

FROM RESEARCH IN MATHEMATICS EDUCATION TO TEACHERS' TRAINING THROUGH INTERNET

Rossella Garuti - IRRE Emilia Romagna

Abstract: The aim of this paper is to present and discuss some criteria that have been elaborated and used to select and organise materials for pre-service and in-service teachers' training through Internet. Materials came from research in mathematics education performed by some Italian teams; selection and organisation of materials (in terms of teaching sequences, and related theoretical frameworks and protocols coming from teaching experiments) were performed by teachers-authors within their research teams, according to shared ad-hoc criteria.

INTRODUCTION

In recent years, Italian Ministry of Education and Research (MIUR) decided to support projects aimed at the diffusion of didactical innovations concerning education in Science (including Mathematics) and Technology, and enhancement of related education research in the school system. In particular, in this paper we will consider two of these Projects: the national SeT Project¹ (1999-2002) and the MIUR - Mathematics Departments Project (2001-2002).

The SeT Project (Special National Project for Education in Science and Technology) had the following goals:

- To set scientific and technologic education as a matter of general interest for the Italian school system, and involve research institutions dealing with science and technology in the support to school effort of innovating teaching in these areas.
- To implement materials, on-line services, support actions for teachers.

Schools and research institutions were invited to apply for funding by presenting coordinate Projects. In particular, the proposed Projects had to be based on a strict cooperation between research institutions (that hold the scientific responsibility and coordination of the project) and schools involved in the Projects as partners for preparation of innovative didactic materials and related experimentation. 562 projects were presented, 27 of them were funded. Some research teams in Mathematics Education (from the universities of Genova, Modena, Napoli, Pavia, Pisa, Torino) engaged in the preparation of projects: indeed it was an occasion to move from the "research for innovation" perspective (see later) to a large scale diffusion of research results, in terms of materials for pre-service and in-service teachers' training. In other words, to move from research for innovation, to the offer of ideas and tools (derived

¹ All projects are in the following address http://www.bdp.it/set/area1_esperienzescuole/cm131/5/htm

from research) for the innovation of the teaching of mathematics on a national scale. This paper concerns some features of the SeT Projects² jointly elaborated by the research teams of Genova, Modena and Pisa:

- I) *Mathematics and science languages, and rationalisation of common phenomena and experiences* (13 “Working units” mainly addressed to primary school: grades I to V)
- II) *Elementary mathematical modelling and the approach to theories in mathematics and science* (14 “Working units” addressed to secondary school – grades VI to X).

The MIUR- Departments of Mathematics Project (MIUR-DM Project) was intended to promote both training of school teachers-researchers, and diffusion of innovative material concerning teaching and learning of mathematics in primary and secondary school. This paper presents some features of the Genova team activities in this Project. In particular, the Genova team interpreted the commitment inherent in the Project as an occasion to investigate and exploit the potential offered by Internet as a medium for in-service teachers’ training, and an occasion to train teachers-researchers as authors of materials (derived from experimental research) to be diffused through Internet. Eight “working units” are being prepared (for primary and lower secondary school).

In order to understand the meaning of the engagement of mathematics education research teams in the above mentioned Projects and to frame the content of this paper, it is useful to refer to some peculiar aspects of Italian research in mathematics education. According to the Italian tradition in this field (see Malara&Zan, 2002), the need for socially relevant outcomes of mathematics education research was a crucial motive for research since the constitution of research teams in many universities thirty years ago. These teams involved (and still involve) researchers and school teachers in research activities strongly linked to classroom practice. During the last decade, most of Italian research in mathematics education progressively assumed a more precise and shared feature, defined as “research for innovation” (see Arzarello&Bartolini Bussi, 1998; Bartolini Bussi, 2001). Investigations are characterised by the following elements:

- three components: the epistemological component, related to the analysis of the mathematical content; the cognitive component, related to the analysis of individual and social learning processes; the didactical component, related to the analysis of classroom teaching situations;
- an experimental counterpart for theoretical investigation, with a dialectic relationship between the evolution of the theoretical frameworks and the analyses of teaching experiments;
- the role of the teachers involved in the research teams as “teachers-researchers”, i.e. as members of the teams who share main decisions concerning choice of research problems, planning and analysis of teaching experiments, evolution of theoretical frameworks.

