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# Teacher Education in Finland: Knowledge Building in the Chemistry and Physics Teacher Education Programme at Helsinki University

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## Abstract

Teacher education in Finland is described and analysed. The main organising theme of the teacher education programmes is a research-based approach, which aims at supporting student teachers in constructing a solid knowledge base and the potential to apply such knowledge in their work. Furthermore, all student teachers are to gain a competence for continuous professional development, e.g., consuming theoretical educational knowledge in their work. As an example, the pedagogical studies of pre-service chemistry and physics teachers are analysed from the viewpoint of knowledge building. The theoretical framework of this analysis is based on two facets related to teacher knowledge: the domains and the origin of teacher knowledge. The division of teacher knowledge domains into three main categories, content knowledge, pedagogical content knowledge and pedagogical knowledge, is based on the work of Shulman. An additional view: the teacher as a consumer and producer of educational research is added to the model. Based on the analysis, the research-based teacher education programme provides both contents and activities that support the formation of the different knowledge fields needed for acting as a teacher. The research approach and reflective activities seem especially to play a special role in the programme.

*Key words:* teacher knowledge, chemistry and physics teacher education, pedagogical studies, student teacher, course evaluation

## Introduction

This paper analyses firstly, in general, the Finnish education context and teacher education as a part of this context. Secondly, pedagogical studies of chemistry and physics teachers will be analysed in order to clarify how the pedagogical studies support the student teachers' process of becoming a teacher and building the knowledge base they need in order to act as autonomous actors in the teaching profession.

The framework for discussing the teacher education programme is based on the domains and origin of teachers' professional knowledge: the structural view of teacher knowledge constructed on separate knowledge domains, and the origins of the knowledge. The structural perspective is based on the different domains of teacher knowledge, such as subject matter knowledge, pedagogical content knowledge and general pedagogical knowledge, and the distinctions between these separate domains (Carlsen, 1999; Hashweh, 2005; originally based on the theoretical framework of Shulman 1987). An additional view considering teachers as consumers and producers of educational research is also used as a view of teacher knowledge.

It is known that students have difficulties in understanding the role of professional knowledge and those of the theoretical and research aspects as well as combining these with practice. In addition, student teachers have difficulties in integrating different knowledge domains into a

coherent entity. (e.g., Gitlin, Barlow, Burbank, Kauchak, & Stevens, 1999; Brandsford, Brown & Cocking, 2000) In these processes, pedagogical studies including teaching practice and a special orientation towards becoming a teacher are essential. In order to understand the support of pedagogical studies for knowledge construction in the chemistry and physics teacher education, the courses of the pedagogical studies from the perspective of teacher knowledge domains and origin of teacher knowledge will be analysed. The research question is: *How is teacher knowledge approached in the pedagogical part of chemistry and physics teacher education?*

## A framework for analyzing teacher knowledge

### *Domains of teacher knowledge*

Discussion on teacher knowledge, regarding different models and the meaning of knowledge domains for the teaching profession, like pedagogical content knowledge, has been the focus of research for a number of years (e.g. Carlsen, 1999; Grossman, 1990; Hashweh, 2005). The characterising feature for the structural model of teacher knowledge is that separate knowledge domains are distinct from each other and defined by their relationships with each other. The starting point for the concept of teacher knowledge is in Shulman's work (1986, 1987) in which the distinction between content knowledge, pedagogical content knowledge and curricular knowledge in general was made. There have been further developments of the model. For example, Carlsen (1999) has further developed the model and stated that models of teacher knowledge vary according distinct to knowledge categories. He divided pedagogical knowledge into five categories: (1) knowledge of the general educational context, (2) knowledge about the specific educational context, (3) general pedagogical knowledge (GPK), (4) subject matter knowledge, and (5) pedagogical content knowledge (PCK). Various scholars have modified conceptualisations of science teachers' knowledge to better present an academic construct (e.g., Van Driel, Verloop & de Vos, 1998; Magnusson, Krajcik & Borko, 1999; Appleton, 2002; Loughran, Mulhall & Berry, 2004). However, because the structure of the teacher education programme focused on in this article is comparable with Shulman's original vision of teacher knowledge, we follow the model which provides established and clear categories for addressing the features of the educational context (see also Gess-Newsome, 1999a).

The first main category of teacher knowledge is *pedagogical content knowledge* (PCK). PCK is a special knowledge domain distinguishing teachers from other subject specialists (Shulman, 1987; Carlsen, 1999). PCK is a knowledge domain that is a synthesis of all the knowledge needed for teaching and learning a specific topic (e.g., Grossman, 1990; McCaughtry, 2005; Nilsson, 2008; cf. Bromme, 1995). As such, PCK has paved the way for understanding the complex relationship between the contents of chemistry and physics and teaching those subjects by using specific teaching and evaluation methods. PCK has been developed through an integrated process rooted in classroom practice, as Van Driel et al. (1998) state. The aim has been to find implications for PCK both in research and in practice (Gess-Newsome & Lederman, 1999). For example, Hashweh (2005) has defined PCK as:

> *the set or repertoire of private and personal content-specific general event-based as well as story-based pedagogical constructions that the experienced teacher has developed as result of repeated planning and teaching of, and reflection on the teaching of, the most regularly taught topics*. (p. 277)

Actually, following the idea of Hashweh, teaching practice experience is the only plausible way for developing PCK and integrating readiness as a teacher.

