FROM UNIVERSITY COURSES TO TEACHING PRACTICE IN SCHOOLS: AN EXAMPLE

Lidia Borghi, Anna De Ambrosis, Paolo Mascheretti,

Dipartimento di Fisica "A. Volta", Università di Pavia, Italy

Introduction

The research we report deals with teacher preparation and aims at designing and testing strategies to help prospective teachers reflect on a physics content area in connection with their teaching practice. The research is carried out within the Italian national project "Physics as a Cultural Formation" (FFC), funded by the Italian Ministry of Education, involving researchers of different universities. The guiding lines of the project are described in a general talk of this GIREP Seminar (Sperandeo, 2003).

Our work consisted in developing a proposal on thermodynamics, in particular on internal energy, for the initial preparation of high school teachers and in testing it with student teachers attending the 2-year Post-graduate School for Teaching of our University. The proposal aims at promoting the prospective teachers' reflection both on their physics knowledge and on pupils' ideas on thermal phenomena, which constitute an articulated base of spontaneous knowledge to be taken into account (Sciarretta et al., 1990; Rozier & Viennot, 1991; Kesidou & Duit,1993; Viennot, 1997). The approach we propose is based on the analysis of a wide range of simple experiments and every-day life phenomena connected with temperature or phase changes and develops a microscopic model to interpret macroscopic properties of the observed systems.

We propose to use computer simulations to address both mechanical and probabilistic features of the model and to introduce the microscopic approach not only in introductory physics courses for university students (Alonso & Finn, 1995; Chabay & Sherwood 1999; Reif, 1999), but also in high school. This requires that prospective teachers have a direct experience in using a microscopic approach to understand macroscopic phenomena and in exploring the boundary between mechanics and thermal phenomena, which many authors recognize as a crucial point in understanding the behaviour of real systems (see, for example, Arons, 1999; Besson, 1999).

Specific aim of the research was to explore if and how our approach improves student teachers' mastering of the considered content area and supports them in introducing innovative approaches in the classroom. The context, the methods and the first results of our research are described in the following

Context

The work was carried out with a group of twenty student teachers attending the post-graduate School for Teaching Mathematics and Physics.

The reference material has been a multimedia hypertext, prepared by our research group, and available at the web address: http://fisicavolta.unipv.it/didattica/energia/homeEnergia.htm.

Student teachers' activity developed in five phases with different aims. Initially, observation of systems increasing their temperature due to work aimed at suggesting that each system has an energy, enclosed within its surface, which can be increased by work done on the system.

In the second phase, laboratory activities concerning measures of temperature variations were proposed, to convey the idea that heat is energy exchanged between two systems in contact, at different temperatures. Simple experiments on phase changes, exothermal chemical reactions, visible and infrared radiation were then considered in order to exemplify different forms of energy released by a system. The variety of types of energy involved in the interaction of a system with the environment was underlined, to suggest a connection between the concept of internal energy and the microscopic structure of a system.

Afterwards, the student teachers worked with the hypertext which contains applets and simulations, implemented by using the software Interactive Physics (I.P.), to analyse models of molecular motion. Particular attention was devoted to studying the transfer of energy in elastic collisions between systems with different degrees of freedom, to introduce the idea of equipartition of energy, essential to explain the macroscopic properties of an ideal gas.
At this point student teachers, working in groups of two or three, began to prepare plans for their work with high-school pupils by selecting, in the explored content area, a topic to be developed in the classroom. Teaching plans were elaborated under the guide of "supervisors" (experienced high-school teachers) and in correlation with the in-service teachers who receive, as tutors, student teachers in their classrooms. Both supervisors and tutors were involved, by our research group, in a parallel analysis and discussion of the material used by student teachers.
Finally, the student teachers implemented their plans during the teaching practice and prepared reports on their activity in the classroom.
The above-described path of formation, together with the material produced, constitutes what we called MIF (in Italian "Modulo di Intervento Formativo", i.e. Path of Formation).

Methods

In order to evaluate the effectiveness of our MIF in deepening the conceptual understanding of the considered content area we analysed, initially, the worksheets filled in by the student teachers during their laboratory sessions, and their portfolios. Results of this analysis have been presented at the ESERA Conference 2003 (Borghi et al. 2003). Then, aiming to understand if our materials influenced the quality of teaching practice, we focussed the attention on student teachers' reports on the work with pupils. These were compared with analogous reports prepared by the same students on teaching practice, developed outside this research context (in the following we refer to the two kinds of reports as "MIF reports" and "non-MIF reports", respectively). All reports were analysed by using two grids, addressing different aspects: an "evaluation grid", prepared within the research project FFC, and a "profile grid", prepared by the STEDE Micronetwork 6b in which the authors are participating[1]. The "evaluation grid" focuses on the student teachers' ability in designing and implementing the teaching sequence; the "profile grid" describes their attention to the different aspects and the dynamics of the teaching/learning process. The structure of the "evaluation grid", whose different components were grouped in categories, is shown in Table 1.

