IS THE "TEACHER-AS-RESEARCHER" MODEL WORTHWHILE FOR PRE-SERVICE TEACHER EDUCATION?

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Introduction

The contradiction between the dominant role of Science in Society and the growing disaffection of young people towards science subjects is nowadays evident and alarming. Many studies, among which the European investigations published by UNESCO (Sjøberg, 2002), show that disaffection towards Science, in particular Maths and Physics, is strictly interwoven to the following phenomena:

- crisis of the public image of Science;
- failure of the traditional teaching of Science at various school levels (from primary to upper secondary school).

One of the consequences of disaffection is the decline in students' enrolment in university courses in Maths and Physics (the so called "vocational crisis") that in a few years may cause a decrease of qualified teachers, also in Italy.
The crisis is worrying and requires a radical re-thinking about all the overlapping and interdependent aspects involved in the processes of teaching/learning: what idea of Culture School intends to promote; what re-construction of content knowledge must be operated for promoting that idea of Culture; what effective teaching/learning model looks like and last, but not least, what teachers are needed.
The experience presented in the paper is based on the assumption that initial teacher education is a crucial point for entering the complex process of renewing Physics teaching.
In the last four years an experience carried out at the University of Bologna seems to have started off a virtuous circulation of ideas among university researchers and school teachers. The experience consists in the implementation of a model designed for pre-service Physics teacher education within the new Italian institutional context for pre-service teacher education (Frabboni et al., 1994): the Post-graduate School for Secondary School Teachers (SSIS).
Since 1999 SSIS is the unique channel in Italy for certifying a secondary school teacher: it is a two-year closed-number university school divided into different branches, among which the Physics-Computer Science-Maths branch. SSIS is managed at regional level as a consortium of Universities. In Emilia/Romagna (our region), Bologna University is one of four "associated" Universities but SSIS of Bologna is attended by almost the 50% out of the total number of student-teachers (STs) of the Region. In order to get the certificate for teaching Physics or both Maths and Physics, after the graduation in Physics, Maths, Astronomy or Engineering, one must enter SSIS (about 50 STs per year at Bologna University), attend the activities briefly indicated in table 1 (the attendance at the courses is compulsory) and pass a final examination.

Table 1 – *Curriculum at SSIS of Bologna University for certifying Physics or Maths& Physics teachers*

	Physics Certificate	Maths&Physics Certificate
"Common area" courses (24 ECTS)	General Education & Teaching Methodology Psychology Pedagogy Socio-Anthropology	
"Branch area" courses (48 ECTS)	Epistemology/History of Physics I Epistemology/History of Physics II Physics Education I Physics Education II Lab of Physics Education I Lab of Physics Education I	Epistemology–History of Maths Epistemology /History of Physics Maths Education Physics Education Lab of Maths Education Lab of Physics Education

Supervised teaching practice period in school (30 ECTS)	Seminars-workshops about school as institution (laws, curricula…) Observation of classroom activities (about 50 hours) Designing a teaching project to be accepted by a special board Implementing the teaching project in a real classroom setting (20-24 school-periods) and monitoring the classroom activities
Dissertation Thesis (18 ECTS)	Reflection on the work done Discussions with tutor and supervisor teachers Elaboration of the Dissertation Thesis
Final examination	Written task (design of a teaching path) Oral discussion about both the written task and the dissertation thesis

The "teacher-as-researcher" model

Within the branch Physics-Computer Science-Maths, the reference teacher model has been shaped on the professional profile of "teacher as researcher", i.e. teacher who looks at:

- teaching as a project activity to be planned and realised with in mind both an aware image of Physics and a model of teaching/learning;
- classroom dynamics as a complex phenomenon to be analysed and understood in order to find a good fitting among the different components of the teaching/learning processes and the subject matter structure;
- classroom activities as "reflection in action" activity and as source of educational content knowledge to be shared and discussed within a community.

The perspective at the basis of the model is a constructivist approach to teacher education strictly connected to a constructivist approach to education in Science (Grimellini Tomasini, Pecori, 1998).

As the description of SSIS activity will stress, the model foresees a strict interrelation between theoretical competencies and practical ones. Research results show this choice as necessary to minimize the well known phenomenon of the "reality shock" experienced by the young teachers when they face school reality (Schwedes, 2003).

The paper will focus on the specific competences SSIS aims to provide Physics teachers in the frame of a radical re-thinking of teaching/learning: The competences should allow a future teacher to look at his/her professional role as *curriculum-maker*, *cultural mediator* and *socio-cultural operator*, at the same time.