The second main category of teacher knowledge is *general pedagogical knowledge* (GPK). As Gore and Gitlin (2004) point out, teachers dismiss pedagogical knowledge based on academic research on the grounds that it is not practical, contextual, credible, and accessible enough. Regarding teachers' pedagogical knowledge, Morine-Dershimer and Kent (1999, 22) argue the particular importance of 'interplay between general pedagogical knowledge, which is derived from the research and scholarly literature, and personal pedagogical knowledge through reflection. Personal pedagogical knowledge is fuelled by personal beliefs and personal practical experience'. In their review of educational research of this area, they claim that general pedagogical knowledge consists of (1) classroom management and organisation, (2) instructional models and strategies, and (3) classroom communication and discourse. Personal pedagogical knowledge is divided into two subcategories, personal beliefs and perceptions, and personal practical experience.

The third main category of teacher knowledge is *subject matter* (*content*) *knowledge*, here expertise in chemistry and physics as a discipline. In addition to subject knowledge teachers need to understand the nature of their discipline and the origins of the knowledge in this discipline. Consequently, subject matter knowledge is the knowledge base, which is essential for a chemistry and physics teacher. According to Gess-Newsome (1999c), research into the knowledge and beliefs of secondary teachers about their subject matter and its impact on the teaching process have been of wide interest. She concludes that attention should be paid to methods of teaching through which the attitudes and knowledge of teachers could be influenced.

An essential characteristic of teacher education in Finland involves research orientation (Jakku-Sihvonen & Niemi, 2006). From the point of view of this orientation, the cognitive skills of a teacher are discussed from two perspectives regarding the stance of a teacher towards pedagogical knowledge; the teacher as a *consumer* and the teacher as a *producer* of knowledge (Gitlin, Barlow, Burbank, Kauchak, & Stevens, 1999; Pendry & Husband, 2000; cf. Reis-Jorge, 2005). A teacher should be able to be both a critical consumer of provided educational knowledge, and be able to build on this knowledge on the based on his/her practical experience. As Cohen (2008) argues, a teacher should gain a vast knowledge base of various domains related to the teaching profession, but applying or reformulating knowledge in order to promote the learner's processes is another story. The role of experience seems to be a central factor when discussing teachers' stances toward educational knowledge and its verification (Joram, 2007). The origin and nature of knowledge are special issues when thinking about the meaning of practical experience as a source for pedagogical knowledge (see also Kosunen & Mikkola, 2002).

In order to face the problem of combining theory with practice, student teachers have been required, for example, to carry out their own small-scale educational research (Gore & Gitlin, 2004). In Finnish teacher education, knowledge about educational research and research methodology are introduced during pedagogical studies. The students become familiar with research literature in their pedagogical studies courses. The argumentation in their final year dissertations must be clear and easy to follow, and their conclusions should follow from the data that they presented. However, like Reis-Jorge (2005) states, it is a challenge for some students to move from reading and consuming educational research towards connecting research knowledge and skills as a part of being a teacher. In this paper, we have considered

educational research (Res.) as a separate subset of pedagogical knowledge due to its special role in the programme.

In all, several disadvantages have been recognised for the domain-based approach of teacher knowledge. Cognitions of teachers, such as the ability to make pedagogical decisions and individuality, are not addressed in the structural models (Carlsen, 1999; cf. Hashweh, 2005). Moreover, basic academic competences, such as research competences, are not emphasised, at least, in the original knowledge categories introduced by Shulman (1986, 1987). However, the structural model is widely used for designing study programmes and clarifying the knowledge base for the teaching profession. When focusing on the teacher education for secondary school chemistry and physics teachers, the domains of teacher knowledge are of special interest.

*Distinction between professional and practitioner knowledge*

When teacher knowledge is a basis for defining the professionalism of a teacher, i.e. defining the knowledge and skills that a teacher should possess, the question of how to obtain and use this knowledge is essential. Hiebert, Gallimore, and Stigler (2002) have examined epistemological features of teacher knowledge by distinguishing between two types of knowledge based on the origin of knowledge: *professional* (*theoretical*) *knowledge* and *practitioner knowledge*.

Professional knowledge because of its generalizability and scientific character, is built upon research-based knowledge on science teaching and learning. However, providing research-based knowledge in such a form that student teachers could adapt it as part of their professional knowledge, is a challenge due to the difficulties of transforming research based knowledge of student teachers' realities, into school practice. Cohen (2008) discusses the requirements for teacher knowledge so it is able to help learners attain expert knowledge that teachers already possess. In this adaption process, a student teacher could be seen not only as a consumer but also as a producer of educational knowledge, i.e., of so-called research-based knowledge (Pendry & Husbands, 2000). The students could become familiar with professional knowledge on pedagogical issues through the research literature and publications. Besides reading the literature, students could get also acquainted with this type of knowledge through doing small-scale educational research. Gitlin, Barlow, Burbank, Kauchak, and Stevens (1999) state the conceptions that student teachers have of research should form the basis for inquiry-oriented teacher education and should pave the way for action research as a part of their training programme. According to Brinkman and van Rens (1999), one solution might be to combine research activities with practical experiences through a research project as a part of teaching practice. Consequently, student teachers need professional knowledge for their professional development.

