

SOME TRENDS IN SCIENCE TEACHER TRAINING: THE EXPERIENCE IN THE UNITED STATES AND THE CZECH REPUBLIC

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Abstract

The paper looks at key trends in the concept of the science teacher training in two different institutions: Furman University in US and Palacky University Olomouc in the Czech Republic. It focuses on the description of study programs at these institutions and comparison of the approaches to the science teacher training. There are two basic concepts used to identify the essence of the professionalism of the science teacher: the scientific knowledge and professional competence of the science teacher.

Key words: science education, professional competence.

Introduction

Science education has become an important prerequisite for a vital economy especially with the emerging global economy. Many industrial nations are seeking to improve the quality of science education because of the vital role science and technology play in a nation's economy and standard of life. The recent report *Rising Above the Gathering Storm* (2006) noted "The United States takes deserved pride in the vitality of its economy, which forms the foundation of our high quality of living, our national security, and our hope that our children and grandchildren will inherit ever greater opportunities. That vitality is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical innovations they produce." The report estimates that as much as 85% of the growth in US income was due to technological change.

People use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society very often. Science education strengthens many of the skills that people use every day, like solving problem creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning. And the economic productivity of our society is tightly linked to the scientific and technological skills of our work force. A new way of teaching and learning about science reflects how science itself is done, emphasizing inquiry as a way of achieving knowledge and understanding about the world. There is no doubt that science teachers have a central and crucial role to play in a shaping the future of science education. Teachers must have theoretical and practical knowledge and abilities about science, learning, and science teaching. The quality of science teacher training and its relationship with improving the quality the education systems generally have become key issues of public concern across the world in recent years.

We try to focus on major events and activities in the fields of science teacher training in different part of the world: the Czech Republic and United States. It makes no sense at all to attempt to deal with science teacher training in the Czech Republic and United States as

a single entity. Even within each country, the programs for the preparation of science teachers vary from one institution to another. We will describe the programs at our institutions: Palacky and Furman Universities. These case studies are not generalizable across the entire countries but provide an opportunity to look for commonalities and contrasts.

Science Teacher Training at the Czech Republic

The government of the Czech Republic by its resolution No.113 from the 7th February 2001 approved "The National Program of Development of Education in the Czech Republic", that was published under the title „The White Paper" (2001). The document is a part of the strategy of further social and economic development of the Czech Republic, which highlights the education and human resource development as one of the priorities, since it has, in accordance with the government policy, decisive impact on human and social capital of society, value orientation of people, their democratic citizenship and quality of every day life. After the political change in 1989, followed by social and economic reforms during 1990s resulting in transformation process in the area of education, this is the first project of systematic reform initiated by the government itself.

The White Paper expresses the main ideas, general outlines and development programs, which are presented as basic guidelines for the development of the whole education until 2010. The adopted strategy should have an impact on legislative, financial and organizational decision making not only on the government and central administration level, but also on the decision making in the self-administered regions, communities and public institutions of higher education. White Paper (2001) strategies also stresses the change of roles and professional perspective of teachers and academics:

To support a change in the approach and performance of teacher profession in all institutions of education, to strengthen social and professional status of teachers and academics, to improve the quality of their preparatory and further education, to create conditions for their career development, growth and stronger motivation towards personal development and team work.

What is important from the point of view of our contribution, in this document of the Ministry of Education (White Paper, 2001), the following measures were planned:

- to define the qualification level of all categories of pedagogical workers, so that the required minimum level of attained higher education should be Magister"s (Master"s) degree in case of teachers at primary level of basic schools, teachers of special education, teachers of general subjects at basic and secondary schools, teachers of vocational subjects at secondary schools and higher professional schools, the Bachelor"s level at teachers of kindergartens, instructors of vocational training and social pedagogues (pedagogues of leisure time activities, educators),
- to upgrade the quality of pre-service training of teachers stressing the psycho-pedagogical component, acquiring necessary pedagogical competences and safeguard the necessary proportion and quality of pedagogical practice during the whole period of teacher training.

This far nothing was done on the side of national institutions: qualification levels have not been describe yet, national science education standards do not exist, competences of science teachers and pedagogical competences are not designed. The proportion between psycho-pedagogical component, academic subject component and pedagogical practice during the whole period of teacher training also needs to be completed.