² These projects are also accessible through the following address: www.didmat.dima.unige.it

The main challenge of the SeT and MIUR-DM Projects can be summarised by the following questions: is it possible to communicate through Internet (and make exploitable by “external” teachers) results that have been achieved within specialised research teams in the perspective of “research for innovation”? What kinds of research results are suitable for communication through Internet, and how to communicate them?

The aim of this paper is to present and discuss some criteria that have been chosen in order to select and make some research results (produced in the “research for innovation” perspective) available through Internet for pre-service and in-service teachers’ training and (possibly) direct exploitation in their classroom work.

WHAT RESEARCH RESULTS TO DIFFUSE THROUGH INTERNET?

Referring to Boero&Szendrei’s classification of research results and Boero, Parenti & Dapuzo’s discussion about results that are suitable for use in teachers’ training (see Boero&Szendrei, 1998; Boero, Parenti & Dapuzo, 1996), the choice was to select both experimented innovative teaching sequences and innovative manners of describing and interpreting teachers’ and students’ behaviours (with an effort of integrating, for some aspects; and distinguishing, for other aspects, the two kinds of contributions). The reasons for this choice depend both on elaboration presented in the literature (see Comiti & Loewenberg Ball, 1996; Clements, 2002; Ruthven, 2002) and on preceding local experiences. Both sources bring to a common conclusion: results of the first kind are difficult to exploit in correct terms if they are not framed in an explicit theoretical framework, concerning their motivations and the interpretation of students’ behaviours; while results of the second kind have scarce impact on teachers’ professional choices if they are not implemented and made operational through concrete examples referred to reliable, well documented experiments. In concrete terms, this choice translated into macro-criteria to organise the information presented through Internet. Each working unit comes from a long term and wide experimental research activity (usually, different teachers experimented it in their classrooms in different years, possibly with several changes). Each working unit carries three kinds of information:

I) a teaching sequence (covering about 20 hours of classroom work), organised according to some (from 2 to 5) didactic situations. Each didactic situation includes some tasks (from one to five). Didactic situations and tasks are accompanied by suggestions for the teacher, and protocols taken from teaching experiments concerning the teaching sequence. Most suggestions come from experimented ways of managing tasks in the classroom. Students’ protocols concern excerpts of classroom discussions, and individual solutions and reports. Most protocols are commented. Both comments and suggestions for teachers make reference to some key-words that carry the relevant theoretical motivations of educational choices and interpretation of students’ behaviours.

II) The general motivations and aims of the teaching sequence, the links with national programs, the requirements (both on the students’ and the teacher’s side), the list of the

relevant keywords to understand the motivations of the teaching sequence and the analysis of classroom outcomes.

III) The links with other working units concerning the same field of experience (e.g.: bunch of “Sun shadows”, bunch of “Gears”, bunch of “Representation of the visible world”) and a short synthesis of the content of the working unit.

Key words concern crucial aspects of the theoretical framework of the working units: for instance, the *classroom discussion* orchestrated by the teacher, the *management of hypotheses*, the *role of verbal language* in reporting and elaborating students’ thought, the meaning of *theory* and *theorem*, etc. Key words can be accessed from the navigation within the working units, or at the very entrance in the Project (as a whole theoretical framework for it).

An example: one working unity home page

This is the home page of a working unit concerning the field of experience of Gears. It is addressed to primary school. In the centre of the page, few lines introduce the content and the aims of the working unit: “*The activities in the field of experience of gears can promote the production of hypotheses, argumentation and, even with very young students, the approach to mathematical theories. The theory dealt with in this Working Unit is kinematics, related to problems of functioning of gears*”. The main button (“*Il percorso didattico*”) allows to access the sequence of the classroom activities (with suggestions for teachers and commented protocols from classes).