According to Hiebert et al. (2002), practitioner knowledge has three essential features for a teacher. Firstly, practitioner knowledge is linked with practice, as it develops in response to practical problems in the classroom. Hence, it is grounded in the real life context and addresses specific problems of processes that really exist in the classroom. Secondly, practitioner knowledge is specific, detailed, and concrete. Thirdly, it is integrated, meaning that it is linked with practice and organised by the particularities of practice. Van Driel, Beijaard, Verloop and de Vos (2001) have conceptualised experienced teachers' practical knowledge as action-oriented and person-bound. This knowledge integrates experiential knowledge, formal knowledge, and personal beliefs. When the students participate in the pre-

service teacher education programme, they hardly have any teaching experience and, therefore, it is difficult to adopt strategies like peer coaching or collaborative action research, which work out well in in-service training or in professional development programmes.

In order to transform practitioner knowledge into professional knowledge, some additional requirements have to be addressed in pre-service teacher education. These features relate to making knowledge public and commonly shared. It is important to support teacher students to learn from their experiences in order to face the requirements. Hiebert et al. (2002) emphasise that in order to fulfil such a requirement of publicity, knowledge has to be represented in such a way that it can be communicated with others. Therefore, a different type of support to reflection is needed, for example to reflect on experiences through writing a portfolio during the teaching practice periods. Reflection refers to a process in which an experience is recalled, considered, and evaluated, usually in relation to a broader purpose (Zimmerman, 2002). For example, self-reflective activities such as portfolio assessment work aim at combining theory with practice, and transforming practical experience into a conceptualised and communicative form. Consequently, collaboration becomes essential as it forces participants to make their knowledge public and understood by others. Korthagen (2007) argues that teachers have difficulties in conceptualising their knowledge. Besides being public, knowledge has to be sharable and accumulative. Lastly, Hiebert et al. (2002) state professional knowledge has to be accurate, verifiable, and continually improved.

## A framework for the study: the Finnish education context

### *Finnish Education policy*

This review is based on several official Finnish education policy documents, such as the Education and Research 2003-2008 Development Plan (2004) and Teacher Education Development Programme (2002) and, moreover, on articles written by the people working at the Finnish Ministry of Education (FME) or Finnish National Board of Education (FNBE), such as Jakku-Sihvonen and Niemi (2006) and Laukkanen (2008). Education policy is controlled by FME and FNBE and they are responsible for dthe evelopment of school education, preparation of the *National Core Curriculum for Basic Education* (FNBE, 2004), and the organisation of national evaluations based on samples.

The most important feature of the policy is a commitment to a vision of a knowledge-based-society. This vision can already be found in national documents published in the 70s, where the idea concerning the common comprehensive school and university level teacher education were presented. A central aspect of the vision has been a broad conception of knowledge. In the Finnish school curriculum, equal value has been given to all subjects, with there being a dynamic balance between humanities and science subjects.

Another long-term objective of Finnish education policy has been to raise the general standard of education and to promote educational equality. Basic decisions in this direction were also made during the 1970s along with other Nordic countries, when it was decided to change to a comprehensive obligatory school system. According to this policy all students should go to common comprehensive schools and learn together for as long as possible. Comprehensive school education is provided free of charge, including schoolbooks, meals, transport and health care. According to PISA 2006 School Questionnaire data, 97.1% of the Finnish schools participating in the PISA 2006 were public schools (OECD, 2007a, 2007b). This high percentage can be compared to the average for countries in the Organization for

Economic Co-operation and Development which was 82.7%. Although, the policymakers' vision is that Finnish students complete the same nine year comprehensive school education, some minor grouping of students are made for example in mathematics and foreign languages at the local level, based on students' abilities. Altogether 64.3% of the schools participating in PISA 2006 in Finland reported that students were not grouped by ability into different classes in any subject. Again, the percent for Finland is compared to the average for OECD countries—43.7%.