Categories	***Components***				
Design	Pattern	Path	Rational	Motivation	
Fitting	With the curriculum	Prerequisites			
Methodology	Approach	Method choice	Choice motivation	Use of technology	
Content focus	Quality of exposition	Deepening	Disciplinary competence	Additional material	Completeness
Attention to pupils	Pupils' reactions	Assessments	Learning	Teaching context	
Bibliograhy	Variety and pertinence of the references				

Table 1-Evaluation grid

Three levels of score were assigned to each component of each category: 3 for a good performance;1 for unsatisfactory performance and 2 for intermediate performance.
Categories and components of the profile grid are shown in the Table 2.

[1] STEDE (Science Teacher Education Development in Europe) is a thematic network funded by the European Union.

Categories	*Components*				
Epistemology	Theories of teaching and learning guiding student teachers				
Activities	Lectures	Laboratory	Exercises	New Technology	
Expectations	Motivation of students	Disciplinary knowledge	Skills	Behaviour	Socialization
Learning	Active learning	Constructivism	Socio-constructivism		
Focus	Cognitive dimension	Affective dimension	Peer interaction	Social dimension	
Bibliography	Variety and pertinence of the references				

Table 2 - Profile grid

For each component of each category three levels were defined: 1 in case of a positive response; 0 in case of a negative response; 0.5 for intermediate situations.
In both grids, the score obtained by each student teacher for each category was calculated by summing the scores obtained for each component and dividing by the number of components.
The average score for each category was obtained by summing the previous values and dividing the result by the number of student teachers.

Results

The average scores obtained by using the "evaluation grid" for MIF and non-MIF reports are shown in Figure 1.

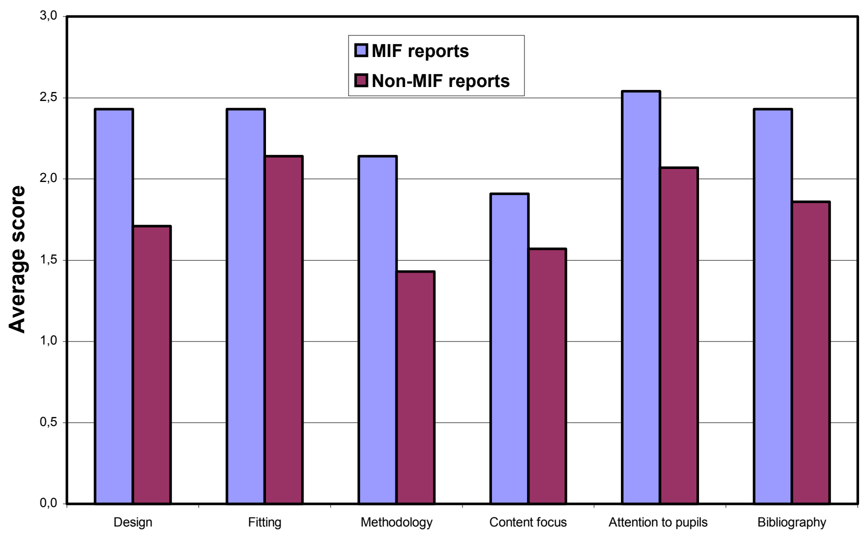

Figure 1 – Data obtained by using the evaluation grid

The graph indicates that the MIF approach increased the student teachers' performance in the classroom. The highest differences concern methodology competence and design ability.
An improvement is evident also by considering the data obtained with the "profile grid" (Figure 2).
In this case the highest improvements refer to epistemology (i.e. to the student teachers' capability of expressing their ideas on teaching and learning, guiding their teaching choices) and to the variety of approaches used in the classroom.

