AN E-LEARNING WEB ENVIRONMENT FOR MATHEMATICS AND PHYSICS COMMUNITIES OF PRACTICE

Giuseppina Rinaudo, Daniela Allasia, Daniela Marocchi, *Physics Department of the University of Torino, Italy*
Ornella Robutti, Tiziana Armano, *Mathematics Department of the University of Torino, Italy*
Alessio Drivet, Ada Sargenti, Claudia Testa, *SIS Piemonte and University of Torino, Italy*

Abstract
It is well known that the quality of the long term results of the scientific education depends crucially on a teacher formation based on valid interaction schemes between educational research and teachers. To support this interaction, we have set up an e-learning web environment for mathematics and physics communities of practice, from infancy to higher secondary school, which supports a variety of activities, didactical proposals and documentation. In the paper, we discuss the "rationale" of the organization, some of the problems which have arisen, the response of the users and present some example of materials regarding both the mathematical and the physical contents.

1. Introduction
The project is based on a decennial experience of conducting university courses in the teacher training schools of the Piedmont universities, both at the level of Secondary School ("SIS", Scuola di Specializzazione per l'Insegnamento Secondario) and of Infancy/Primary School ("SFP", Scienze della Formazione Primaria), which has shown that a methodological and operational organisation of teachers formation must be based on valid interaction schemes between teachers and educational research. To support this organisation, in a joint effort between mathematics and physics researches who have shared this ten-year-long experience, we have recently set up an e-learning web environment for Mathematics and Physics communities of practice, from infancy to higher secondary school, sponsored by the Science Faculty of the University of Torino and by the Province of Torino, called "DI.FI.MA.", which stays in Italian for "Didactics of Physics and Mathematcs"; its web address is "http://teachingdm.unito.it/porteaperte".
The reasons for the choice of a web environment were essentially two. The first is related to the results of the educational research and practice, which underline that there are many aspects of teacher's formation which are as important as the disciplinary contents, such as sharing educational experiences, connecting different fields of knowledge, using non formal as well as formal languages, opening towards new technologies, etc. In particular, it has become clear that learning, and therefore teaching, is a social phenomenon and establishing connections, sharing experience, communicating and discussing the educational results is an important aspect of the teacher profession. These are all typical achievements of a community of practice (Wenger 1998) and an e-learning platform can be easily adapted to this purpose (Trentin 2008).
The second reason for the choice of a web environment is related to the effective Italian educational situation. On one hand, there are, at present, practically no incentives to foster a permanent teacher formation: the motivations to maintain a high professional profile rely thus on the teacher desire of responding to the students and families explicit or implicit demands. On the other hand, the teachers have to face, with little support, a rapidly changing society, growing difficulties and requests of students and families, the lack of stable reference objective, poor student's results in mathematics and physics as indicated from national and international assessment tests (INVALSI and OCSE-PISA). For both motivations, a web environment can provide a valid background support.
The DI.FI.MA. platform was activated about one year ago, it has now more than 600 participants, whose profiles are shown in figure 1. Although mathematics is the dominating discipline, there is a

highly qualified presence of physics teachers, or of teachers of both disciplines, because in Italy Physics and Mathematics are taught jointly in most high schools.

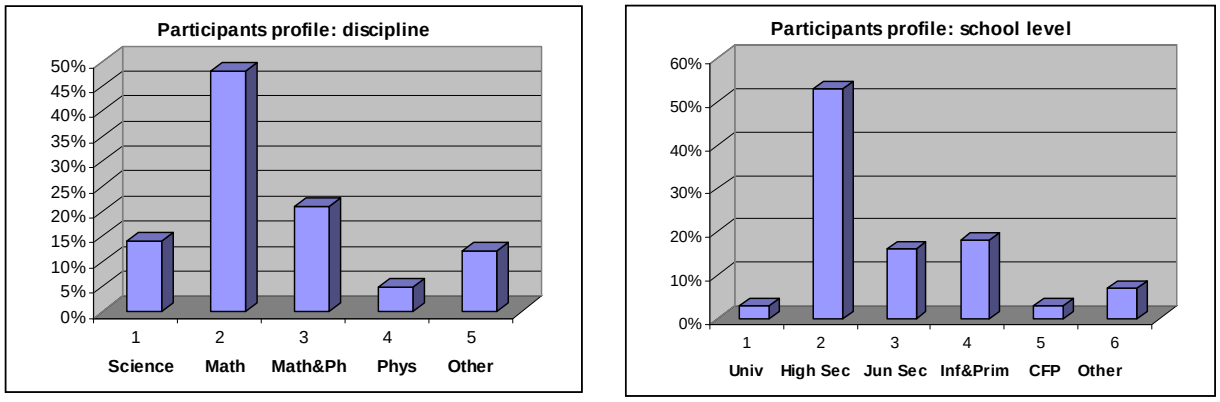

Figure 1: Profile of the participants according to the type (left) and to level of discipline being taught

DI.FI.MA. has different sections covering a variety of activities, didactical proposals and documentation; it is organized in six "categories", globally subdivided in 24 "courses"; most courses are accessible through a specific registration, two are completely open, seven require a key for the access.

