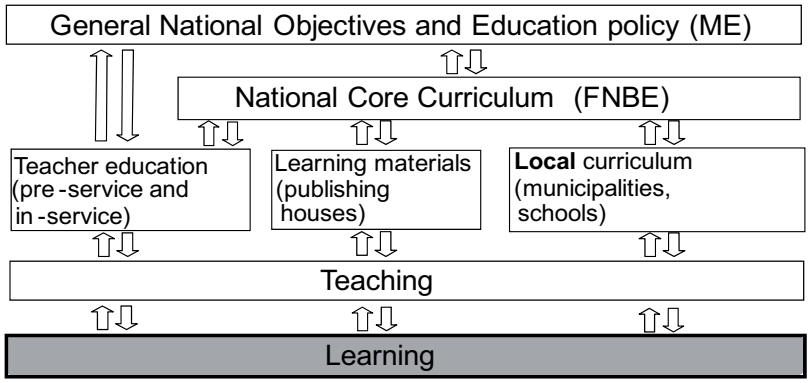

Figure 1
The systemic view of Finnish educational policy and its implementation. (cf. Halinen, 2008)

Teacher education is organised in eight universities and each university designs the programme in its own way on the grounds of the national level guidelines. The universities responsible for the teacher education in Finland have a strong autonomy regarding the implementation of the education policy (Kosunen & Mikkola, 2002).

Learning materials, like school books, are influencial part of implementing the educational policy. Private publishing houses play a key role in designing and preparing textbooks. At the beginning of the publishing project, some background information of the needs is collected through interviews with teachers and survey questionnaires. Then, the team of textbook authors, consisting of school teachers and university lectures, is assembled. The manuscripts are prepared in collaboration with editors from the publishing house. The process of writing a textbook is iterative while the manuscripts are tested in practice. Consequently, the production process takes several years. Only in this way, several issues, like teachers needs, research based knowledge on teaching and learning and usability of the learning materials can be taken into consideration.

Basic Principles of Finnish Educational System

According to Finnish educational policy documents, the most important feature of the educational policy is a commitment to a vision of a knowledge-based-society. This vision was already established in the national level educational documents in the '70s, when the ideas of common comprehensive school (Committee report, 1970) and university level teacher education (KATU-project, 1978) were presented. Since then, knowledge has had a central role in building up a developed society.

Another objective of Finnish education policy is to raise the general standard of education and to promote educational equality. The political decisions towards this direction were made during the 1970s along with other Nordic countries, when a comprehensive obligatory school system was established (Committee report, 1970). In accordance with the main idea of comprehensive school system, all students of the age group should study in public comprehensive schools together as long as possible. In practice, education in comprehensive schools is free of charge, including learning materials, school meals, transportation and social services.

Devolution of Decision Power

One essential principle in Finnish education policy is the devolution of decision making and responsibility at the local level. Even if Finnish National Board of Education (FNBE) is responsible for the implementation of education policy, local authorities have an autonomous role, a lot of freedom and power in

providing education at local level. For example, the local education providers, municipalities, are responsible for planning a local level curriculum, organising general assessment of learning, and furthermore, evaluating how well the goals have been achieved based on the data gathered through assessment of learning. A head teacher has an important role in school development and evaluation processes, and, through that, in implementation of educational policy at the local level. Already in 1985, it was proposed that schools should develop their own local curriculum. This movement was strengthened in the framework curriculum guidelines for primary and secondary schools. The decision power does not take place only through curriculum work but also through decisions about learning material to be used in a particular school. Schools and their teachers have the power to choose learning materials that they want to use in school teaching in order to achieve the learning objectives. No national level inspection of learning materials has taken place since early 1990s.

In all, Finnish educational policy is based on culture of trust. National level educational authorities and policymakers entrust decision-making to teachers who together with principals, headmasters and parents, are seen as professionals in providing the best possible education for children and youth. The parents trust also teachers.

National Core Curriculum

Guidelines for education are presented in the national curriculum for basic education and in the national curriculum for upper secondary school education (FNBE, 2004 and 2003). The curriculums in Finland have been renewed gradually during the existence of the comprehensive school system, in 1970, 1985, 1994 and 2004. It is stated in the latest national curriculums, *National Core Curriculums* (FNBE, 2004 and 2004), that education providers, typically municipalities, prepare the local level curriculum. Decisions over the local curriculum should be made in accordance with the educational and teaching tasks set for comprehensive school. Moreover, the objectives and contents specified in the core curriculum as well as other factors bearing on provision of the education should be taken into consideration.

The structure, the underlying values and mission of basic education are described in the general part of the National Core Curriculums (FNBE, 2004 and 2003). In addition, the core curriculums contain views and recommendations on learning, learning environments, operational cultures and teaching methods. The National Core Curriculums emphasise sosio-constructivist and situational views of learning, and the view of good learning is described as follows:

> *"…. In addition to new knowledge and skills, both learning and work habits are to be learned that will serve as tools of lifelong learning. … Learning results from the pupils' active and purposeful activity, in which they process and interpret the material to be learned on the basis of their existing structure of knowledge. Although the general principles of learning are the same for everyone, learning depends on the learner's previously constructed knowledge, motivation, and learning and work habits. … In all its forms, learning is an active and goal-oriented process that includes independent or collective problem-solving. Learning is situational, so special attention must be given to the diversity of the learning environment. In learning, new possibilities open up for understanding culture and the meanings that culture contains, and for participating in social activity.*

The general goals and subject specific goals, basic concepts in each subject (syllabus), integration and cross-curricular themes, and final-assessment criteria (standards) are described in the National Core Curriculums. The municipalities and the teachers are to follow these guidelines stated in the Curriculums.

