Pre-service mathematics teacher education orienting the formation of teacher identity - mathematical education as the basis for development

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Abstract: *The article discusses mathematical education as a part of Finnish secondary teacher education and its meaning for orienting the formation of individual teacher identity. Theoretical framework of the research is based on a concept of teacher identity which can be described in different developmental phases through cognitive and affective aspects related to becoming and being a teacher. Formation of teacher identity can be seen as a process of filling the gab between a present state and an ideal image of a good teacher representing conscious personal aims. The structure of the teacher education programme is described and the focus is on mathematical education guiding individual development. Results of evaluative case study are based on two sources: the written curriculum and semi-structured interviews of teacher educators (N=11) responsible for the implementation. According to the data, the aim of mathematical education is to form a basis for academic expertise in teaching and learning mathematics as well as ability to further development in work. Still, affective aspects of becoming and being a teacher are not especially addressed during mathematical education. Academic teacher education seems to fail to support student teachers in combining subjective aspects with academic cognitive knowledge and skills in the best possible way.*

Introduction

In this paper, pre-service mathematics teacher education in Finland is discussed focusing on mathematical education included in the programme and its meaning for the formation of teacher identity. The role of studies in university mathematics is emphasised in Finnish pre-service mathematics teacher education. The central idea is that all subject teachers qualified for teaching in secondary or upper secondary school should be experts both in teaching and learning and in subject matter knowledge and skills. Mathematical education included in the programme is examined due to its meaning for becoming a teacher, i.e. for the formation of individual teacher identity.

Master level studies in university mathematics are the main component of the mathematics teacher education programme. The studies in question embody a master's degree pre-service mathematics teacher education programme (300 cp[1]) which takes approximately five or six years to complete. The programme consists of mathematical education, i.e. studies in university mathematics as a major (150 cp), studies in another school subject like chemistry or physics (60 cp) besides one year of educational studies (60 cp) including supervised teaching practice modules (20 cp). In addition, language and communication studies are included in the programme. Moreover, the characterising feature of Finnish teacher education is a research-based approach as the main organising theme, emphasising teacher's pedagogical thinking. A teacher is seen as a reflective practitioner who has a strong personal-practical theory of mathematics education. In practice, all mathematics student teachers complete both master's thesis in their

[1] 1 credit point (cp) means approximately 27 hours work

major subject (30 cp) and a minor educational thesis (10 cp) within the educational studies. The aim is to achieve high level thinking and reflective skills both in subject matter and educational issues as well as skills for continuing professional development in future. (see Lavonen et al., 2007)

The Department of Mathematics is responsible for mathematical education which is the same for all university mathematics students on bachelor's level despite their intended specialisation. However, two special mathematical courses for future teachers are provided on master level; one course on geometry (10 cp) and another course for teacher students (12 cp) focusing on integrating university mathematics with school contents. Students may apply in the teacher education programme in every phase of their studies in mathematics. Still, the educational studies provided by Department of Applied Sciences of Education are usually completed after 4th or 5th study year because of the structure of the programme. The constraint is that students have to complete enough studies in mathematics and in another school subject to ensure the level of subject matter knowledge and skills before entering teaching practice.

Following the principals of evaluative case study (Stake, 1995; Patton, 1997), it is necessary to discuss the purpose of the research. Firstly, research on process that takes place during the programme is needed to understand the meaning of different components of the programme. The programme is designed in a way that basic knowledge and skills on teaching mathematics should be acquired during separate courses on university mathematics and educational studies. Still, it seems to be a challenge for students to combine discrete pieces of knowledge and skills as an integrated part of their own development. Secondly, evaluation on programme implementation is needed in order to make hidden agenda visible behind the official written curriculum. In Finnish academic tradition, all teacher educators have freedom to interpret the aims and implement the programme from their viewpoint. However, when developing the study programme it is important to be aware of all aspects influencing programme implementation. In addition, written curriculum is a way to inform both students and all teacher educators about the aims and contents included in the programme.

This case study is a part of wider evaluation study on the programme implementation which examines what kind of processes take place during the programme and how individual development of student teachers is supported. It seems to be important to look carefully how student teachers are guided toward personal development as a teacher, not only within educational studies but also during mathematical education. Creating a positive environment for personal development is on all teacher educators' responsibility during the study programme. In this paper, the focus is on the role of mathematical education and how student teachers are guided toward adopting teacher identity during teacher education. The research question is what is the meaning of mathematical education integrated into the programme for orienting the formation of individual teacher identity.