Pre-service Teacher Training at Palacký University

Primary Teacher Training

The responsibility for initial training of teachers at the first stage of the basic school (zakladni škola) rests mainly with Faculty of Education Palackž University. The study model for teachers (Spilkova, 2004) is predominantly a one-stage concurrent program (i.e. the aca-

demic and the professional parts run simultaneously) with elements of integration primarily between the theoretical and practical parts of the training. In addition to traditional methods (lectures, seminars), the “learning by doing” approach is also employed, as well as various theoretical methods, and experience learning through practical exercises, workshops etc. Practical training in schools is a significant element of the course. Teaching practice accounts for between 4 and 6 hours a week over the course of the whole study program, or in blocks amounting to a total of 10 weeks within the program. Graduates are qualified to teach all subjects.

The curriculum in concurrent courses of initial teacher training generally consists of five basic modules:

- subject module (the basics of all subjects taught at the first stage of the basic school);
- pedagogical and psychological module (including practical training);
- basics module (philosophy, history of education, rhetoric, ecology, computer technology etc., this courses are leading to broad knowledge of prospective teachers);
- didactic module (theory and practice of teaching individual subjects at the first stage of the basic school);
- upgrading module (implementation ICT, courses in languages).

Every student is obliged to choose one specialization - music, visual arts or physical education. There is no specialization for elementary science teachers. The studies usually consist of eight to ten terms, each of 15 weeks, and there are, on average, 20 hours of direct teaching each week. Emphasis is placed on the student’s own attempts at teaching and their reflection on this practical experience. Teachers at the compulsory primary level (until 5th grade) are qualified as generalists and would need further study at the faculty of education to teach at other than the primary level.

Secondary Teacher Training – Science Subjects

Teachers at the second stage of the basic school (grade 6-9) are trained at Faculty of Education PU in four to five-year Master’s studies, which are mostly concurrent (Nezvalova, 2001). This Faculty offers only courses leading to the qualification to be a biology teacher (with combination in mathematics or technology). Teachers at this level are usually licensed for teaching of two subjects, which were studied during their Master’s studies.

Teachers of science subjects at upper secondary schools can gain their qualification at Faculty of Science Palacky University Olomouc (Nezvalova, 2001). The studies at the Faculty can be both concurrent and consecutive, and are usually 5 years in duration. Recently only consecutive programs were accredited with Accreditation Committee of Ministry of Education on the basis of Bologna Declaration. The concurrent studies are in the end in the year 2007. This Faculty also offers study program in physics and chemistry to be a teacher of these subjects at the second stage of basic school (lower secondary or middle school). This program is also five years in duration.

Teachers at upper secondary schools are qualified as subject specialists. The subject combination of specialists depends on their choice at the beginning of the study and can be selected from a list of combinations or from a list of individual subjects set by the Faculty. Faculty of Science has accredited: biology, chemistry, physics, geography, computing, mathematics, and geology. The following components are always present: general education, education in a specific field (education in the field of future teaching), pedagogical education (psychological, pedagogical, didactic) and pedagogical practical training. This five years program is divided in two parts.

First part is in three years duration and students can earn a Bachelor’s degree. This program consists of 180 credit hours: A typical semester course receives 2-4 credits. The offered courses are compulsory (A), elective (B) or optional (C). One credit means that the class will meet one hour each week for semester which takes usually 15 weeks. This part of the program is mostly oriented on education in the fields of two subjects of the future teaching. The general education of prospective science teachers consists from the following courses:

Table 1. Courses in General Education (Bachelor's program).

Course	Number of Credits	Type	Recommended Year
Pedagogy and Comparative Education	2	A	1
Introduction of Psychology	2	A	2
Pedagogical and social psychology	3	A	2
General Didactics	2	A	3
English/German/Russian	4	B	2
English/German/Russian	4	C	1
Computing	2	C	2
Physical Education	1	C	1

The students need to pass successfully the state exam to obtain Bachelor degree. They have to continue in Master's program to be a science teacher which takes usually next 2 years. In this second part teacher training the following components are present: education in a specific field (education in the field of future teaching), pedagogical education (pedagogical sciences and subject didactic) and pedagogical practical training. This program consists of 120 credit hours. The offered courses are again compulsory (A), elective (B) or optional (C). This part of the program is more oriented on professional studies. Teaching practice lasting 6 weeks in a cooperating school is included. The general education of prospective science teachers consists from the following courses:

Table 2. Courses in General Education and Pedagogical Education (Master's program).