National guidelines for teacher education programmes

Class teachers teach almost all subjects in primary school at grades 1-6 (pupils 7-12 years old), including mathematics and science teaching. Secondary teachers teach typically two subjects, for example mathematics and physics, at grades 7-9 (students 12-16 years old) in lower secondary school or at grades 10-12 (students 16 - 19 years old) in upper secondary school.

Both class and secondary teachers are educated in Master level programmes consisting of 300 credit points (cp) offered by eight universities in Finland. The credit points are in accordance with European Credit Transfer System (1 ECTS = 1 cp = 27 hours work). Master's degree is justified by a central role that teachers have in preparing each new generation to meet the global world and changes in technology, economy, politics, and security influential in everyone's life. Moreover, the citizens should master skills to analyse and manage these changes in the society. Therefore, since the welfare and economy of society is decisively dependent on educational outcomes, teacher education is connected to national level goals and purposes. Teachers have also high societal status and class teacher education programme is one of the most popular university level programmes, especially among female students.

Only minor structural changes were needed for existing teacher education programmes when Finnish universities adopted the Bologna process (3 + 2

years study programme) in 2005 (Jakku-Sihvonen & Niemi, 2006; see also. Reform of university degrees, 2005). However, several pedagogical changes took place while developing the teacher education programmes. For example, the idea of personal study plan was introduced. The renewals were established and coordinated by co-operational networking project called "the National Level Coordination of Degree Programme Development in Teacher Training and the Sciences of Education". Furthermore, teacher education provides a sufficient background also to continue studies in post-graduate programs (Phil. Lic. and Ph.D.) in chemistry, mathematics and physics education. Teachers with higher degree education have typically positions in university departments and teacher training schools, institutes of technology and polytechnics, and to some extent also in upper secondary schools.

Decision-making at local level and strategy based guidance

Universities in Finland have autonomy and, in practice, it means full responsibility for developing the study programmes and evaluating what and how students are studying. There is no a national level organisation taking care of teacher qualification or organising an exam to evaluate competences of teacher candidates. However, some interaction between national educational policy and university level decision making takes place. A Finnish tradition is that professionals in all levels from primary education to universities are not implementers of decisions but partners in decision making. For example, local level experts give feedback of the national strategies during developmental process.

Education at the university should be based on scientific research and professional practices in the field, as stated in the general national education strategy *Education and Research 2003-2008* (2004) and several previous ones. The study programme should especially provide the students knowledge and skills needed for operating independently as an expert and developer of their field. In addition to the general strategy, there have been and there are other strategies describing goals for teacher education, like *Teacher Education Development Programme* (2002) and *Education, Training and Research in the Information Society* (1999). According to them, the teacher education programmes should help students among other things to acquire:

- high-level subject knowledge and pedagogical content knowledge, and knowledge about how knowledge is constructed,
- 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.

Research-based teacher education

The main organising theme of the research-based teacher education is to promote the teacher's pedagogical thinking. In other words, being a professional is not only based on expertise in separate knowledge domains, like mathematical content knowledge and pedagogical knowledge, but also on being able to apply such knowledge and skills in practice (Kansanen et al., 2000; Lavonen et al., 2007). The aim is to achieve thinking skills both regarding subject matter and pedagogical issues as well as skills for continuous professional development in the future. The teacher education programme can be described as a highly academic way to educate prospective teachers when cognitive knowledge and skills are critical to the research-based programme. Special courses in research methods are introduced from the very beginning of the studies. However, students not only deepen their understanding of central concepts and familiarize themselves with research literature and methods, but are given an opportunity to experience being a reflective practitioner, as a professional who may act as a researcher in future work (see also Westbury et al., 2005).

Pedagogical knowledge needed in the teaching profession is composed of three subsets: pedagogical content knowledge or subject didactics, educational theories and practical knowledge (Kansanen et al., 2000). A teacher needs this knowledge in pedagogical decision-making and justifying the pedagogical decisions in the classroom. A teacher is seen as a reflective practitioner who has a strong personal-practical theory of education. The main idea is to help students to combine educational theories with practice and their previous knowledge base. The need to combine theory with practice is to be addressed by combining different courses together through timing and contents.

Pedagogical content knowledge integrates subject knowledge and research-based knowledge about teaching and learning in secondary teacher education (Carlsen, 1999; Hashweh, 2005). This approach is especially emphasised

within the pedagogical studies but also in the studies at the subject department. Compared to this, subject knowledge is seen as a tool for different orientations towards learning and thinking in class teacher education. Different teacher education programmes have naturally a slightly different emphasises in this process. However, the main aim of the pedagogical studies in both programmes is rather similar, and thereupon, we think it is important for the future development of Finnish school system: class teachers and secondary teachers are encouraged to work as teams in united primary and lower secondary schools.

