E-LEARNING IN MATHEMATICS UNDERGRADUATE COURSES
(an Italian experience)

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ABSTRACT

The teaching of mathematics in Italian Universities is going through a period of deep transformations, partly due to general reasons and partly to national ones. The strongest drives are probably:

1) a recent reform of the Italian University system, which allows every single University more autonomy and decisional power than in the past;

2) the deep changes occurred in the past decades all over the world in the perception of the relations between mathematics and its applications;

3) technological innovations, and the major changes they imply both in teaching methods and in the mathematical contents we teach.

In March 2001 a group of nine mathematicians and computer experts working in Università Bocconi in Milan – a well-known business University – started a project focused on integrating heavy e-learning technologies into the traditional structure of Mathematics courses for undergraduates.

We would like to present at Creta ICTM-2 Conference a comprehensive description of our experience: the project (March-July 2001), the courses (September 2001-April 2002) and a first analysis of the results (May-June 2002). We chose to present at the Conference three independent papers (see also the works by M. Impedovo and F. Iozzi); each one takes a different point of view.

The first part of the paper describes the Italian context and our project, following the above framework.

The second part analyses some aspects of the project, referring in particular to the courses in which the author is more deeply involved:

1) a complete e-learning course, specifically dedicated to students with poor performances in mathematics (approximately 100 students);

2) a basic e-learning course, to be further developed next year and to be dedicated, presumably, to all first-year students in Università Bocconi (approximately 2500 students).

Finally, we try to draw some conclusions.

1. The context

In this paper we try to write down a whole year's experience on the use of e-learning technologies as a support to traditional classroom teaching. We describe the context in which it took place, the main features of the project and the reasons for some of our choices, and then we try to draw some conclusions.

We don't claim to point out any new and brilliant way; our main goal is to tell our story, and possibly compare it with others who are or have been in similar situations in other countries.

Since the academic year 2000-2001, a reform of the Italian University system has organised its first steps in two levels:

1) a three-year "short degree";

2) followed by two optional years, ending with a five-year "specialised degree".

Till the year before, the Italian system provided as a first step only a four-year first degree.[1]

Moreover, many reasons led to a considerable stretching of the actual length of the degree, up to an average of more than six years; and also to great many students giving up their University studies, with the percentage of graduates with respect to matriculated students running as low as 30-40%.

It's a widespread opinion that this reform will succeed if and only if:

1) the idea will get through that the "real" degree, that is the one sufficient for the majority of occupations, is the three-year degree;

2) both the lengthening of studies and the abandonment of studies phenomena will be reduced.

It is not difficult to foresee that a fundamental issue about the future three-year degree courses will be that of coping with a reduction in quantity and quality levels of the University studies, while trying at the same time to guarantee an acceptable standard (as least as professional needs are concerned) and to increase the efficiency of the system in a significant way (both in terms of length of studies and percentage of graduates).

With the reform each University has obtained more autonomy than in the past, and can decide for example to reduce or increase the space given to each subject in each degree course, remaining within a broad range established by the central authority.

The distribution of Italian students whose course of studies contains mathematics as an important subject has changed in the last decade: in particular, there has been a reduction in the percentage of students belonging to scientific faculties, and a dramatic cut in strictly mathematical courses; the percentage of students in Engineering and Business Administration courses is either stable or increasing.

Thus, the majority of math students, courses and professors is referable to faculties where mathematics have not a strong academic status; this implies that the spaces for mathematics, in the immediate future, will go through possible reductions or at least through long and difficult negotiations. The relations with other disciplines in the course of studies and with our colleagues will be very important, as well as the existence of reliable and positive evaluations on the effectiveness of math courses for the purpose of the global education of students.

In the last decades, a fundamental change has taken place in the mathematical community with regard to the perception of the relations between mathematics and its applications. The image of the Bourbakists' follower, sitting and writing his neat formulas in an ivory tower, unshakeably sure that in a few centuries' time a prince will understand their great utility, come and bring them

[1] This account of the Italian University system oversimplifies the real situation; many faculties, such as Medicine or Architecture, have a completely different story.

to life with an enchanted kiss is no longer plausible. And this has reflected on mathematical education, of course; though we must say the Italian situation is behind times in this respect.

The observation that a mathematics course in a faculty such as Engineering or Business Administration must be strongly related to the other courses and to the overall and specific preparation required from the students doesn't sound so obvious in Italy; a few years ago many Italian mathematics professors simply did not care about the opinion, prevailing just outside their office doors, that math courses are a separate and almost useless body in the students' curriculum.