Course	Number of Credits	Type	Recommended Year
Science Teaching and Learning	2	A	1
Psychology for teachers	2	A	1
Methodology of Education	2	B	1
Curriculum Design	2	B	1
Quality in School	2	B	1
European Dimension of Education	2	B	1
History of Education	2	B	1
English/German/Russian (3)	4	C	2
English/German/Russian (4)	4	C	1
Computers in Science Teaching	2	C	2
Individual Teaching Practice	3	C	1

Note: year 1 of Masters program=4th year of total length of studies
year 2 of Masters program=5th year of total length of studies

Students are assessed through a system of partial and comprehensive exams, credits and classified credits. These can be in an oral, written or practical form or in the form of a seminar paper. After each term the students sit for examinations mostly in subjects taught

during that term. Some subjects are taught over several terms. In order to be allowed to sit for an exam, students must demonstrate that they have completed the relevant course work. Evaluation of the student teaching practice depends only on the report of teachers of school where teaching practice was completed. There are no criteria of the student performance.

At the end of a three-year Bachelor's program the student sits for a final state examination, a defense of Bachelor's thesis is usually part of it. The content is determined by the various faculties. It consists mostly of an oral examination in licensed subjects. Students continue in Master's programs for next 2 years. In the end of studies the students sit for a state final examination, which consists of an exam in subject field(s), subject didactics and the defense of a Magister's thesis. The content is determined by the faculties. On passing the state final examination, he/she receives a certificate and a diploma, which acts as a qualification for the upper secondary schools and gives them the right to use the title Magistr (Mgr.) and teach two subjects at upper secondary school.

Furman University

In the United States, the federal government does not determine national standards for science teacher licensure. Each individual state sets the requirements for a teaching license. The states typically adapt or modify the recommendations of professional organizations and typically require exit exams produced by national testing companies.

Furman University is an independent liberal arts college located in Greenville, South Carolina. The teacher education program is designed to address South Carolina's teaching standards that are aligned with the National Council for the Accreditation of Teacher Education (NCATE) and, for science, with the National Science Teachers Associations standards. The Education Department offers a major in education (elementary grades 2-6), and preparation for licensure in biology, chemistry and physics for grades 9-12. The program for elementary and secondary science preparation consists of an integrated four-year bachelor's degree plus an extended post-baccalaureate set of courses including an internship resulting in licensure.

Unlike other professions in which newcomers receive a substantial period of training and a gradual increase in responsibility, new teachers must assume the full extent of their responsibilities from the very first day. First year teachers are often expected to perform with the same level of expertise as seasoned teachers. In addition, many first year teachers are assigned the most difficult students and have access to the least resources. Classrooms are usually equipped with few materials and, in many instances, the teacher feels that they have no support from the administration and their colleagues. Research estimates that as many as 50% of new teachers leave the teaching profession within their first five years. One attempt to end this first year flight is through mentoring. Compounding the problem for science educators is that science is a critical needs area. This shortage of qualified teachers results in non-licensed educators teaching science therefore, it is especially critical to retain the licensed teachers who teach science.

Furman's extended licensure program was the results of a university-school district partnership developed with the goal of improving new teacher retention (Crockett, Cantrell, Ritter, & Svec, 2003). Key features include classroom inquiry into teaching, extensive field experiences, and a yearlong paid internship in which the new induction teacher is the full time teacher in a classroom and is supported by a school district mentor teacher. The mentor helps the induction teachers with teaching and managing the classrooms as well as integrating the teachers into the existing school community. Now in its 7th year, the program has demonstrated significant improvement in new teacher retention at the 3-year and 5-year marks (see table 3). The model has significantly improved new teacher retention.

Table 3. Retention of New Teachers: Elementary Teacher to Teach.

GROUP Year of internship	Number Interns starting internship	1 st year teaching- completing internship	2 nd year still teaching	3 rd year still teaching	4 th year still teaching	5 th year still teaching
2000-2001	10	10	9	7	8	7
2001-2002	21	21	20	20	20	18
2002-2003	11	11	11	9	8	9
2003-2004	13	12	13	13	12	
2004-2005	11	11	11	10		
2005-2006	16	16	15			
2006 -2007	29	29				
Total percentage still teaching	111	99%	96%	89%	87%	83%
National percent of teachers still teaching (approximate)*		86%	76%	66%	60%	54%

* Source: Richard M. Ingersoll, "The teacher shortage: A case of wrong diagnosis and wrong prescription" NASSP Bulletin 86 (June 2002) pp. 16-31.