Although there is a national office, the FNBE, for the implementation of education policy, the local education providers, the municipalities, have strong autonomy. In 65.3% of the schools a principal teacher together with regional or local education authorities (68.1%) formulate the school budget. These percentages are higher than the OECD averages which were 53.2% and 35.1%, respectively. The local education providers are responsible for planning local curriculum and organising general assessment and using these data for evaluating how well the goals have been achieved. The local curriculum is seen more of a process than a product and it has a central role in school improvement. Consequently, there has existed good and flexible interaction between the national, municipal, and school levels. The role of a principal or a head teacher is important in school development and, moreover, in implementation of educational policy at the local level. The participating schools in Finland reported that a principal teacher and teachers were responsible for disciplinary policy (96.0%) and for assessment policy (97.0%). These percentages are higher than the OECD averages—80.5% and 76.9% respectively. (OECD, 2007a, 2007b)

Schools and teachers have been responsible for choosing learning materials and teaching methods since the beginning of the 1990s when the national level inspection of learning materials was terminated. The PISA schools reported that a principal teacher and teachers were responsible for selecting the textbooks (100%), for determining the course content (70.1%), and for courses offered (90.1%). Comparative percentages for OECD were 83.5%, 65.9% and 69.9%, respectively. Moreover, there have been no national or local school inspectors since the late 1980s. Teachers are valued as experts in curriculum development, teaching, and assessment at all levels (FNBE, 2004: OECD, 2007a, 2007b)

The culture of trust refers to education authorities and national level education policymakers believing in teachers, together with principals, headmasters and parents to know how to provide the best possible education for children and youth at a certain level. Also, the parents trust teachers. According to School Questionnaire data only 1.4% of the schools reported *constant pressure* from many parents, who expect schools to help the students more to achieve high academic standards (In OECD the corresponding percentage was 26.1%; OECD, 2007a, 2007b)

*Teacher education in Finland*

Over 30 years ago it was decided that class teachers (for grades 1 – 6 in primary school) and subject teachers in lower and upper secondary schools (grades 7 – 12) should be educated in master's level programmes at universities. Class teachers teach almost all the subjects in primary school, whereas subject teachers typically teach two subjects in lower and upper secondary school.

The present vision in Finnish teacher education of the ideal teacher is that teachers should act as autonomous actors in the teaching profession. This is presented in the Finnish national

level goal setting for teacher education (Jakku-Sihvonen & Niemi, 2006). In addition, according to *Education and Research 2003-2008* (2004) and *Teacher Education Development Programme* (2002) the teacher education programmes should help student teachers among other things to acquire:

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

The research orientation, emphasised in the pedagogical studies, aims to enhance student teachers' capacity for independent critical thinking (Jakku-Sihvonen & Niemi, 2006). The research viewpoint is connected to practice as the students have to learn how to consume and also how to produce educational knowledge (research) as part of being a teacher (Pendry & Husbands, 2000; cf. Gitlin et al., 1999). In addition, reflective and analytical thinking is promoted by reflective activities related to teaching practice experience, for example through portfolio assessment work which supports students in setting personal aims for the practice and in evaluating the practice. Consequently, the general aim of Finnish teacher education is to support students to become experts in planning, implementation, evaluation and the development of teaching. A teacher is seen as a reflective practitioner who has a strong personal-practical theory of education and is able to combine educational theories with practice and their previous knowledge base.

Physics, chemistry, and biology teacher education is organised in co-operation with the Faculty of Science and the Faculty of Education. The studies are divided into two parts: the subject is studied at the department of the particular subject (e.g. physics) and the pedagogical studies at the department of teacher education. In the subject teacher education programme students take a major and a minor in the subjects they intend to teach in school (Lavonen, Krzywacki-Vainio, Aksela, Krokfors, Oikkonen & Saarikko, 2007).

At the University of Helsinki, as well as in other Finnish universities, at the master's level the major subject, chemistry or physics, make up the main component of the teacher education programme. The studies in question embody a master's degree programme (300 cp[1]) which takes approximately five or six years to complete. The programme consists of subject matter studies, i.e. studies in chemistry or physics as a major (150 cp), studies in another school subject such as mathematics (60 cp), and one year of pedagogical studies (60 cp) including supervised teaching practice modules (20 cp) provided at the Department of Teacher Education. In addition, language and communication studies are included in the programme.

During the subject studies the students participate in university level undergraduate courses at the subject department. These courses help students to develop a deep understanding of subject matter knowledge and concepts as part of a conceptual framework of the subject. The advanced study courses introduce the students, for example, to the central notions of science,

1 1 credit point (cp) equals approximately 27 hours of academic work

its epistemology and methodology and the interaction between science and technology, conceptual and process structures of the main areas of school chemistry and physics, methods for planning and carrying out experiments and demonstrations in the chemistry and physics classroom, the history and philosophy of science and its relations to society and technology (Lavonen, Jauhiainen, Koponen & Kurki-Suonio, 2004). One general assumption in secondary teacher education programme is: Teachers need strong competency in the subject (an expert's knowledge) when they guide students' learning and problem solving.

During the pedagogical studies, the students' subject knowledge, knowledge about teaching and learning, mathematics and science education and school practises are integrated into the students' own personal pedagogical theory. 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 broadly on their own personal pedagogical "theory" or assumptions on their own work, and have the potential for lifelong professional development. During the studies the students' become especially familiar with science teaching methods and issues considering learning, attitudes, motivation and interest. As the classroom size is small and heterogeneous according to the abilities of students, much emphasis is given to different types of science learners and teachers' roles through informal assessment and feedback and encouragement to students (Lavonen & al., 2007). An essential characteristic in the pedagogical studies is research-orientation, which supports student teachers in constructing a solid knowledge base. Teachers benefit from the research orientation while they make the school curriculum, plan, implement and evaluate teaching and learning.