Secondary school teacher education programme at the University of Helsinki

At the University of Helsinki, the mathematics, physics and chemistry teacher education is organised in co-operation between the Faculty of Science and the Faculty of Behavioural Sciences as described in Figure 2 (see also Kaivola, Kärpijoki, & Saarikko, 2004). Studies are divided into two parts: the subject is studied at the subject department and the pedagogical studies take place at the Department of Teacher Education and in two University Teacher Training Schools. The pedagogical studies give the students the qualification necessary for teaching positions at all school levels regarding major and minor subject.

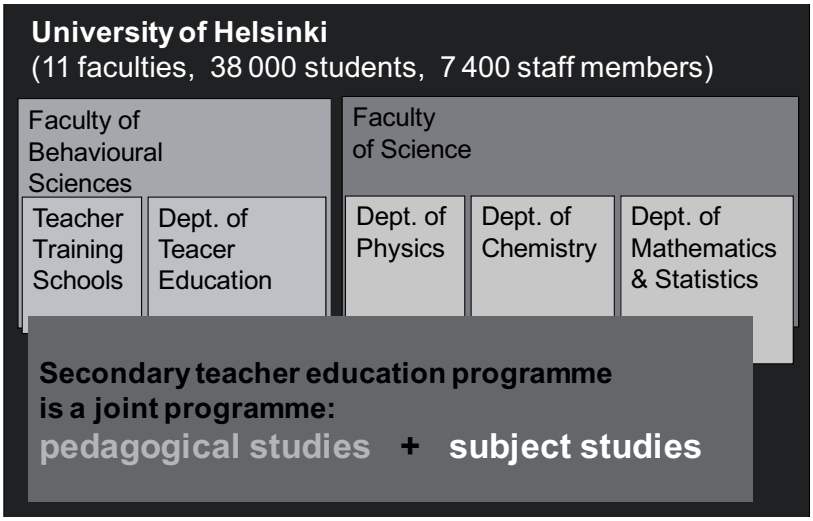

Figure 2
Organisation of the secondary teacher education at the University of Helsinki

Students in secondary teacher education programme take a major and a minor in the subjects they intend to teach in school. Typical combinations in so called mathematical subjects are mathematics combined with physics, chemistry, or computer science, physics combined with chemistry, or chemistry with biology. However, the students are free to choose also other combinations of subjects, like mathematics combined with home economics. In figure 3, the structure of a master's degree for a secondary teacher is described including credit points are allocated for master's and bachelor's level studies.

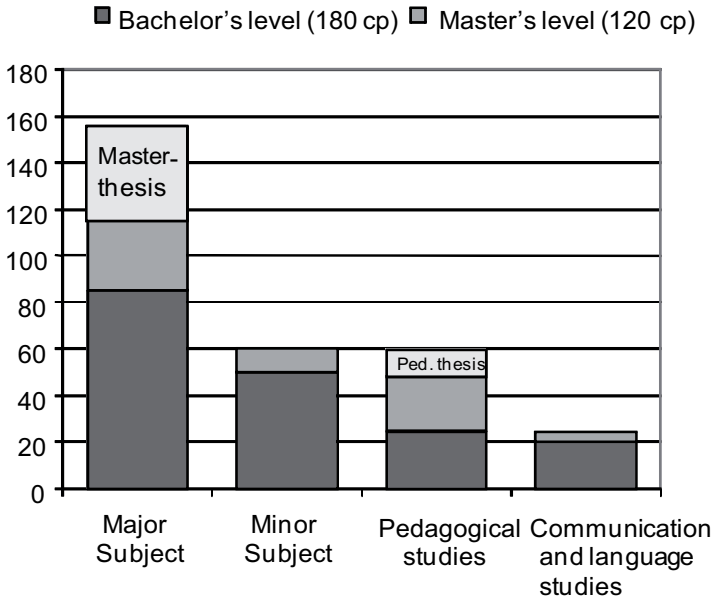

Figure 3
A typical structure of a master's degree of a secondary teacher

The secondary teacher students carry out their master thesis (40 cp) in their major. They can choose the topic of the thesis to be either with pedagogical or subject orientation. Subject departments organise seminars for students when working on their master's thesis. The aim of a pedagogically oriented thesis is to train students to find and analyse problems they face in their future work. In this way, students have an opportunity to carry out a project, in which they are to formulate a problem, to seek independently information for facing the problem and to elaborate the latest research, and to write down a synthesis as a structured report. The aim is to learn about and possibly

internalise an active stance that teachers may act like researchers in their work. However, it varies how the master thesis project is realised in different subjects. In addition to master thesis, the students produce a pedagogical thesis (10 cp) during their pedagogical studies. The underlying assumption is that teachers benefit from research orientation as an approach to professional development and developmental work including e.g., curriculum work and evaluation processes.