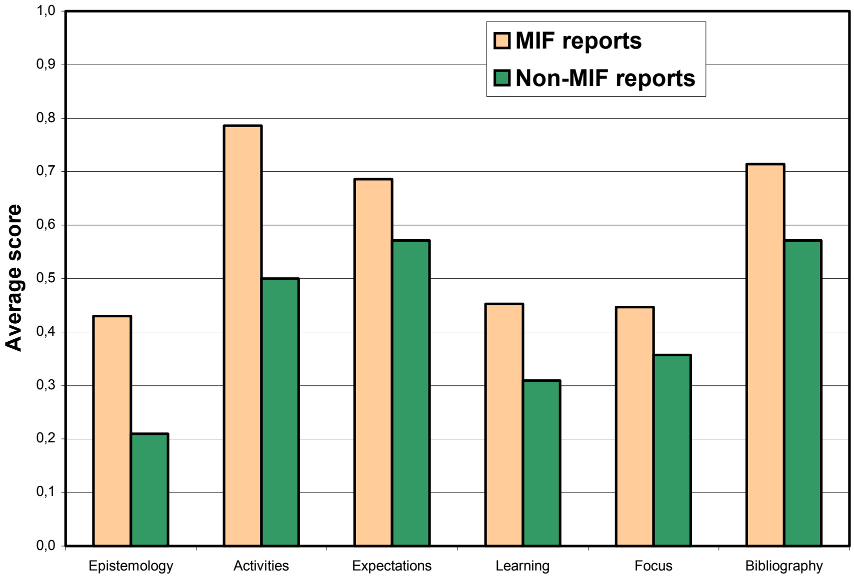

Figure 2 – Data obtained by using the profile grid

To better understand the nature of the improvement in MIF reports, it is useful to look at the single components of each category. For example, the increase in "Activities" is due to a wider use of laboratory and of new technologies in the classroom, probably as a consequence of the student teachers' direct involvement in experimental work and in the use of computer simulations. Mastering a wider set of teaching tools produced a more motivated choice of the methodology and increased the pupils' inquiry work in the classroom. This is reflected in the high score of the category "Attention to pupils" (Fig.1) which refers to student teachers' interest to pupils' reactions and learning. The increase of the score in the "Design" category shows that working with innovative material allowed student teachers to prepare more detailed teaching plans, enriched by material designed for pupils.

The average score obtained for the category "Content focus" in MIF reports (Fig.1) shows a low increase in comparison to non-MIF reports. While considering some components of this category (quality of exposition, deepening, disciplinary competence), it is worthwhile to remark that, in MIF reports, student teachers produced a large amount of material, where it was possible both to find some incorrect statement and to judge the quality of exposition, while most of the non-MIF reports described the subject, in a very schematic way, by simply referring to a textbook. This means that, even if incorrect statements were not present in the reports, the student teachers' mastering of the content area was not evident in non-MIF reports. On the contrary, MIF reports revealed to be a useful tool, to point out critical points in the student teachers' understanding of the subject matter.

Actually, the disciplinary competence is an open problem. In fact, student teachers' reports contain traces of the difficulties already appeared during the formation path, in particular in the work with simulations. For example, the worksheets filled in by the students teachers in these activities showed their initial difficulty in understanding the probabilistic character of microscopic models of gases and in applying their knowledge of mechanics to predict or to explain the properties of the simulated systems (Borghi et al. 2003). These problems, which seemed overcome after lab. activities, reappeared in the reports. This suggests that MIF reports are efficient diagnostic tools to identify student teachers' needs when they apply their content knowledge in a teaching action.

Conclusions and implications

The results obtained in the first trial of the described path of formation show both an improvement of student teachers' preparation and their engagement in designing and implementing their teaching plans, but these results also suggest that further work is necessary. In particular, they seem to indicate that the effectiveness of teacher preparation could be enhanced if the phase of design and implementation of the teaching plans received deeper attention. The student teachers' activity in the classroom, based on innovative proposals, should be supported and carefully discussed in all its aspects, from both methodological and disciplinary point of view. Moreover feedback between the results obtained by student teachers with pupils and the design of the courses of the Post-graduate School should be promoted, to enhance both the student teachers' mastering of the content matter and their competence in promoting the construction of disciplinary knowledge in the classroom. This requires a deeper engagement of supervisors and tutors of "partner schools" in a research framework and a better connection between pre-service and in-service teacher preparation.

Acknowledgements
This research was funded by the Italian Ministry of Education.

References
Alonso M. and Finn E.J. (1995). An integrated approach to thermodynamics in the Introductory Physics Course, The Physics Teacher, Vol. 33, pp. 296-310.

Arons A. B. (1999). Development of energy concepts in introductory physics courses, American Journal of Physics, Vol. 67, N. 12, pp. 1063-106.

Besson U. (1999). Bilan Energetique: une mise au point conceptuelle, Bulletin de l'Union des Physiciens, Vol. 93, N.812, pp. 383- Mars 1999.

Borghi L., De Ambrosis A., Mascheretti P. (2001). A proposal on thermodynamics for teacher education, ESERA Conference (Ed. Psillos D. et al), 316-318.

Borghi L., De Ambrosis A., Mascheretti P.(2003). A teaching proposal on internal energy, ESERA Conference "Research and the quality of Science Education", August 2003.

Chabay R.W.& Sherwood B. A. (1999). Bringing atoms into first-year physics, A.J.P. Vol 67, N.12, pp. 1045-1050.

Kesidou S. & Duit R. (1993). Students' conceptions of the second law of thermodynamics – an interpretative study, Journal of Research in Science Teaching, 30, 1, 85-106.

Reif F.(1999). Thermal physics in the introductory physics course: Why and how to teach it from a unified atomic perspective, American Journal of Physics, Vol.67, N. 12, 1051-1062.

Rozier S. & Viennot L. (1991). Students' reasonings in thermodynamics, Int. J. Sci. Educ., Vol.13, N.2, 159-170.

Sciarretta M.R., Stilli R. & Vicentini, M. (1990). On the thermal properties of materials: common-sense knowledge of Italian students and teachers, Int. J. Sci. Educ, Vol.12, N.4, 369-379.

Sperandeo R.M. (2003) The pre-service physics teacher education model implemented by the FFC research project involving 8 Italian Universities: guidelines and preliminary results, Second international GIREP Seminar, Udine, September 2003.

Viennot L. (1997). Experimental facts and ways of reasoning in thermodynamics: learners' common approach. In A. Tiberghien, E. L. Jossem & J. Barojas (eds.), Connecting research in Physics Education with Teacher education, An I.C.P.E book.