According to PISA 2006 School Questionnaire data, 97.2% of the schools reported that there was no serious lack of physics, chemistry, or biology teachers (OECD 81.9%). On average 10% of full-time teachers in the participating schools did not have the appropriate qualification. Consequently, in most of the schools there were highly educated and qualified teachers with an in-deep subject matter and pedagogical knowledge. As there are no inspectors, national evaluation of learning materials or national assessment, teachers are entrusted with a lot of responsibility for their pupils' learning.

The teaching profession in Finland has always enjoyed great public respect and appreciation (Simola, 2005). Teachers can independently select the most appropriate pedagogical methods. The teacher profession, especially at the primary level, is also very popular and teacher-education departments can select from among the nation's best students with the highest scorers in the university entrance examinations (Jakku-Sihvonen & Niemi, 2006).

*Chemistry and physics teachers' pedagogical studies*

The main idea of the pedagogical studies is to help students to combine educational theories with practice, their former knowledge about and of chemistry and physics as well as with their personal history (cf. Trotman and Kerr, 2001). The courses can be classified in three categories: general courses in education, subject courses in education and teaching practice (Table 1).

Typically, the following areas are discussed within studies in chemistry and physics pedagogy courses: teaching and learning science, students' interest and motivation in science, national and local curriculum including curriculum planning, teaching methods, ICT in science education. Within the courses in education, student teachers become familiar with the

Table 1. The structure of the pedagogical studies in subject teacher education

| Pedagogical studies | | | |
|---|---|---|---|
| General courses on education, teaching and learning 13 cp | Chemistry and physics Pedagogy 17 cp | Educational research 10 cp | Teaching practice 20 cp |
| - Psychology of development and learning, 4 cp<br>- Special needs education, 4 cp<br>- Social, historical, and philosophical basis of education, 4 cp | - Psychological basis of teaching and learning the subject,<br>- Curriculum development and the planning of teaching<br>- Evaluation of teaching and learning of the subject | - Research methodology in education 3 cp<br>- Teacher as a researcher-seminar 3 cp<br>- Minor dissertation in pedagogy, 4 cp | - Supervised teaching practice (basic, applied and advanced) 18 cp<br>- Reflection supported by portfolio assessment work 2 cp |

psychology, sociology and philosophy of learning, the history of education, multicultural aspects of education and special education. One-third of the pedagogical studies consist of teaching practice (20 cp).

It is a challenge to combine theoretical studies with teaching practice. Many students feel, especially at the beginning of their studies that theory and research-based knowledge about teaching and learning a subject is something that they must study but which is not closely related to their actual work as a teacher. Therefore, theoretical studies within the programme are linked to school practice in several ways. The need for combining theory with practice has been addressed by intertwining different courses together through timing, methodological choices, and contents within the pedagogical studies. At the beginning of the students' studies, the theoretical basis for teaching and learning of a subject is introduced and students also visit schools to observe lessons and, moreover, participate in micro teaching sessions. Apart from this, the students have to read reference books, web pages and, research articles while also participating in lectures and teaching practice.

Moreover, professional knowledge is combined with practice by using portfolio assessment work as part of the pedagogical studies in order to promote reflective thinking. When processing portfolios, teacher students are made to combine both theoretical knowledge and practical work. The learning of analytical skills for reflection has been considered an important aim in the teacher education programme. These skills are needed in the teacher profession in decision making and in justifying actions. During the basic teaching practice, the students plan teaching sessions in small co-operative groups and also teach together in a classroom. The students collect empirical data, based on research questions, analyse the data and write a small-scale pedagogical dissertation during the advanced teaching practice period. The aim is to reflect broadly on one's own personal pedagogical 'theory' and stances towards the teaching profession in order to gain potential for lifelong professional development.

**Method for analysing the pedagogical studies**

In order to answer the research question, the study programme of the pedagogical studies was analysed following the principles of theory-driven content analysis (Patton, 2002). The curriculum of the study programme includes general descriptions of the content and goals set for all six courses and three teaching practice periods. In all, the programme document is 32 standard pages long. Content analysis started with the themes of teacher knowledge domains and origin of teacher knowledge derived from the following research literature:

- Teacher knowledge domains: General Pedagogical Knowledge (GPK); Pedagogical Content Knowledge (PCK); Educational research (Res)
- Origin of teacher knowledge: Professional (Theoretical) knowledge (Prof); Practical knowledge (Prac)

Expressions in the programme referring to knowledge construction through practical experience were classified into the category of teacher knowledge domains 'Educational research'. In the analysis, we deduced that student teachers are seen as critical consumers of research knowledge while they are conceptualising their experiences during the teaching practice periods. Secondly, reduced expressions were established after categorising the original expressions of the programme document. Lastly, the reduced expressions were coded and categorised by the same researcher. It was a challenge to analyse and not possible to categorise the courses exclusively because support for constructing different knowledge domains overlaps with general courses on education and subject pedagogy (subject didactics) courses. Moreover, practical knowledge is not only constructed in teaching practice but also during the theoretical courses (e.g., educational research). Similarly, theory is applied in teaching practice for example when justifying pedagogical decisions in the classroom. Therefore, each expression was categorised independently, and as a result, some courses focus on all three knowledge domains.