Theoretical framework

The theoretical framework is based on a concept of individual teacher identity and its formation during teacher education. Three features of teacher identity and its formation seem to be essential on the basis of literature. Firstly, the state of teacher identity can be characterised through different cognitive and affective aspects related to teacher profession in certain time and place, like taking a photo. From cognitive viewpoint, teacher identity might be seen as associated with professional knowledge and skills in terms of expertise on subject matter, pedagogy and didactical issues (Beijaard et al., 2000, see also Shulman, 1987). It is not only about knowledge of something but also skills related to specific content. These cognitive aspects like mathematical knowledge and analytical skills are emphasised in academic mathematics teacher education in

Finland (e.g. Lavonen et al., 2007). In this research, special interest is in the role of mathematical knowledge and skills in student teacher's process of becoming a teacher. Besides cognitive aspects, teacher identity includes affective aspect as subjective viewpoints that take place in development process (e.g., Hodgen & Askew, 2007). Individual feelings and beliefs related to becoming and being a teacher arise during teacher education and should be taken into consideration. It is not only about attitudes toward and values related to teacher profession but also experiences and feelings when acting as a teacher. Analytical tools for reflection do not always promote student's ability to connect affective aspects brought up during the development process with academic knowledge (cf. Smith, 2007).

Secondly, image of an ideal teacher is essential in formation of individual teacher identity (Sfard & Prusak, 2005; Arnon & Reichel, 2007). Students have conceptions of good teaching and learning in mathematics, especially of ability and skills needed as a mathematics teacher. Their own individual experiences in learning school mathematics form the basis for their conceptions. An ideal image might also change partly because of new ideas and experiences provided in teacher education. The image of an ideal teacher changes through interaction with others, not only during teacher education but further in school work as well. At the same time, student teachers reflect on their present state based on their experiences and notions of similarities and differences with others. Formation of teacher identity may be seen as process of filling the gap between present and ideal images (Sfard & Prusak, 2005). Identity is seen here as dynamic and never fixed as it is continually in flux and under construction (e.g., Danielewicz, 2001). However, a state of identity can be recognised in different moments and contexts through aspects described above which makes reflection of identity possible.

Thirdly, it is a challenge to support student teachers' engagement in the intrinsic processes related to formation of teacher identity during teacher education. Danielewicz (2001) discuss the meaning of engagement in becoming and being a good teacher that is crucial in the process. In academic teacher education, the basic idea is that student teachers should be willing to develop themselves as a teacher, i.e. to be aware of their competence momentarily and intentionally fill the gap between present and ideal image representing conscious personal aims. The concept of teacher identity includes the idea of difference between acting as a teacher and being a teacher, i.e. adopting teacher identity (Beijaard et al., 2000; Danielewizc, 2001). The growth of academic competence in mathematical knowledge and skills has a central role in Finnish university teacher education. However, as Atkinson (2004) claims, it is not simple to offer the proper learning environment with stimulating activities for student teachers. Teacher identity cannot be influenced directly and all knowledge and skills offered during the teacher education programme will not be adopted by students (Korthagen, 2004). Moreover, both cognitive and affective aspects described above should be addressed in order to support students' personal development.

Methods

The research is engaged in evaluative case study approach (Stake, 1995; cf. Patton, 1997). According to Patton (1997), the internal dynamics and actual operations are emphasised when trying to understand the procedures within a programme. The research data is based on two different sources, the written curriculum of the pre-service teacher education programme in University of Helsinki and interviews of eleven teacher educators selected based on purposeful sampling: mathematical education (2), mathematics education (2), general educational studies (4), and supervised teaching practice in mathematics (3). Teacher educators responsible for implementing different parts of the programme gave an insight of procedures experienced and understood by them. The semi-structured interviews took place in the spring of 2006. The idea of the interviews was to reveal teacher educators' main intentions and experiences related to the programme. Starting points and background of the educators were primarily discussed in order to

better understand and interpret the main intentions of the educators. The following themes were discussed during the interviews:

- Role as a teacher educator and cooperation with other teacher educators involved in the programme
- Conceptions on teaching and learning in general and especially in mathematics (How is a good subject / mathematics teacher like? What kind of knowledge and skills is required as a mathematics teacher?)
- Relevance and objectives of teacher education: own course(s) and the whole study programme (goals, implementation and evaluation)

The interview data was analysed following the principles of the analytic induction starting with three themes described above (Patton, 2002). The researcher used semi-structured interview technique in order to reveal each teacher educators' starting points and role in implementation of the programme. The overall view of programme implementation was formed based on the descriptions of separate cases of each teacher educator in which intention and central aims of the courses were of interest. In addition to the interview data, the written curriculum was analysed concentrating on aims and descriptions of implementation. Reduced expressions were formed and the description of the programme was made. In the final state of the content analysis, descriptions of the data based on the interviews and curriculum were juxtaposed and compared. Besides, member checking was used and teacher educators were asked to review the descriptions for accuracy and palatability (Stake 1995, 115-116).