Bachelor level courses in the subjects at the department of chemistry, mathematics and statistics, and physical sciences are basically the same for all students despite their intended specialisation. Undergraduate courses are rather conventional regarding the implementation of the courses in Finnish universities: lectures are accompanied with exercise classes. Special laboratory courses are included in the physics and chemistry programmes.

There are some master's level courses tailored especially to the teacher students. The aim is that students deepen their understanding of factual knowledge and concepts as a part of a conceptual framework, and knowledge is organised in such a way that facilitates retrieval and application. This kind of knowledge can be used, for example, in recognising features and meaningful patterns of information in nature through observations or experiments. Moreover, students should learn how to approach problems in the field (Bransford, Brown and Cocking 2000, 31). Naturally, in addition to research orientation acquired during the studies, teacher students should become experts in their subject. This expertise in subject knowledge is needed when teachers guide their students' learning and problem-solving processes in the classroom.

In the following section, a short description of the studies at university departments is given. The section is based on the article "Pre-service teacher education in chemistry, mathematics and physics" (Lavonen, Krzywacki-Vainio, Aksela, Krokfors, Oikkonen, & Saarikko. 2007).

Studies in chemistry

Pre-service teacher students take mostly the same courses in chemistry (altogether 92 cp) as chemist students at the undergraduate level. Lectures, laboratory courses, seminars, and computer-aided learning are part of the course implementation. Basic courses in chemistry are offered to students in in-organic, organic, physical, polymer, radiochemistry, and biological chemistry, and the courses include laboratory activities. Two courses especially provided to student teachers are included in the programme: *Introduction to Chemistry Education* (3 cp) and *Chemistry in the Community* (4 cp).

Teacher students complete 30 credit points in chemistry education and 14 in chemistry included in master's level courses at the Department of Chemistry. Some special courses are provided also as part of advanced studies: *Chemistry as Science and Discipline* (5 cp), *Models and Visualization in Chemistry Education* (5 cp), *Practical Work in Chemistry Education* (10 cp), *Central Areas of Chemistry Education I* (6 cp), and *Central Areas of Chemistry Education II* (4 cp). In addition, a seminar in *Chemistry Education and its Research* is organised monthly. Two of the courses are described below in order to illustrate the approach.

Practical Work in Chemistry Education (10 cp) emphasises working in small groups. The aim of the course is to support learning of the chemical concepts having a key role in the secondary-school chemistry curriculum. The course includes mainly laboratory activities, inquiry-based learning, design of new laboratory activities, and research into the role of practical work in learning chemistry. For example, micro-scale experiments and Microcomputer-based laboratory (MBL) investigations are included in the course.

Models and Visualization in Chemistry Education (5 cp) emphasises the usefulness of Information and Communication Technology (ICT) in supporting better understanding of chemistry. The aim of the course is to learn about visualization of the chemical concepts central in the school curriculum.

Studies in mathematics

Similar to other programmes, all students take mainly the same courses in mathematics despite their intended specialisation in future. These courses have been quite stable during the last 30 years. A good approximation is to say that mathematics in Finnish universities is very much the same as mathematics in rest of the western world, and students study, for example, introductory real analysis, linear algebra, vector analysis, topology of metric spaces, differential equations, probability, abstract algebra, and logic. Modern ideas of teaching and learning, for example social construction of knowledge, and new technology have recently entered the scene.

The mathematical education of teacher students is aimed at giving understanding of mathematics covering those areas taught at Finnish schools. It is a challenge for student teachers to find the links between university mathematics and school mathematics in their thinking. Furthermore, an even greater challenge is to help the students to combine their mathematical education with pedagogical thinking. Some courses and seminars are focused especially for future teachers at master's level. One of the aims within the

courses is to tie together and deepen the teacher student's knowledge about the real numbers and analysis. A course in geometry combines university level mathematics with school geometry. There is also a new seminar aiming at building up an overall view of university and school mathematics, i.e. how teaching and learning mathematics could be seen from a mathematician's point of view. The course addresses also a need to focus on the issues regarding teaching and learning mathematics already during mathematical education in order to lay the foundation for educational research. The special focus on the issues relevant for a future mathematics teacher but which are not addressed during the university studies.

Studies in physics

The basic undergraduate studies for major or minor in physics include courses *Fundamentals of mechanics, electromagnetism and wave motion*, as well as *Laboratory works of basic studies*. For the students having physics as their major, the intermediate studies in physics include courses *Fundamentals of the theory of relativity, Thermal physics, Structure of the matter, Electronics*, and either *Digital electronics* or *Measurement techniques*, as well as *Laboratory works of the intermediate studies.* Students are to take the courses during the first two or three years. There are also some courses focusing on issues special for a particular field in working life (e.g. Orientation to physics education).

The advanced courses designed for a future physics teacher are research-based taking into account requirements set for teacher profession. Student teachers acquaint themselves, for example, with central notions of physics, epistemological and methodological issues regarding physics as a discipline. In addition, the interaction between science and technology, conceptual and process structures of the main areas of school Physics, methods for planning and carrying out experiments and demonstrations in the physics classroom, the history and philosophy of physics and its relations to society and technology are addressed (Lavonen, Jauhiainen, Koponen, & Kurki-Suonio, 2004).