## Results

We present the results of analysis in two parts in accordance with the research questions. The analysis of the curriculum of the pedagogical studies as a part of the teacher education programme started with two broad categories that reflected the primary focus of the study of how teacher knowledge is approached in the pedagogical studies of chemistry and physics teacher education. Therefore, the aim of the content analysis was first to clarify what kinds of knowledge and topics are indicated in the programme and how knowledge construction is to be promoted in the studies. In Table 2, the main categories that emerged in the document are presented alongside the definitions of the categories and examples of the original expressions for each category. The main categories indicate which themes students are to get familiar with during their pedagogical studies. In general, diverse aspects of teaching, studying and learning are discussed in the pedagogical courses in order to provide a broad readiness for acting as a teacher.

In Table 3, the results of the content analysis about separate courses of the pedagogical studies in accordance with the domains of teacher knowledge are presented. The original expressions were classified according to the domains of teacher knowledge. The reduced expressions about learning objectives for student teachers were divided almost equally into the different domains of teacher knowledge: General Pedagogical Knowledge (GPK), Pedagogical Content Knowledge (PCK), and Educational research (Res). Student teachers' ability to support their students to gain knowledge and skills through different teaching and learning activities was frequently mentioned as a learning objective (14). The second most common theme regards reflection. It is noteworthy that some courses, e.g., teaching practice periods, consist of different knowledge basis and therefore, analysis is not exclusive.

Since the other perspective to knowledge construction was concerned with the origin of knowledge, the programme was also analysed starting with the themes of professional (theoretical) and practitioner knowledge. Altogether, 45 original descriptions in the programme reflecting professional (theoretical) knowledge and 33 descriptions reflecting

Table 2. The main categories of the contents presented with definitions and examples of the original expressions

| Main categories | Definition | Examples of original expressions *) |
|---|---|---|
| learning of an individual | Student teachers learn to guide students at school to learn knowledge or skills through teaching and learning activities | - School as a learning and operating environment<br>- Student teachers learn to use versatile teaching methods, information and communication technology in chemistry and physics (Eval.) |
| different needs of students | Student teachers learn to take into account different needs of students and learn to identify their learning difficulties | - Student teachers learn to identify different kinds of learners (B_prac.)<br>- Student teachers learn to identify pupils' learning difficulties (Spe.) |
| learning (and development) of a group | Student teachers learn to guide students at school to acquire knowledge or skills through co-operative teaching and learning activities | - Student teachers become familiar with the development of a group (Psy.) |
| designing instruction based on the nature of science | Student teachers learn to design chemistry and physics teaching and take into account the nature of science | - Student teachers learn to design chemistry and physics teaching by taking into consideration the epistemological and ontological assumptions of the subject (Eval.) |
| consuming of educational research | Student teachers learn to apply research based knowledge to the planning of teaching and to the organising of the teaching and learning activities | - Student teachers learn to apply research based knowledge in school teaching (Sem.) |
| producing educational research | Student teachers learn to do small scale educational research | - Student teachers learn in seminars how to use research methodology for education (Sem) |
| reflection | Reflection refers to an activity in which an experience is recalled, considered, and evaluated (this process is grounded in research) | - Student teachers learn to think and to analyse their own and others' teaching, (B_prac.) |
| school – society link | Student teachers learn about school as an institute having a curriculum and being a part of society | - Student teachers learn to design chemistry and physics teaching by taking into consideration the national curriculum (Cur.) |
| school practice | Student teachers learn about school as an operational environment where different kinds of professionals are working | - Student teachers learn to work in an expert network of the school and take into consideration responsibilities and co-operation (Ad._prac.) |
| skills for interaction | Student teachers learn interactional skills | - The significance of the interaction between an individual and a group is highlighted (Psy.) |
| use of ICT in learning | Student teachers learn to use ICT in teaching and learning | - Student teachers develop a readiness to utilise information and communication technology in the teaching of chemistry and physics (B_prac) |

*) Psy. = Psychology of development and learning; Spe. = Special needs education; Phil. = Social, historical, and philosophical basis of education; Cur. = Curriculum development and planning of chemistry and physics teaching; Eval.= Evaluation of chemistry and physics teaching and learning; Sem. = Research methodology in education and teacher as a researcher-seminar; B_prac. = Basic Supervised teaching practice; Ap._prac. = Applied Supervised teaching practice; Ad._prac. = Advanced Supervised teaching practice

Table 3. The study programme from the perspective of different teacher knowledge domains (number of reduced expressions).