Scuola di base Unità di lavoro M ... dagli ingranaggi alle ruote ...

home progetto home unità lavoro grappolo struttura U.L. sintesi U.L. download U.L. per scrivervi

L'introduzione nella classe del campo di esperienza degli ingranaggi favorisce la produzione di ipotesi, l'argomentazione e, anche con alunni molto giovani, l'approccio al sapere teorico. La teoria in gioco è la cinematica in relazione a problemi di funzionamento degli ingranaggi.

il percorso didattico

Motore a lucertola per tartarughe stanche, tratto da "Le macchine di Munari", Einaudi

chi siamo quali scelte per programmare per realizzare parole chiave schedario

The buttons on the top of the page allow: to come back to the home pages of the Project or the Working Unit; to make links to the bunch of related Working Units, to the structure of the working unit, and to a synthesis of it. A button allows to download the working unit, another creates an E-mail connection with the author (for comments, request of further information, etc.). The buttons in the lower part (“*chi siamo*”, “*quali*

scelte”, etc.) allow to make links to main relevant information about: the authors; main cultural and educational choices; present and forthcoming national programs, conditions for feasibility in the classroom; key-words; worksheets.

The following one is the home page of one of the two SeT Projects. While entering the home page of the Project, one can find another opportunity to access some relevant aspects of the theoretical framework elaborated for it: the Gymnasium. (“*esercitazioni*”). Possible theoretically grounded interpretations of a protocol or ways of managing a classroom situation are offered in an interactive way (see later).



Buttons allow to access an overall view of the project (“*presentazione del progetto*”), the Working Units (“*Unità di lavoro*”), the Gymnasium (“*esercitazioni*”), the authors (“*Chi siamo*”), external references (“*riferimenti esterni*”) that include present and forthcoming national programs for Mathematics, and the *Forum* (see later).

HOW TO EXPLOIT THE OPPORTUNITIES OFFERED BY INTERNET AND ESCAPE RELATED LIMITATIONS?

It is well known that Internet offers many opportunities, but also severe limitations in comparison with the traditional ways of communicating information through books, articles and lectures. In particular, Internet provides teachers with the opportunity of a low cost, permanent and easy-to-manage access to information in the field of education. And Internet navigation allows to select and reach the needed information in a very short time. But reading and understanding long documents on the screen is much more difficult than in the case of paper documents (and the computer printing facilities are demanding in terms of time!). Moreover, the lack of an overall vision of complex information (yet, complexity is relevant in the case of mathematics education!) can

make information difficult to evaluate and exploit in an appropriate way. Keeping into account such specific opportunities and limitations, the following choices were made:

- Different kinds of approach for different kinds of results: hierarchical organisation (for presentation of the didactical sequences) and multiple access, from inside the didactical sequences as well as in parallel (for presentation of theoretical tools).
- Different levels of detail (from general statements or titles, to more precise content) for the presentation of the Working Units: in the home page of each working unit one can find an overall view of its content and the possibility to access inner, more detailed levels of information, while from the inner levels one can come back to more general information (e.g. key words, or the general structure of the working unit);
- Privileged navigation routes, in order to favour an integrated approach to theoretical tools and didactical sequences;
- Possibility of both selective, and massive download (selective download allows teachers to check, print, etc. specific documents with no time or network restriction, while massive download concerns whole Working Units)
- Possibility of accessing a group of working units (a bunch referred to the same theme) and get an overall vision of their educational impact, or select the needed Unit.

HOW TO PREPARE MATERIALS FOR DIFFUSION THROUGH INTERNET?

According to the aims of the SeT Project, and even more explicitly in the case of the MIUR-DM Project, the teachers involved in the Projects had to become protagonist of the research activities related to these Projects; in particular, they had to be the authors of the working units. In our case, all teachers involved in our Projects were already teachers-researchers in our research teams, and so their effort was concentrated on the manners of selecting and communicating research results (deriving from the research performed in their teams) through Internet.