Teacher as curriculum-maker

A teachers should be strongly encouraged to live his/her profession as a creative work implying Physics content knowledge to be analysed from an educational perspective. In our model this means to take into account the historical-epistemological dimension and the reflective-metacognitive one as necessary components for designing and performing teaching paths that should be at the same time:

- "longitudinal" – the product of a overall re-construction of content knowledge (from Classical Physics to Modern Physics) carried out so as to respect and to foster cognitive and cultural students' growing up;
- "transversal" – paths able to open and encourage connections with other subject matters or other parts of Physics;
- "culturally founded" – the product of an inquiring process aimed at situating a physical theory within a problematic context (at disciplinary, historical, epistemological, methodological, conceptual and experimental/theoretical level) as well as aimed at highlighting how the theory influenced the general world-view and, vice versa, how physicists' world-views influenced the research programmes.

Teacher as cultural mediator

As intellectual, a teacher is a specialist in cultural mediation, i.e. in the process of:

- shaping Physics content knowledge so as to trigger a "resonant approach for a cultural transmission" (Guidoni, 1995);

- fostering and supporting a teaching/learning environment where each student is guided toward the construction of a personal critical world-view, in which Physics has an integrated and meaningful position.

Teacher as socio-cultural operator
A Physics teacher should also be able to manage professionally the responsibility in the renewal of Physics public image and to provide students with cultural tools to reflect critically on the complex relationship among Science-Technology-Society (in its practical, ethical, political implications).

The implementation of the model
In order to implement the model, all the "branch area" courses have been designed as "laboratories of ideas and experiences", in which STs are guided through a variety of activities, languages and situations so as to enter both the hardness of the subject matter to be taught and the complexity/specificity of the teaching/learning processes. In particular STs are supposed to:

- reflect on the historical development of ideas, on the comparison among different interpretations of the same theory, on the role of models, lab activities and formalization processes in content knowledge construction, on the link between public and private knowledge,…, in order to develop a personal way of looking at Physics;
- analyse different texts (papers from research on Physics education, original memories and papers from research on History, Epistemology and Foundation of Physics, popular books, and so on), in order to grasp what there is behind a physical concept and a net of concepts and what is hidden among the lines of textbooks;
- analyse "research" materials (for example transcripts of students interviews, answers to questionnaires, video-tapes), in order to gain the habit of trying to interpret students' reasoning and to think about possible strategies of intervention;
- analyse conceptual paths as examples of Physics re-construction from an educational perspective in which lab activities, problems, historical-epistemological aspects are chosen and situated on the basis of specific cultural and cognitive aims;
- write papers (reports about the activities carried out, short essays about selected Physics topics and related teaching strategies, and so on) in order to develop a personal way of looking at Physics teaching;
- design/discuss teaching projects.

All the courses are performed on the basis of some common presuppositions:

- "interactivity" in leading the different activities;
- "agreement of mutual assumption of responsibility" among Teachers and STs for reaching the common goal of improving Physics teaching/learning;
- "coherence" between the teaching model proposed for secondary school contexts and the teaching activities realised in the contexts of pre-service teacher education.

The courses find their main legitimacy in the common aim of providing the STs with tools for living the teaching practice period as a real research experience. The period is scheduled in the fourth (and last) semester of SSIS and aims at supporting processes of "conceptual change" in terms of transition from "teacher as content knowledge dispenser" to "teacher as researcher". The practice period is carried out through a cooperative work among STs, experienced teachers and university researchers in Physics Education, along the phases listed in table 1. The Dissertation Thesis is based on the description/analysis/discussion of the results obtained during the classroom activities and on the reflection about the whole work from different perspectives (cognitive, disciplinary, educational, personal and so on).

First results

The discussion will focus on the results concerning the effectiveness and the level of feasibility of the described model. The number of STs is about 120 and the data sources are: essays about STs images of Physics and Physics teaching, presentation/discussion of analyses carried out on research papers and teaching materials, open questionnaires, portfolios, teaching projects and, above all, the Dissertation Theses of each ST.

The first finding concerns the most frequent STs reaction of “satisfaction” in discovering the creative dimension of the teacher profession. Evidences of crisis are also frequent at the beginning of the transition phase from traditional images of Physics and Physics teaching toward new perspectives: The problem is monitoring and holding back as much as possible forms of regression toward traditional teaching practices that too often appear at the first clash with the class reality. The “regression phenomenon” is well-known in literature and it is, maybe, one of the main open-ended problems in teacher education (Abd-El-Khalick et al., 1998).

Since the first cycle, some elements preventing STs’ transition have been evident. The main evidences are:

- lack of self-confidence in the subject matter preparation and the consequent defensive attitude toward new and demanding models (more frequent among STs graduated in Maths);
- exaggerate self-confidence in the subject matter preparation and the consequent idea that one’s own learning path is the best possible one for everyone (more frequent among STs graduated in Physics);
- rigid, stereotypical and a-critical images of Physics received by the Degree Course (Grimellini Tomasini, Levrini, 2001);
- high level of the demand and the consequence reaction of considering it “idealistic”, not respectful of the school constraints;
- difficulties in finding supporting materials.