| *) **) | GPK (25) | PCK (27) | Res (25) |
|---|---|---|---|
| Psy | learning (and development) of a group (5)<br>skills for interaction (1) | | |
| Spe. | different needs of students (4)<br>learning (and development) of an individual (1) | | |
| Phil | school – society link (3) | | |
| Cur. | | learning of an individual (3)<br>school – society link (2)<br>learning of a group (1)<br>use of ICT in learning (1)<br>design teaching based on nature of science (1) | reflection (1) |
| Eval. | school – society link (1) | learning of an individual (4)<br>school – society link (4)<br>design teaching based on the nature of science (1) | reflection (2) |
| Sem. | | | consuming educational research (4)<br>producing educational research (4) |
| B_prac. | different needs of students (2)<br>school – society links (1)<br>school practice (1) | learning of an individual (1)<br>use of ICT in learning (1) | reflection (3)<br>consuming educational research (2) |
| Ap._prac. | school practice (1) | learning of an individual (1) | reflection (2) |
| Ad._prac. | different needs of students (2)<br>school – society links (1)<br>school practice (3) | learning of an individual (4)<br>school – society links (2)<br>use of ICT in learning (1) | reflection (2)<br>consuming educational research (1) |
| Ref. | | | reflection (3)<br>consuming educational research (1) |

*)
Domains of teacher knowledge
GPK = General Pedagogical Knowledge
PCK = Pedagogical Content Knowledge
Res. = Educational research

**)
General courses on education, teaching and learning 13 cp
Psy. = Psychology of development and learning, 4 cp
Spe. = Special needs education, 4 cp
Phil. = Social, historical, and the philosophical basis of education, 4 cp
Chemistry and physics Pedagogy 17 cp
Cur. = Curriculum development and planning of teaching
Eval.= Evaluation of teaching and learning
Educational research10 cp
Sem. = Research methodology in education and teacher as a researcher-seminar 10 cp
Teaching practice 20 cp
B_prac. = Basic Supervised teaching practice 7 cp
Ap._prac. = Applied Supervised teaching practice 5 cp
Ad._prac. = Advanced Supervised teaching practice 8 cp
Ref. = Reflection supported by portfolio assessment work.

practitioner knowledge were found. The distinction between these two categories was not easy to interpret based on the written document, which was focused on the contents and main principles of the pedagogical studies. We also needed to consider the methods used in the course when categorising the expressions of the written document. An academic approach to learn how to teach emerges in the curriculum, for example, through aims related to getting familiar with the psychological basis of teaching and learning and carrying out a minor piece

of educational research. Practitioner knowledge is naturally brought up in the section concerning teaching practice and activities related to practical experiences. A student teacher is supposed to develop skills through practical experience. Some examples of the original expressions are given below.

Examples of the original expressions in the programme reflecting professional (theoretical) knowledge:

- A student teacher becomes familiar with the development of an individual
- A student teacher learns to identify different needs for the pupils'
- Student teachers improve their ability to discuss contradictory claims which are directed at the school system,
- Student teachers learn how to design chemistry and physics teaching while taking into consideration the national curriculum
- Student teachers learn how to use diverse evaluation methods in teaching and learning chemistry and physics,
- Student teachers learn in seminars how to make a pedagogical research plan.

Examples of the original expressions in the programme reflecting practitioner knowledge:

- Student teachers learn to think and to analyse their own and others' teaching,
- A student teacher learns how to design and carry out chemistry and physics teaching sequences independently and to take responsibility for teaching following ethical principles
- A student teacher learns how to act in a multicultural school environment

## Discussion

The aim of this paper was to discuss the Finnish education context in general and especially the chemistry and physics teacher education programme from the point of view of teacher knowledge construction. We have analysed the curriculum of the teacher education programme from two perspectives related to teacher knowledge: the domains and the origin of teacher knowledge were of special interest. In the following, we illustrate how the findings could guide decisions for development of the teacher education programme and how the results can add to empirical knowledge about teacher education. Furthermore, even if building up readiness as a professional teacher with a solid knowledge base and potential to apply such knowledge in teaching is a complicated phenomenon, a structural approach to knowledge construction is helpful in designing and developing educational programmes (cf. Carlsen, 1999).

### *The domains of teacher knowledge approached in teacher education*

The general aim of pedagogical studies in Finland is to help the students to integrate subject knowledge, knowledge about teaching and learning and school practice into their own personal pedagogical theory about teaching, studying and learning processes (see Lavonen et al., 2007). However, the teacher education programme is organised according to separate knowledge domains. The study programme of the pedagogical studies consists of three different subsets: general courses in education, pedagogical courses concentrating on the questions of teaching a specific subject and teaching practice periods. Student teachers learn about different domains of teacher knowledge while they participate in the courses. General Pedagogical Knowledge (GPK) is learned during the general educational courses and, the course in subject pedagogy and also during the teaching practice. Pedagogical Content Knowledge (PCK) is learned especially during the pedagogy courses alongside the teaching practice. The potential to consume and produce educational research is at the focus of the pedagogical courses and teaching practice periods.