Program Description

The elementary requires the candidate for grades 2-6 to complete a minimum of 20-hours of incremental field experiences that are fully integrated into education coursework. Prior to the spring term of the senior year, elementary teacher candidates have accrued 220-hours of field-based experience. Education course work includes three foundations courses: Perspectives on American Education, Human Growth and Development, and Education of Students with Exceptionalities. Education teaching methods courses include; Reading and Writing, Language Development and Children's Literature, Social Studies Methods, and Science Methods. Students complete two laboratory science courses. The elementary senior year block is comprised of three courses: Assessment for Planning and Instruction; Diverse School Cultures: Teaching, Learning, and Management; and Integration of Curriculum and Technology. These block courses are woven into a single sequence of seminars and field experiences. The spring senior block practicum offer a minimum of 30-full days in the school placement including at least three-weeks of full-time teaching. The candidate then graduates with a bachelor's of art degree. During the fifth year, they satisfy the requirements for the license by teaching full time with university supervision and passing the state mandated test.

Furman certifies biology, chemistry and physics teachers. Candidates must major in their science discipline and then complete the required education courses and field experiences. Each of the three required education foundation courses includes a 20-hour field experience. Prior to the senior block, the science teacher candidates have an early experience in the classroom at the beginning of school spending 12 full days in the classroom. That same placement is used throughout the senior year methods field experiences and senior block full-time teaching practicum. The practicum consists of 30 full days in the schools with at least two week of full time teaching. The senior block for secondary teachers including science teachers consists of a general secondary methods course, a science teaching methods course and a practicum course. The candidate graduates with a bachelor's degree of science and then fulfills the remaining licensure requirements during the fifth year.

Inquiry in the classroom

The National Science Education Standards (NRC, 1996) call for the teaching of science through inquiry. In an attempt to foster a disposition toward inquiry teaching and to encourage the teachers to themselves engage in action research about their instruction, and sets the expectation that the candidates make data-driven decisions about their classroom teaching. The intent is to use action research to encourage the candidates to use inquiry teaching methods in their classrooms.

In order to develop the research skills of the pre-service teachers and establish dispositions toward data-driven reflection and classroom practice, research skills are spread throughout the program especially during the senior year and the fifth-year internship, in different classes and in different assignments. Assignments that focus on gathering information and then making decisions based on classroom data:

- *Community Interviews*: Conducting data collection about the communities and schools in which they are teaching – includes individual interviews of community members, students, counselors, and district personnel. Completed during the senior year.
- *Classroom Profile*: Development of a classroom profile in their classroom setting using interest surveys, learning preference inventories, and socio-grams. Data are also used in the senior block during the design of the instructional units.
- *Multicultural Inquiry*: Candidates engage in several culture-related mini-inquiries on issues important to multicultural education. Project is designed to help the candidates begin to see themselves as a life long learner about issues related to diversity and noticing opportunities for learning that globalize their current perspectives. Completed during the spring block term.
- *Teacher Work Sample*: The work sample requires teacher candidates to produce a narrative that is a culminating teaching performance exhibit developed during the internship. Central to this culminating performance is the requirement that the interns demonstrate the end result of their teaching in terms of its impact on student learning. Completed during the fifth year internship.

The most innovative aspect of the Furman program is the fifth year mentoring made possible because of partnerships formed with local school districts. Collaboratively created, the Furman program promises aspiring educators the opportunity to develop their teaching abilities under the direct mentorship of master teachers and university supervision. Through a senior block and supported induction year internship, candidates experience teaching in its real form while reaping practical advice and teaching tips from mentor teachers. After successfully graduating with their bachelor's degree, candidates are then hired by cooperating school districts and placed into classrooms. These fifth-year induction teachers receive a salary, fringe benefits, and reduced tuition costs from the school districts. A full-time Teacher-in-Residence is on hand at the university to offer guidance and instruction to teacher candidates and support to mentor teachers, thus establishing a direct link between school and university. The salary of the teacher in residence is shared between the university and the cooperating school districts.