2. The project

As reflected in its name, DI.FI.MA. is principally directed to mathematics and physics teachers, from infancy to higher secondary schools, although in the last months we also activated some "courses" directed to scientific disciplines in general.

The actions of the project can be grouped in four types:

1. teacher's formation and upgrade on disciplinary and methodological contents,
2. services aimed to the collaboration and to the sharing of didactical materials between teachers and researchers (communities of practice),
3. support to working groups for professional exchange through an open source technology ("Moodle" platform),
4. general purpose info and documentation.

The four actions are present, with different weights, in almost all courses and with similar layout for mathematics and physics.

2.1. The introductory sections

This "category" contains general purpose introductory information and documentation ("action 4"). It is organized in three "courses":

- General information about the activities of DI.FI.MA.
- How to register and use the platform (obviously accessible also to the unregistered "guest")
- Essential aspects of "Moodle"

2.2. Continuity from Secondary School to University

This "category" is dedicated to a large national project, PLS or "Progetto Lauree Scientifiche", aimed to promote the choice of scientific university courses in students of the last years of Secondary School. At present, it is organized in four "courses":

- the first contains general information about PLS in Piedmont: it illustrates all PLS activities and provides useful info to teachers and schools; it concerns essentially "action 4";

- two math courses, both with key access, “PLS-Math1, the geometry of the universe” and “PLS-Math2, geometry in two dimensions”, concern mainly “action 1” and “action 2”;
- the fourth course, “PLS-Physics, the Mompellato experience”, requires also a key access and it is an example of use of the platform for exchange of materials within working groups (“action 3”). It regards an activity which has been carried on in the last seven years by a group of physics teachers associated to the “AIF” (Associazione per l’Insegnamento della Fisica) in collaboration with the Physics Department of the University of Torino. “Mompellato” is an alpine resort where a 3-days spring Physics school takes place: the school is reserved to selected students of the last year of secondary school and regards unconventional physics lab activities, theatre, puzzle, games etc. The organization and the preparation of all the materials is taken care by *teacher’s working groups* and the DI.FI.MA platform provides the support for communications, exchange of documentations, archive, etc.: this support not only makes the connections easier than in the previous editions of the school, but gives a kind of “virtual consistency” to the working groups, showing the effect, in the long term, of the use of this virtual tool. Once the materials are ready, they are published in the section “Physics” of DI.FI.MA and are made available without the request of the key.

2.3. The Physics-Mathematics permanent conference

This is the central section of DI.FI.MA. It contains at present nine “courses” related directly to the needs of a community of practice for mathematics and physics didactics, in particular

- research results on disciplinary didactics (“actions” 1 and 2),
- specific “courses” at different levels from infancy to higher secondary school (“actions” 1 and 2),
- examples of materials developed by teacher’s communities at different levels from infancy to higher secondary school (“actions” 2 and 3),
- teacher formation in Italy and in other European countries (“actions” 1 and 4),
- the DI.FI.MA. seminar (“actions” 1 and 3)

With regards to disciplinary contents, the aims are

- *recovering the teacher motivation with regards to the discipline*: physics (mathematics) is nice, it helps to understand the world,
- *re-analyzing the essential aspects of the disciplinary contents in a “bottom up” approach*: learn to use correctly, through examples, “problem posing” and “problem solving” methods,
- *using the documentation*: national standard indications, educational research literature, debate on educational issues, etc.

With regards to the methodology, the emphasis is on the typical aspects of an active approach, such as

- *a “bottom-up”* approach to think, learn and teach*,*
- *the use of technologies,*
- *the education to collaborate, mediate, negotiate,*
- *the analysis, evaluation and dialog* capacities,
- *an interdisciplinary* education

As an example in physics, we discuss in some detail two sections, which we consider indicative of the spirit of the platform.

The first is the section on “Everyday Physics” (Fisica del Quotidiano), included in the main Physics page. It originated from a “Lauree Scientifiche” project, in which working groups of Secondary School teachers developped experimental activities on everyday Physics, sharing their own experience. The result was a collection of materials on ten themes, which range from the physics of the automobile to magnetism in everyday phenomena.

The interest of this section does not consist in the originality of the proposed experiments, since on the physics of everyday phenomena there is a rich and well known literature, with many proposals at all levels, but on the general frame, on the fact that the activities are tested in real class situations, included in the class planning, presented in the teacher's words after discussions and negotiations among the authors: they thus reflect the dynamics of a real working groups and their progressive efforts, which can hopefully draw other teachers to follow the example.
The second type of sections is more conventional, it regards essentially "action 1", since it presents materials developed in the "SIS" or "SFP" physics labs at different levels: they concern mainly the disciplinary and methodological contents, which are discussed starting from concrete examples and practical problems. At the level of higher secondary school, they are organized according to the standard chapters of a physics course (Mechanics, Thermodynamics, Electromagnetism, Optics, Modern Physics), in order to facilitate the access. For the lower school levels, the materials are organized according to large themes (Space and time, Force, Energy, Light and Sound, etc.) with particular attention to interdisciplinary aspects. They can be found either in the general course on "Physics" or in the courses dedicated to each level (Infancy and Primary school, Junior Secondary School, Physics for Higher Secondary School).
Many materials are still dispersed in different sites, where they were initially developed and their transfer to the DI.FI.MA. platform is still under way: indeed, a possible use of the e-learning platform is also to serve as an unique archive, ready for consultation but also for upgrading.
Another interesting aspect, which is becoming more evident with the development and the use of the platform, is the fact that the materials are accessible to all participants, independent from their school level, and this forces a particular attention to the continuity and consistency of approach between the different levels. An example is the approach to energy: one cannot propose to discuss the energy when playing on a twisted slide at the playground starting from definitions such as "energy is the capacity for doing work", because this might be fine at the High School level, but would not work for an elementary school teacher! This simple fact is now leading to a profound revision and to a debate on our approach to energy.