In order to achieve the aim of constructing a solid knowledge base, an individual should be able to internalise and integrate pieces of separate knowledge domains as a coherent entity. With the help of guidance, student teachers should be able to integrate separate knowledge areas into a coherent knowledge base that constitutes a starting point for pedagogical thinking and for individual decision-making (e.g., Jakku-Sihvonen & Niemi, 2006; Kansanen et al., 2000). The structure itself does not enhance integration of different knowledge domains as a coherent entity. However, based on the students' course evaluations, the research orientation of the programme seems to support the knowledge building of most of the student teachers.

The special challenge is whether and how it is possible to teach and learn issues included in pedagogical content knowledge (PCK). As Hashweh (2005) states, knowledge domains should be called 'teacher pedagogical constructions' instead of pedagogical content knowledge. Furthermore, he claims that pedagogical constructions are mainly developed through practical experience through continuous planning and teaching activities (see also Gess-Newsome, 1999b). In the programme, some issues are discussed concerning the teaching and learning of a particular school subject, e.g., chemistry and physics. Therefore, some methods and pedagogical ideas especially related to particular topics are discussed in the pedagogy course. Furthermore, since the amount of teaching practice is rather limited in Finnish secondary teacher education, special attention should be paid to the quality of activities and support for student teachers' personal process. Teacher students' ability to reflect on their actions is essential in this matter, and furthermore, to be aware of the aim indicating the potential of acting flexibly and innovatively in different educational situations. Reflective activities play a special role in pedagogical studies when looking at pedagogical content knowledge.

*The origins of teacher knowledge in teacher education*

The Finnish teacher education programme appreciates both practitioner and professional knowledge (Hiebert et al., 2002). On the one hand, professional knowledge is learned through courses, through reading academic books and through making one's own small-scale pedagogical research. On the other hand, students analyse their practical experiences acquired in teaching practice. Practical knowledge also provides a readiness for surviving the practicalities of the teaching profession. Consequently, science teaching is not only based on different knowledge areas, but a teacher should also be able to apply knowledge (consuming educational knowledge) and competences as a part of his/her pedagogical thinking when making decisions and justifying actions in the classroom. The teaching practice periods are important not only for learning practicalities but also as an opportunity to apply knowledge and skills acquired in theoretical studies. It is noteworthy that in addition to acting in the classroom, designing and evaluating one's actions is also significant (see e.g., Hashweh, 2005).

From the epistemological viewpoint, it is a challenge for students to combine two forms of knowledge, practical and professional knowledge (Hiebert et al., 2002). The research-based approach in the teacher education programme influences both the contents provided during the programme, such as the literature to be read and the theoretical parts of the studies, and activities that students engage in, such as producing an educational minor dissertation in chemistry and physics education. The aim of portfolio work can also be interpreted as transforming practical knowledge into professional knowledge. The requirements for knowledge to be professional knowledge, such as being public and precise as well as

conceptualised, are essential to the process (Hiebert et al., 2002). It is a two-way process with a starting point based on particular practical experience as well as professional educational knowledge constructed beforehand. Practical experiences are needed in this process, and therefore, with a limited amount of practical studies, teacher education should provide for students basic competences for further development in school work.

*The research orientation in the pedagogical studies*

The original division in the domains of teacher knowledge does not especially consider the meaning of educational research knowledge for a future teacher. From the viewpoint of a professional and practical approach for the origin of teacher knowledge (Hiebert et al., 2002), the programme implementation appears slightly complicated. Students acquaint themselves with professional knowledge through different courses, taking both roles as a consumer and a producer of research based knowledge (Pendry and Husbands, 2000). Students claimed that they wanted to build up a coherent understanding of educational issues that could be used as a ground for conceptualisation in the future. Later during the studies, practical issues were seen as being more crucial for their own development. Altogether, emphasis on the dichotomy between theory and practice does not describe the experiences of students in a purposeful way. One solution could be to discuss the differences between taking a role as a producer and consumer of the pedagogical research during the studies. The students have reservations about the research orientation in pedagogical studies (cf. Gitlin et al., 1999). Based on the students' evaluations, they evaluate the pedagogical studies from the point of view of their current situation – not holistically from the point of view of the teacher profession of which they have no experience. It is a challenge to motivate the students in their own research and how to get them to learn the professional knowledge needed in developing their own teaching professions. The second challenge is to help students to connect the educational research-orientation with being a future teacher and as a vital part of their pedagogical thinking and decision making, not just as a part of their pre-service studies. Students need help with getting familiar with research based knowledge and the use of that knowledge.

*Conclusions*

In all, the teacher education programme can be developed on two levels, regarding the aims and contents in the curriculum and the implementation of the programme. We need to consider not only the structure of the programme and organisational issues but also the origin of knowledge and epistemological assumptions underlying the teacher study programme. The way student teachers are supported in knowledge construction, referring to the methods used in the courses, is essential. Naturally, different knowledge domains need to be discussed in the courses, but in the long run, reflective thinking skills and support for personal professional development matters the most. The main challenge is to support future teachers in fulfilling their potential as professionals through integrating theoretical knowledge, individual experiences and knowledge created in practice and readiness for the developmental process with each other. Both practical and theoretical approaches are at the core of knowledge construction.

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