The roots of the first three elements are deep and it is unrealistic to think that SSIS or every form of preservice teacher education can completely remove them.

The last two points, instead, represents challenges for research on Physics Education and the main commitments of our current research work. In particular these problems are discussed and analysed within the Italian National project FFC coordinated by P. Guidoni.

In the cases in which the regression phenomenon did not occur, SSIS was able to support interesting practice periods, some of them characterised by the originality and the quality of typical research work (Grimellini Tomasini, Levrini, 2003).

A positive effect of the successful experiences is the interest shown by the host teachers who found the opportunity to come into contact with research results on Physics Education and to re-think about their own Physics content knowledge and teaching. Such an effect is of great relevance for the success of the model since it is fostering the creation of a community composed by prospective and in service secondary school teachers and university teachers and researchers (in Physics, Physics Education but also in other disciplines such as Maths, Maths Education, General Education and so on): community which could represent a context in which teachers can realise a self-long-life-education and researchers can check the feasibility of their proposals.

Concluding remarks and open questions

An estimation of the preliminary results shows that about 50% of prospective Physics teachers attending SSIS (average value over the three cycles) has been resonant with the proposed model. Given the starting point, we consider such a percentage an important and encouraging result, that however must be checked as far as the stability of the result is concerned. A deep reflection must be done about the other 50% of STs falling short our expectations and the questions we are wondering are: did we “loose” them or their transition phase is simply longer? Can something sown sprout out or is the model completely unfruitful in these cases?

At the moment these are open questions, whose answers should be searched in a tangle of circumstances, among which the features of the school context in which STs will teach.

However, some factors encourage us to go on. The first one is the coherence of the model with the current educational trends of the most European school reforms (Sjøberg, 2002) and with international research results concerning pre-service teacher education (for example, Schwedes, 2003). Another factor is the positive trend of the number of successful STs passing from the first to the third cycle as well as of the number of interested and involved host teachers. In our opinion, such a trend seems to indicate that the model implementation can still get better.

Nevertheless, some worrying evidences are worth to be mentioned. The researchers in Physics Education are few and the problem of finding qualified university teachers is becoming urgent. But the more alarming evidence is the confused and regressive situation of the Italian School, exhausted by the "stream" of different reform projects, the last of which seems to go in the opposite direction respect to the European trends and no encouragement seems to be given to teachers who want to look at their work as an intellectual and creative activity. Consequently, the precious contribution of the experienced teachers in initial teacher education risks to be seriously hindered.

References

Abd-El-Khalick F., Bell R.L., Lederman N.G. (1998), The Nature of Science and Instructional Practice: Making the Unnatural Natural, *Science Education*, 82, 4, 417-436.

Frabboni F., Grimellini Tomasini N., Manini M., Pellandra C. (eds.) (1994), *Scuola di Specializzazione all'Insegnamento Secondario*, CLUB, Bologna.

Grimellini Tomasini N., Levrini O. (2001), Images of physics and pre-service teacher education – in R. Pinto, S. Surinach (eds.), *Physics Teacher Education Beyond 2000*, Elsevier Edition, 355-358.

Grimellini Tomasini N., Levrini O. (2003), History and philosophy of physics as tools for preservice teacher education, paper to be presented at Second Girep Seminar, Udine (Italy).

Grimellini Tomasini N., Pecori B. (1998), Investigación sobre la formación inicial de los profesores de física, in E. Banet, A. de Pro (ed.) "Investigacion e Innovacion en la Enseñanza de las Ciencias", Vol. II, 131-139.

Guidoni P. (1995), Il senso di fare scienze a scuola: quale mediazione culturale (ad esempio in fisica), in F. Alfieri, M. Arcà, P. Guidoni (ed.), *Il senso di fare scienze*, IRRSAE Piemonte, Bollati Boringhieri, 501-521.

Mattozzi I. (2002), La formazione iniziale degli insegnanti: avvertenze per pensarla, *Rassegna*, n.19, anno X.

Schön D. (1983), *The reflective practitioner*, Basic Books, New York.

Schwedes H. (2003), How to Shape a Curriculum for Teacher Education. The Effects of an half year Practical Work in School, pre-print.

Sjøberg S. (2002), Science and Technology Education - Current Challenges and Possible Solutions, to be published in Jenkins E. (ed) (2002) *Innovations in Science and Technology Education Vol VIII,* Paris, UNESCO (http://folk.uio.no/sveinsj).