In the following, two courses developed with special focus on the needs of physics teacher education are described in more detail as an example. The course *Concepts and structures of physics I: Classical physics* (5 cp) discusses the structure and methods of physics. The viewpoint is how to take into account the structure of knowledge in designing physics teaching (Loughran, Mulhall, & Berry, 2004). Special attention is paid on the interplay between theory and experiments. Teacher students are to develop their physical thinking and understanding of physics from the point of view of their fitire occupation.

In the course *Experimentation in school laboratory* (10 cp), students study in small groups of two or three students. The methods of experiment-based teaching are discussed and 19 experiment-based teaching units of school physics are introduced during interactive lectures. Each small group chooses 5-10 units to be further elaborated including experiments that students need to carry out. Since some of the experiments are not ready-constructed, the group has to plan activities on their own. In addition to design work, students are to construct a concept map that illustrates the procedure of conceptual formation. The execution of a plan has to be based on well defined conceptual goals. Both qualitative and quantitative experiments are represented in the teaching units.

Pedagogical studies for secondary teacher students

In the pedagogical course, the main idea is to help students to combine educational theories with practice and their previous knowledge of subjects to be taught in school. Separate knowledge domains should be integrated in order to become a solid base for applying knowledge and skills in practice. According to the curriculum, the students should, for example, be aware of the different dimensions of the teaching profession (social, philosophical, psychological, sociological, and historical basis of education), be able to reflect on their practice, and have potential for lifelong professional development.

The pedagogical studies are divided into bachelor's level studies (25 cp) and master's level studies (35 cp). The core of the bachelor's level studies is to acquire basic skills that a teacher should master. In the master's level studies, the students deepen their pedagogical understanding. The pedagogical studies consist of courses in general education, mathematics and science education besides teaching practice periods. Typically, the following areas are discussed during the courses: teaching and learning mathematics and science, students' interest and motivation in mathematics and science, national and local curriculum and curriculum work, teaching methods, ICT in mathematics and science education, evaluation and research methodologies in mathematics and science education research.

Theoretical basis for teaching and learning of a particular subject is introduced at the beginning of pedagogical studies. In addition, students visit school and observe lessons and thereafter, they participate in micro teaching sessions. During the bachelor level courses, students have their first teaching practice which includes both planning the teaching sessions together with other students and teaching in the classroom.

The master's level courses start with issues about evaluation and reflection from different perspectives starting from students' self evaluation and ending up with discussing the evaluation of operations on school level. Moreover, the students participate in an applied teaching practice which may take place in alternative institution, for example, in a vocational school or in a publishing house. Finally, the students have their masters' level teaching practice between times they collect empirical data on the grounds of the research questions, analyse the collected data and write a pedagogical thesis.

One third of the pedagogical studies consist of teaching practice (20 cp). According to the feedback from the students, teaching practice is evaluated very highly by the students when compared to other courses in the pedagogical studies. Teaching practice is practical and related to 'real' work which explains, at least partly, why students find it useful. Another reason for students' positive opinions seems to be supervision and mentor teachers' expertise. Since the supervisors are teaching 'ordinary' pupils in the teaching practice school, they are able to provide authentic experiences of teaching profession. Moreover, they are professionals in supervising student teachers in practice, helping the students in planning the lessons and reflecting on activities together with the students. Portfolio assessment work is part of reflection activities helping the students to combine research based knowledge about teaching with practice.

However, even if many students feel, especially at the beginning of the pedagogical studies, that theory and research-based knowledge about teaching and learning a particular subject is something needed in a teaching profession, it is a challenge to combine such knowledge with actual work as a teacher. Formal teaching about educational theory is easily apart from teaching practice and, therefore, may not be an appropriate approach to combine "theory" and practice together. Therefore, theoretical studies within the programme are linked to school practice in several ways. For example, most of the lectures and seminars are based on the idea of problem-based learning, which means that the students need to read reference books, web pages, research articles in addition to attending the lectures. Moreover, theory and practice are connected by using portfolio assessment work as part of the studies.

One of the main ideas in the teacher education is that a teacher student should not consider a single teaching method as a solution to all pedagogical problems in the classroom. We have prepared a web-based learning environment in order to introduce several teaching methods suitable for science education, In the environment, teaching methods are divided into four subsets: 1) experimental teaching methods, 2) teaching method that support social interaction, 3) teaching methods that support information processing and 4) teaching methods that support problem solving (Joyce, Weil, & Calhoun,

2003). There are several models of teaching in each subset. The descriptions of each model start with an introduction where theoretical background of the model is given, e.g. how the model supports learning, and what is the cognitive background of the model. Then, the syntax of the model is introduced through several examples and some cases in the context of different content areas of science and technology are presented. Furthermore, there are information sections about evaluation and different models of evaluation.

Co-operative designing of the teacher education programme

In this chapter, the essential features of co-operation and planning of the programme between different actors in the teacher education programme are described. Developmental issues have been the focus when evaluating and fitting the different elements of the studies together.