Figure 2: a twisted slide at the playground for an approach to energy

In the mathematical courses, particular interest is focused on "mathematics laboratory", introduced by the Italian Mathematical Association, UMI, (Anichini et al., 2004): a methodology based on structured activities aimed at the construction of meanings. It involves people, structures, and ideas, as well as a "renaissance workshop", where the apprentices learn by practicing, namely with a perceptual-motor learning and not only with a symbolic-reconstructive one (Nemirovsky, 2003).
The mathematical section contains the curricular project from primary to secondary school: "Matematica 2001" (grade 1^{st}-8^{th}), "Matematica 2003" (grade 8^{th}-12^{th}), "Matematica 2004" (grade 13^{th}), all organised in the same nuclei: Numbers, Space and Figures, Relations, Data and Previsions, Measuring, Solving and Posing Problems, Argumenting and Conjecturing. The nuclei are declined in competences and contents with many examples of experienced activities.
The section contains also:

1. materials for teacher training, for in-service teacher courses (at different levels from infancy to higher secondary school) in a joint protocol UMI-Minister of Education ("actions" 1),

2. research product in Mathematics Education (“actions” 2),
3. materials for teacher training in mathematics with technology, for distance pre-service e-learning (“actions” 1 and 3),
4. information about mathematical associations and events: seminars, congresses, conferences, expositions (“actions” 4).

As an example in mathematics, we present the section “Senior Secondary School”, organised in: international research articles, articles for teacher journals, and experiences carried out in classes. The themes are: number sense, symbol sense, and graph sense, developed in rich contexts for perceptual-motor learning. Having *number sense* means not only knowing numbers and operations, but also estimating a quantity, the order of magnitude, the uncertainty related to a measure (Sowder, 1992). Similar meaning has the *symbol sense:* “a tool for understanding, expressing, and communicating generalization, for revealing structure, and for establishing connections and formulating mathematical arguments” (Arcavi, 1994, p. 24). Even *graph sense* is related not only to the mere ability of representing points or curves in a graph, but also to decipher information contained in a graph, both at a global and at a local level (Robutti, 2005).

In the same section, as in the other section referring to other school levels, we ask the teachers to send their meaningful experiences, to share and discuss them in the community (through the forum), in order to select the best practices (“actions” 2 and 3). In fact, the general aim of the platform DIFIMA is not only to give materials, but to exchange and develop ideas on teaching-learning processes.

Particularly interesting are the activities which use a dynamical geometry software (DGE) such as “geogebra”, because they are very powerful in developing the exploration and the validation of geometrical situations through their online graphical facilities. This type of software is now being used also in some physics pages of the platform, to model, explore and test rapidly the effect of changing parameters, etc., thus showing how a common platform for mathematics and physics can favour the transversality between the two disciplines.

Besides the main sections regarding specifically Physics and Mathematics, two sections are dedicated to the historical biennial seminar on the Mathematics and Physics Didactics, which has now reached the 4th edition. Besides providing information, real time and static documentation as most conference sites do, the peculiar use we did of the e-learning facility was to exploit its interactive aspects to solicit the participants to express their opinions, requests, preferences, etc., before, during and after the conference through the forum and the “assignments”: these facilities would require special features in conventional web sites, while are routinely in e-learning platforms.

2.4. The “lifelong learning” and other categories

The other categories of DI.FI.MA. have a more dynamical structure compared with the previous one. They are mainly used for development projects, which might have a temporary function: their aim is to support working groups being formed, encouraging small communities of teachers to start new activities or experiment new paths.

3. Conclusions

Although it is known, since a long time, that the joint participation of teachers and researchers to communities of practice is an efficient way to promote the interaction between the teachers and the educational research, only recently a practical way to organize and keep alive such communities has become accessible with the diffusion of easy and low cost internet platforms. The results obtained in our experience with the DI.FI.MA. platform seem encouraging, though they need further analysis and tests. One of the unsatisfactory aspects, which will deserve particular attention, is the real-time participation: the users generally access the platform “statically” to obtain information or to download documents, while active contributions to discussions and materials are rare and mainly limited to the sections with key-access. This might be due to difficulties in handling

on-line tools, but might also indicate the intrinsic limit of this method of supporting the community of practice.

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