Results

The meaning of mathematical education within mathematics teacher education is discussed and described according to cognitive and affective aspects of teacher identity. It is essential to understand how the whole programme is implemented and what kind of role mathematical education has for identity formation according to both curriculum and other teacher educators. On one hand, studies in mathematics are described and discussed according to cognitive aims set for the studies. On the other hand, the meaning of mathematical education integrated into the programme is discussed from affective aspects related to formation of teacher identity.

Mathematical education comprises approximately a half of the studies in teacher education (150 cp). Written curriculum for studies in mathematics in the department of mathematics is actually a description of central concepts and themes which are examined during the courses with no explicated aims for learning and understanding. Particular learning objectives are described only for master's thesis in mathematics where the central idea is to learn more about mathematical formulation and to be able to produce simple but precise mathematical text in a master level thesis.

Firstly, basic knowledge and skills in university mathematics seem to be the basis for mathematics teachers. All bachelor degree courses are the same for all students in all programmes including courses in algebra, analysis, geometry, topology, and probability for example. According to the interviews of lecturers in mathematics, the central aim is to provide all students basic knowledge and skills needed in future despite further specialisation. Actually, both educators who were selected to participate in the research as key persons of mathematical education discussed their role as a real teacher educator with doubts. They considered their role as educators not only for teacher students but for all mathematics students. Teacher education seemed to be more like administrational tasks for them.

> It is hard to say if I'm really a teacher educator. One could say so on the basis of administrational tasks… but the main part of my work has been to support all students at the beginning of their mathematical studies. Teacher students are among others but perspective and intention differs a little bit… (Educator 3, 4-5)

Secondly, discrete pieces of mathematical knowledge and skills are not enough. It is important to help teacher students to construct a coherent view on mathematics on the basis of separate courses during studies in mathematics. Expertise in subject matter knowledge and skills is more than competence in separate parts, understanding the nature of mathematics as a discipline. Furthermore, mathematical reasoning and thinking are also a central aim for pre-service teachers which can be gained only through student's own active learning process. Both educators in mathematical education emphasised a need to combine university mathematics with school teaching during two special courses in master level studies.

> One has to construct more coherent and accurate view on mathematics, defining of separate pieces. Teaching is localised, piece by piece, but a teacher should be able to integrate the pieces with wider mathematical context. It is not always successful as integration should take place in students' mind. It is a matter of learning, not teaching. (Educator 5, 36)

> A teacher should know mathematics deeply, more than actually is taught as constructing a coherent view on mathematics is important. Separate pieces of mathematical knowledge are not enough. (Educator 5, 55)

Thirdly, mathematical education seems to have a slightly different role from perspective of the whole programme. An overall view on the programme is needed when picturing up the meaning of mathematical education for individual development during the programme. Through studies in mathematics, students should be able to gain expertise in subject matter knowledge and skills which is the basis for becoming a good teacher but relevant only when combined with educational knowledge. The importance of mathematical education is related to teacher's ability for pedagogical thinking and being able to apply subject matter knowledge in a meaningful way in the classroom. Besides, mathematical language which is hopefully learned during studies in mathematics is also a tool for learning.

> Students should gain ability to think, expertise on subject and education of that particular subject. Still, they should become educators in general at the same time. (Educator 2, 52)

Expertise in mathematics is needed also in further development in work. Teachers should be able to study on their own to strengthen their subject matter knowledge and skills. Within the teacher education, student's readiness for acting as a teacher is put to test in supervised teaching practice.

> Surprisingly, subject matter knowledge is not good enough, no coherent view on mathematics… some students do not even master contents which are taught in high school. It is not problematic for classroom management or acting as a teacher in front of the classroom but for finding the central idea. Subject matter knowledge might be fragmentised. (Educator 7, 130-132)

Although only cognitive aspects are emphasised in mathematical education according to the written curriculum, themes related affective aspects in studying mathematics in general were brought up. Hidden agenda seems to exist behind the written curriculum. It is important to motivate and support all students at the beginning of studies in mathematics. Entering a new world of mathematics after high school might be shocking and thereupon students need help in committing to work for learning and understanding mathematics. Teacher students should also become truly interested in mathematics as a discipline.