Partners responsible for secondary teacher education, three Subject Departments, Department of Teacher Education, University Training Schools and municipality schools, and representatives of teacher students have approximately three meetings during the academic year. The focus of the co-operation is on common vision and strategies for teacher education, development and evaluation of the programme, and moreover, on research dealing with the secondary teacher education (see e.g., Aksela, 2005; Koponen, Mantyla, & Lavonen, 2004). The discussion about the core strategy has been guided by national and university strategies, research findings, and student evaluations of the programme.

The overall framework for designing and implementing the teacher education programme at the University of Helsinki is presented in Figure 4. Students are to construct a base of professional knowledge through the courses provided by different university departments and the teaching practice in university teaching practice schools. Therefore, co-planning and coordination within the study programme are needed to ensure that different domains of teacher knowledge, such as subject matter knowledge, pedagogical content knowledge and general pedagogical knowledge as well as distinctions between these separate domains are discussed in a balanced way during the programme (Carlsen, 1999; see also Shulman, 1987; Grossman, 1990). Furthermore, co-operation between university partners and student teachers has also been considered to be of importance in the planning and developmental process in Finland. The collaborative work does not only concern practical issues regarding the implementation of the teacher education programme, but it also involves general level visions of the teacher education. For example, the

parties involved in the physics teacher education have agreed together about a common vision for the whole teacher education programme, including description of knowledge and skills in the subject matter and pedagogy as well as of competence for continuous professional development (see more Lavonen et al., 2007).

The national level strategies for Finnish teacher education have been taken into consideration when planning the teacher education programme and its implementation. Education policy documents are prepared in Finland by the Finnish Ministry of Education (ME). According to the general national education strategy *Education and Research 2003-2008* (ME, 2004), education at the university shall be based on scientific research and professional practices in the field. The teacher education programme should especially provide the students with the knowledge and skills needed for operating independently as an expert and developer in the field. In addition to the general strategy, there are also other strategies describing the goals for teacher education, such as the *Teacher Education Development Programme* (ME, 2002).

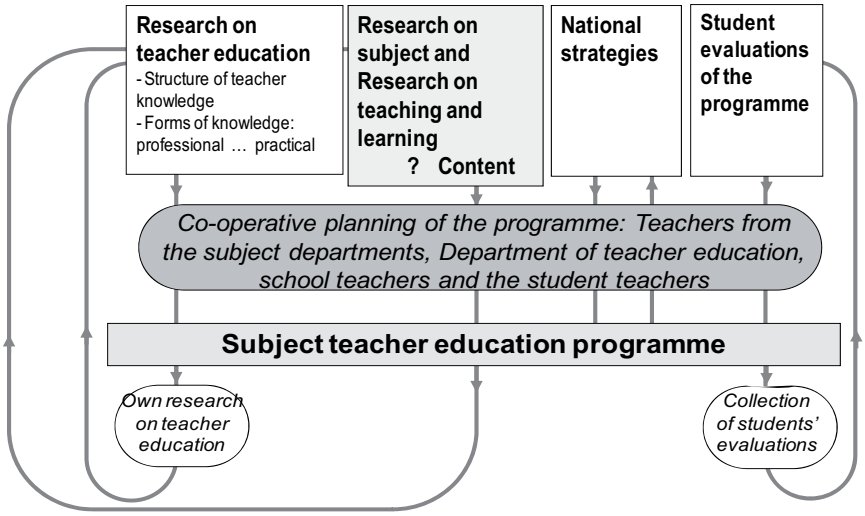

Figure 4
Framework for designing and implementing the teacher education programme at the University of Helsinki.

The partners have agreed together about underlying principles of the secondary teacher education programme. Accordingly, the secondary teacher

education programme at the University of Helsinki should help student teachers to acquire:

1. ***subject knowledge and skills***
   - well organised knowledge structure (expert),
   - understanding nature of knowledge,
   - how new knowledge is acquired in the subject (nature of experiments),

2. ***pedagogical knowledge and skills***
   - an ability to plan, implement and evaluate learning activities (use of teaching methods),
   - an ability to justify pedagogical decisions by psychological, philosophical, historical and sociological knowledge,
   - a competence to choose a variety of teaching and motivation methods,
   - an ability to use ICT in pedagogically meaningful way,

3. ***competence for continuous professional development***
   - readiness to learn new subject and pedagogical knowledge and skills,
   - an ability to reflective thinking and collaborative working with colleagues.

In order to know better the implementation of the programme, students are active partners in the cooperation and, moreover, the feedback is gathered systematically through student questionnaires and feedback discussions about the programme. The themes discussed are the quality of teaching, relevance of the pedagogical studies for personal professional development, how well the goals of the programme are achieved, and general study arrangements. In the feedback discussions, student teachers are to bring out the issues that they feel to be essential. Besides, each teacher educator gathers more detailed feedback about their own teaching according to the personal interest and special characteristics of the course. The evaluation of the programme is not only based on student feedback but also on discussions that take place between teacher educators. It is considered to be an important part of planning the implementation of the pedagogical studies. Teacher students have also an opportunity to take an active role in designing the courses.