The Furman program employs this notion of mentoring as the cornerstone of its foundation and strength. Mentoring is seen as a critical component in creating entry into a new profession for new teachers, as well as supporting and retaining them (Lipton, Wellman, & Hubbard, 2001). Teachers are twice as likely to leave the profession where no mentoring programs are in place. Principals and new teachers emphasize the importance of mentoring and learning from more experienced teachers. According to the 2005 MetLife Survey of the American Teacher, 44% of principals and 38% of new teachers said being assigned a mentor would be the most help training for first-time teachers with year-long internships coming in a close second. The Furman program uses mentoring during the year-long internship to help prepare the best teachers and ensure their retention.

As part of the school district's commitment to the program, mentor teachers are released from other teaching responsibilities so they can mentor three to four of the interns. Mentors

are supported by the Teacher-in-Residence. There are monthly TEAM (Teacher, Encourager, Advisor, Mentor) meetings. These meetings provide training and support as well as a link between the university supervisors and the mentor teachers.

Table 4. Overview: University and District Contributions.

University Contributions	District Contributions
<ul style="list-style-type: none"> Extended five year teacher preparation program Intensive senior year in one partner school If successful senior year, graduate and offered induction contract During induction year, complete licensure requirements University supervision continues into induction year 	<ul style="list-style-type: none"> Administration support in selecting teachers, schools and classrooms Induction year contract at reduced salary, pay for 12 credit hours Mentors who receive release time and on-going training, visit interns for at least 5 hours a week Share salary obligations with university for the Teacher-in-Residence

The Teacher-in-Residence provides the link between the university and school district administrators and teachers. Her responsibilities include teaching the candidates the first year induction teacher class, supporting the mentor teachers, serving as the liaison between the districts and the university, and visiting the first year teachers. She interacts with the university faculty as well as the mentors and the candidates. She helps select the mentors and then provides mentor teacher training, guidance, and support through the year.

The elementary program was implemented during the 1999-2000 academic year and the secondary program during 2002-2003. The enrollment figures summarized in table 5 since 1993 illustrate a steady decline in students graduating with a secondary license to teach. The declines began before the implementation of the new program. Since the implementation of Teacher to Teacher at the secondary level, the enrollment numbers are similar to the few years before the program began suggesting that the new program is not an effective recruiting tool. Reasons for enrollment declines since the mid-1990s might include many of our science majors do not think of teaching as a viable option until late in their third year or as a senior when, because of the design of the program, they are unable to finish the licensure program without adding an additional year of study. In addition, many want to leave the state, will teach at a private school that does not require a teaching certificate, or follow alternative paths to teaching such as Teacher for America. Interviews with graduates indicate the success of the program and the value of the mentoring. The program has been successful at improving the retention of new teachers but the extended program has not been a successful at recruiting more students into the program.

Table 5. Enrollment Number of Secondary Teacher Candidates for the years 1993-2006.

School Year	Total Secondary History, Languages, Sciences, Math, English	Biology	Chemistry	Physics	Math
93-94	36	2	1	0	1
94-95	36	3	0	0	5
95-96	35	4	2	1	7
96-97	21	4	1	1	2

School Year	Total Secondary History, Languages, Sciences, Math, English	Biology	Chemistry	Physics	Math
97-98	19	2	1	0	2
98-99	20	2	1	0	2
99-00	9	0	0	0	0
00-01	11	1	0	0	1
01-02	6	1	0	0	0
02-03	6	2	0	0	0
03-04	16*	0	0	0	2
04-05	12	0	0	0	1
05-06	10	0	0	0	4

*The new model was implemented at the secondary level during the 2003-2004 school year.

Conclusions

Despite operating two very different national context, both Palacky and Furman's teacher preparation programs share several commonalities. Both are being influenced by their nation's economic competitiveness and the need for more science, mathematics and engineering students. Both are also struggling to find students who are interested in teaching science and filling the large need for such teachers. Recruitment and retention of science teachers are problems that still lack a satisfactory solution. Both programs have strong programs requiring deep knowledge of the science content and frequent experiences in the schools. In order to address the science content needs and to develop the pedagogic skills, both programs take 5-years to complete.

There are also distinct differences between the universities. There is a strong link between school districts and the Furman program. University faculty spend more time in classrooms supervising teacher candidates and interacting with school staff. Because of accreditation requirements, Furman professors gather a great deal of data on student performance and are continuously modifying the program to meet the changing needs of the schools. While the Czech government is working on national teaching competencies, in the United States each state develops those competencies. Those competencies are used by the university supervisors during teacher evaluations.

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