> First of all, students should get used to studying mathematics at university level. Secondly, they should learn mathematics enough to be able to continue their studies in mathematics. That means reflection on central ideas and in my course it is related to understanding limiting value. (Educator 3, 64)

In general, mathematics can be learned only through individual process meaning that student's active role in studies is emphasised by the educators. Besides, individual learning process with different phases could also be facilitating the process of becoming a teacher if students became aware of their own learning process and strategies in mathematics on meta-level.

> In teacher education, subject departments have a central and important role… of course learning mathematical skills and knowledge but also providing learning experiences during the studies. It could be positive experience to widen a view both on learning and mathematics, probably on methods as well… (Educator 3, 66)

According to the interviews of teacher educators, the central aim for mathematical education should not only be related to build up subject matter expertise but also to motivate and inspire teacher students for teaching and learning mathematics.

> If students are motivated to become a teacher… It is not about external motives but willingness to develop as a teacher and then it is possible to influence within teacher education. (Educator 7, 154)

Especially, teacher educators responsible for mathematics education and educational studies stressed the meaning of mathematical education in orienting students toward becoming a teacher.

> I'm afraid that many students want qualification as a teacher because they are not competent enough to be researchers. Still, they need to become something…but being a teacher is not their first priority. (Educator 13, 19)

Studies in mathematics are also related to self-confidence and a need for feeling competent enough as a mathematics teacher. On one hand, to be an expert in mathematical knowledge and skills seem to be one way to strengthen students' self-confidence. Mathematical competence could be a solid base for developing authority needed in the classroom. On the other hand, mathematical knowledge and skills are valuable only when combined with sufficient self-confidence as a teacher which should be gained during the programme.

> Subject matter knowledge and skills are not the main point but self-confidence, to trust oneself. If one is self-confident overwhelming subject matter knowledge and skills are not needed. However, expertise in subject matter may enhance self-confidence. (Educator 11, 16)

An active role of students is mentioned based on the central idea of a teacher who is able to develop oneself also at work. Activities which facilitate students' own thinking and make them take responsibility for learning and becoming a teacher are emphasised by the educators as well as in the curriculum. Students should be able to find identity as a teacher during their studies in mathematics and start to construct their own conceptions of being a teacher. It is not only about learning and understanding mathematics through student centred activities but also commitment to becoming a teacher.

Conclusions

Here, the focus was on the meaning of mathematical education as a part of Finnish teacher education programme for orienting the formation of individual teacher identity. The overall view of the structure of the programme was given and a few issues seem to be essential for this particular way of educating mathematics teachers. Firstly, academic cognitive skills and

knowledge are strongly emphasised in the programme in which the solid base for becoming a teacher is on mathematical knowledge and skills (see Lavonen et al., 2007). A teacher is regarded as a professional expert on teaching and learning mathematics besides competence for further development later during the teaching career. From this viewpoint, mathematical knowledge and skills provided during the pre-service education programme are probably a good starting point for future mathematics teachers. Still, a need of coherent view on mathematics and understanding the nature of mathematics as a discipline is emphasised and should be taken into consideration during the programme.

Secondly, supporting students' commitment to becoming a teacher is a challenge when starting teacher education with studies in mathematics with no special orientation toward the profession. Many students apply for the teacher education programme after a couple of years' studies in mathematics. Actually, the special courses of the teacher education programme are provided only just within advanced studies. Subjective viewpoints were stressed by the teacher educators responsible for mathematical education but implementation of the mathematical courses varies as traditional academic freedom takes place. Teacher students are not a special target group in the department of mathematics. From this viewpoint, academic teacher education seems to fail to support student teachers in combining subjective aspects with academic mathematical knowledge and skills in the best possible way.

Thirdly, the overall view of teacher education programme and its implementation is needed. An ideal image of a good teacher provided in teacher education is conceptualised through the aims set by teacher educators. Teacher education can be seen as a learning environment for students to develop themselves autonomously as a teacher but still the active support of teacher educators is needed on different levels (Korthagen, 2004). Especially in mathematical education it might be hard for students to understand intentions and the meaning of subject matter studies for their future profession. It is a challenge to combine educational studies and practical experiences with strong mathematical background.

Last, not all aims and central idea of the teacher education programme are written in the curriculum. It seems that teacher educators emphasise subjective viewpoints of becoming a teacher, like self-confidence as a teacher, during the teacher education programme, especially those related to acquiring mathematical competence. However, hidden agenda is a challenge for further development of the programme as the implementation of the programme varies with different educators. Furthermore, the conclusions of this research are based on the perspectives of curriculum and teacher educators but they are not the only that matter. Teacher students' perspective and experiences are needed for having a coherent insight of the programme implementation. The main idea, after all, is to implement the programme in a way that students are able to understand the meaning of and internalise the central ideas (cf. Sfard & Prusak, 2005).

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