One of the most important underlying principles is the idea of research-based teacher education emphasised also in the national and university level strategies (see Korthagen, Loughran, & Russel, 2006). It means that students become familiar with research, for example, through producing their own bachelor level and master level thesis. All courses have been planned and carried out based

on the research knowledge about the topic. Accordingly, the teacher educators themselves are engaged with research about teaching and learning of a subject as well as about teacher education. Research on teacher education has been carried out in order to better understand how student teachers learn different type of teacher knowledge and how their professional identity emerges during the programme (Krzywacki, 2009). Furthermore, some challenging issues are uncovered with the help of evaluation research about the secondary teacher education programme (Krzywacki-Vainio & Juuti, 2006).

Perspectives to be taken into consideration in programme implementation

Firstly, it is important that the structure of the pedagogical studies is easy to picture up with process-orientation in order to avoid fragmentation. Teacher students do not always understand the relevance of different parts of the programme. Especially, research-based orientation might seems to be irrelevant in the eyes of prospective teachers at the bachelor level. Students might have difficulties in connecting educational research with other parts of the studies. Furthermore, teacher students compare educational studies with their view of mathematics and science as disciplines that appear more exact and scientific to the students (see also Joram, 2007). Various starting-points of the students should be taken into consideration when implementing the pedagogical studies and helping the students in finding educational way of thinking (Younger, Brindley, Pedder, & Hagger, 2004). The motivational background of the students and the preconceptions that the students bring with them into the pedagogical studies vary.

Secondly, it seems to be appropriate to balance the theoretical and practical parts of the studies as well as to build up links between different parts. Practical viewpoints are considered important by the students, especially when practicalities are based on theoretical studies and students feel that they gain new knowledge. Practice is highly valued but not for its own sake but a possibility to learn new things.

Thirdly, practical issues, for example behavioural problems, should be discussed more during the teacher education programme. There should be enough time for thinking over practical issues in relation to the theoretical educational studies. Teacher students stress the importance of interrelations with other students and also with teacher educators. The group activities make it possible to have informal and formal discussions as well as guidance and support of other students.

Concluding remarks

There are several reasons why Finnish teacher education system can be considered to work out well, and consequently, it can be seen to have an impact on good learning outcomes showed in Finnish ninth graders' success in PISA. Five year university level teacher education for all teachers provides a solid basis for being a professional. Teachers in mathematics and science or in separate science subjects in Finland gain readiness for being a teacher through studying scientific knowledge and skills during their teacher education. All teachers, for example, become competent for developing a local curriculum, choosing teaching and evaluation methods to be used in their classroom and selecting of learning materials. There exist nether school inspectors, national evaluation of learning materials nor national-level assessment of learning outcomes. Therefore, teachers can be considered to be entirely responsible for pupils' learning.

In the following, we discuss some other features of the teacher education might also have influenced the PISA success. First, although there are several national strategies, like Education and Research 2003-2008 guiding Finnish teacher education, all universities in Finland have an autonomous position in developing and evaluating teacher education. In the University of Helsinki, the programme is carried out collaboratively together with the staff from subject departments, Department of Teacher Education, Training Schools and student teachers. This freedom has created flexibility including, for example, a possibility to develop special courses for student teachers at the subject departments. During the special courses, the student teachers become familiar with epistemological and ontological basis of the subject. This kind of knowledge is important in school work when teachers get their students carry out different kind of activities, which bring up epistemological and ontological issues. Furthermore, knowledge and skills learned in the activities are needed also in PISA assessment. For example, it is known that the scientific literacy in the *PISA* framework means the capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and make decisions about the natural world and the changes made to it through human activity. The definition, therefore, emphasises epistemological and ontological issues of the subject. Although the students in primary school teacher education programme have only little mathematics and science studies, they still become familiar, in general, with epistemological and ontological issues within their science education studies.

Second, collaborative planning together with the teacher educators from the Department of Teacher Education and the teaching practice schools has also helped us to integrate theoretical studies with practice (e.g., Gore & Gitlin, 2004). For example, we have designed some tools, for example portfolio assessment work, for enhancing reflective process that the students should engage with during their teaching practice periods (e.g., Korthagen, 2007). It is important that reflective process is supported by all teacher educators in order to create an encouraging environment for mentoring, reflecting and goal setting. Besides, students produce a small-scale educational research which is to integrate theoretical studies with practice. Students typically collect the empirical data during the teaching practice period and after that, they complete their thesis at the department during the last part of the pedagogical studies. The shared view of the aims in the teacher education programme is needed when several teacher educators are involved with the process.

Third, as mentioned before, the main organising theme of the research-based teacher education is to promote the teacher's pedagogical thinking. In practice, this principle is realised in masters' level teacher education programme through reflective activities and through producing a masters' thesis. The aim of the thesis is to train students to elaborate and analyse the problems they will face in their future work. The courses with research focus give an opportunity to carry out a real research project with several phases. The idea is not to make all students educational researchers but through research-based training to enhance their potential to act as a professional teacher who takes a broad responsibility on school work and is able to make decisions regarding different aspects of school work.