They had to overcome the following difficulties (according to shared criteria that are listed below):

- To fit the “format” imposed by the national guidelines (in particular, no more than twenty hours of classroom work for each working unit). Grouping a set of working units about the same theme allowed to avoid the dispersion inherent in this constraint.
- To find an appropriate language to communicate innovation and its motivations and theoretical framework. In this case the choice was to use an easily accessible language for the presentation of the teaching sequences and related comments and suggestions, while the key words provide the interested teachers with a more specialised terminology.
- To select appropriate protocols in order both to present a realistic image of what can happen in the classroom, and to motivate the educational choices that have been performed. The cross-analyses of the working units by different teachers who had

experimented them in their classrooms provided the teachers-authors with a lot of suggestions about this issue.

- To encourage “external” teachers to use the proposed teaching sequences. In particular, it was important to avoid that teachers could refuse the educational proposal because they were not accustomed to work in such a manner in their classrooms. So the presentation of the teaching sequences was organised in such a way, to allow “external” teachers to construct gradually the appropriate pedagogical and didactic contract.

- To make explicit some educational choices that were considered as obvious (or implicitly shared) within the research teams. The cross-analyses of the working units by different teams was very useful to overcome this difficulty.

Teachers-authors had to prepare materials according to the general and particular criteria illustrated in this paper. The staff of the Projects (including researchers and some experts for technical problems) fulfilled the following tasks:

- to coordinate the choice of the working units, the elaboration and progressive refinement of the criteria illustrated in this paper, the cross-checking of the working units;

- to organize and realize the interface between the files produced by the teachers-authors and the technical requirements of Internet.

HOW TO ENSURE BOTH FEEDBACK AND ON-LINE SUPPORT FOR TEACHERS’ TRAINING?

This point is the more problematic, because in Italy (differently from other professional domains) the culture of an effective interaction with teachers’ trainers is scarcely developed amongst teachers. This is due to an ancient, and still enduring, tradition of teacher training based on frontal lectures. Add the difficulty to move from a passive fruition of offered products, to an interactive fruition. Add the difficulty consisting in the use of technology (although strong efforts have been performed to make interaction through Internet easy to manage!).

The tools offered to teachers for an interactive fruition of our Projects were:

- * **Gymnasium:** according to a classic, elementary schema of computer assisted instruction, teachers try to answer questions, then they can check the answers proposed by the staff. Questions concern the interpretation of students’ behaviours and difficulties, and how to intervene on these. Teachers are invited to interact with the staff through the Project Forum (if they do not agree with the answers, or would like to know more about criteria used to elaborate the answers).

- * **Project Forum:** it is organised according to two levels of generality: General Project, and specific Didactical Sequences. Teachers are invited to send (through an E-mail link) comments, questions, etc. The addressees are (resp.) the staff, and the teachers who are the authors of the working units.

SOME OUTCOMES

It is early to evaluate the impact of the Projects at the national scale: the SeT Projects were put on line in June, 2000; some didactical sequences of the MIUR-Genova Mathematics Department Project are still in preparation. However, in some regions the SeT Projects have been presented to schools in the last months. As a follow-up of presentations, group of teachers started to work together in order to analyse and (in some cases) implement working units in their classes. In those situations we have observed that teachers prefer to consider bunches of working units. The aim is to create a piece of vertical curriculum (from the early grades to grade VIII) – a strong need in this moment in Italy, due to the fact that a strong institutional pressure was put on the development of a unitary curriculum from grade I to grade VIII.

Interesting indications come on the side of the teachers-authors: in particular, the passage from guided selection and organisation of materials (like in the SeT Projects), to an autonomous production. Indeed we have observed that those authors of the working units of the SeT Project, who were also involved in the elaboration of the Working Units of the MIUR-Genova Mathematics Department Project, were able to prepare materials for this Project in a situation of almost complete autonomy, up to the level of putting them on line (they were supported by the staff only at the last stage of technical management of files). In particular, once the general content of the working units was decided, teachers were able to select and organise the materials according to shared criteria, as concerns both the information about the aims, requirements, management of classroom situations, and the students' protocols coming from teaching experiments (with related comments). This result is interesting for the opportunity it offers to teachers to become protagonists of educational changes in the Internet era, and ensure freedom of circulation of new ideas, independently from institutional pressures and textbook publishers' choices (see Clements, 2002).

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