Last, in summary, the aim of the Finnish teacher education is that teacher students acquire expertise in science and mathematics education in order to take an autonomous role as a teacher (cf. Hiebert, Gallimore, & Stigler, 2002). They should also build up potential for further professional development and find their way of being a teacher. The teacher education can be considered to be highly academic with limited amount of practical training: the emphasis is on learning to reflect independently and gradually internalising the professional identity as a teacher (Krzywacki, 2009).

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Περιληψη

Η κατάρτιση των καθηγητών Μαθηματικών, Φυσικής και Χημείας στη Φινλανδία: Υποθέσεις πίσω από τα προγράμματα προετοιμασίας τους.

Το άρθρο παρουσιάζεται το ιδεολογικό, εκπαιδευτικό, θεσμικό και λειτουργικό πλαίσιο προετοιμασίας εκπαιδευτικών της δευτεροβάθμιας εκπαίδευσης στη Φινλανδία και ειδικότερα των καθηγητών των Μαθηματικών και των Φυσικών Επιστημών. Ως βασικές αρχές του φινλανδικού συστήματος παρουσιάζονται η δημιουργία μιας κοινωνίας βασισμένης στη γνώση, αλλά ταυτόχρονα και η ενίσχυση της ισότητας στην εκπαίδευση. Το ίδιο θεμελιώδες είναι επίσης το χαρακτηριστικό της αποκέντρωσης αρμοδιοτήτων στο επίπεδο των σχολικών μονάδων, οι οποίες αποτελούν τα κέντρα λήψης πολλών και σημαντικών αποφάσεων που αφορούν την εφαρμογή της εκπαιδευτικής πολιτικής.

Η εκχώρηση σημαντικών αρμοδιοτήτων στους εκπαιδευτικούς στο επίπεδο της περιφέρειας και της σχολικής μονάδας αλλά και η ανάγκη σύνδεσης των αρμοδιοτήτων αυτών με τους εθνικούς εκπαιδευτικούς στόχους, κατέστησε αναγκαία την πολύπλευρη όσο και συγκροτημένη προετοιμασία τους σε υψηλό επίπεδο. Γι' αυτό και οι Φινλανδοί εκπαιδευτικοί είναι στο σύνολό τους κάτοχοι μεταπτυχιακού τίτλου σπουδών. Η εφαρμογή των αποφάσεων της Διαδικασίας της Μπολόνια ήρθαν απλώς να διευρύνουν τις δυνατότητες των υποψήφιων εκπαιδευτικών να επωφεληθούν από σπουδές και σε επίπεδο διδακτορικού διπλώματος.

Τα πανεπιστήμια στα οποία προετοιμάζονται οι μελλοντικοί εκπαιδευτικοί απολαμβάνουν βέβαια πλήρη αυτοτέλεια. Παρά ταύτα, τις περισσότερες φορές, λαμβάνουν σοβαρά υπόψη τους τις ανάγκες και απαιτήσεις των προγραμμάτων σπουδών της δευτεροβάθμιας εκπαίδευσης. Έτσι ο στόχος των προγραμμάτων σπουδών των εκπαιδευτικών είναι διττός: πρώτον, η παροχή των κατάλληλων εφοδίων, ώστε οι αυριανοί καθηγητές να είναι σε θέση να λειτουργήσουν ως ειδικοί στο επιστημονικό τους αντικείμενο. Για το λόγο αυτό η εκπαίδευση των εκπαιδευτικών περιλαμβάνει τη μελέτη του γνωστικού αντικειμένου του κλάδου τους (major) και ενός συναφούς δευτερεύοντος (minor). Δεύτερον, η παιδαγωγική κατάρτιση και η διδακτική του συγκεκριμένου γνωστικού αντικειμένου. Παράλληλα, με δεδομένες τις αυξημένες αρμοδιότητές τους στη λήψη αποφάσεων στο επίπεδο της σχολικής μονάδας, η προετοιμασία τους περιλαμβάνει επίσης εξοικείωση με την ερευνητική διαδικασία.

Όσον αφορά συγκεκριμένα το πανεπιστήμιο του Ελσίνκι, η εκπαίδευση των μελλοντικών καθηγητών Μαθηματικών και Φυσικών Επιστημών περιλαμβάνει τη διδασκαλία του γνωστικού αντικειμένου στο αντίστοιχο πανεπιστημιακό Τμήμα και παιδαγωγικές σπουδές στο Παιδαγωγικό Τμήμα του ίδιου ιδρύματος. Στα πρωτεύοντα μαθήματα οι φοιτητές υποχρεούνται να εκπονήσουν και τη διπλωματική τους εργασία, είτε με αντικείμενο κάποιο παιδαγωγικό θέμα, είτε ένα θέμα που αφορά το γνωστικό αντικείμενο.

Στόχος τελικά της κατάρτισης των εκπαιδευτικών είναι η δημιουργία επαγγελματιών που να μπορούν να προσφεύγουν σε πολλές και διαφορετικές διδακτικές μεθόδους κατά την άσκηση των καθηκόντων τους, να μπορούν να καταρτίζουν προγράμματα σπουδών και να λαμβάνουν παιδαγωγικού χαρακτήρα αποφάσεις στο επίπεδο της σχολικής μονάδας.