But things change. And these changes are mainly due, of course, to the conceptual changes occurred inside our subject; but also to the needs for negotiation of academic spaces mentioned above.

Finally, a very important element is technological innovation.

First of all, due to the changes which have taken place inside mathematics and mathematical education. We all understand that the ways of mathematical research and mathematical education, the greater or smaller importance in this historical period of this or that research field, the choice of the subjects we favour in our teaching are all matters which have been modified by the coming of Computer Era. But also because of external reasons, related for example to the academic world that surrounds us.

The wealthiest and farthest-seeing Universities are today eager to invest energies and resources on the use of technological innovations in education. Presumably some of these investments will turn out to be unproductive, but the idea that in the future the issue of education will not do without a deep technological involvement appears strong and widely shared.

In some Italian Universities, Mathematics Departments and Institutes are curiously unprepared to understand these changes; they even risk to be considered a resistance factor to technological innovations. On the contrary, a correct scientific attitude should naturally lead us to an unbiased judgement towards technological innovations. This would also have the positive and not negligible secondary effect of increasing the esteem of the academic world in our capability of participating to a common project.

2. The project

In the last three or four years, Università Bocconi launched and encouraged many different projects related to the use of technological innovations in undergraduate courses.

In March 2001 I proposed to my colleagues in the Institute for Quantitative Methods, at Università Bocconi, to start a project focused on the integration of heavy e-learning technologies in mathematics courses for first-year undergraduate students.

Two problems showed up immediately:

1. the big increase in the amount of work connected with teaching, implied by this project;
2. the doubts on the compatibility of these technologies with some specific issues of mathematics (for example: the difficulties in manipulation of symbols and formulas, the problems connected with the evaluation process).

The first problem is a very serious one.

The Italian University system has not many ways of encouraging the quality of teaching: a great part of the academic career of a University professor is based on the quantity and quality of his scientific production (I will not consider the strong co-optation mechanisms, more or less effective as far as the quality of the recruited personnel is concerned, which are typical of the Italian academic system). Anyway, Università Bocconi is a private University and has enough

autonomy and resources to provide a non-standard academic role, with satisfying contractual conditions and exclusively dedicated to teaching. We decided to count on this kind of academic personnel (*quorum ego*), as it was possible in this case to guarantee correct economical and professional incentives; and to seek only enthusiastic volunteers.

First of all, I involved my friend Michele Impedovo; then we gradually built up a group of nine mathematicians and computer experts. The big push that our University is giving to the issue of technological innovations has done the rest, providing us with favourable working conditions and enough economical and human resources.

The second problem has turned out to be a fake. As it often happens, the statement that "yes, it would be nice, but with the teaching of mathematics things go differently; you can't do that with mathematics" has revealed to be a defence behind which to hide, in order to cover our natural difficulties to come to terms with changes and control them. In this year's work we solved many problems connected with the writing of formulas, with automatic assessments, and other problems; the problems we could not solve, we put them apart or managed to go round them.

In April 2001 we began to build up the web-courses we would carry out in the following academic year.

As far as we know, the use of e-learning technologies in Italian Universities is not very common; when they are used, one of the following two software is employed: *Blackboard*, originally developed by Cornell University (and now bound in a strong partnership with Microsoft), and *Learning Space* by IBM-Lotus.

Blackboard is employed by Università Tor Vergata (Rome), Università Cattolica (Milan) and Università Bocconi (Milan). *Learning Space* is employed by Bergamo, Brescia, Modena, Padova, Pavia and Venice Universities, by Milan and Turin Polytechnics and by Università Bocconi (Milan). They usually organise single pilot-courses, not yet fitted in a comprehensive project; and there does not seem to be a co-ordination of all these experiences, although in the last year CILEA, an Inter-University Consortium, has taken some steps in this direction (see the URL www.teorema.cilea.it).

The only structured projects are, as far as we know, those of Milan Polytechnic and Università Bocconi; both projects utilise *Learning Space*, though in two different versions which are not completely comparable.

Milan Polytechnic has opened, in the academic year 2000/2001, the first On-Line Degree in Italy (in Computer Engineering); here *Learning Space* courses (4.0 version) are meant to be a *substitution* of traditional classroom teaching (see the URL www.laureaonline.it).

Università Bocconi has developed since 1999/2000 a different project, in which *Learning Space* courses (3.5 version) are meant to be an *integration* to traditional classroom teaching; the project foresees that for each traditional course a parallel web-course will be developed, and tries to guarantee a strong co-ordination of these courses by proposing common yet flexible standards (see the URL www.uni-bocconi.it/weblearning).

We got in touch with Roberto Lucchetti, a Milan Polytechnic professor who in 2000-2001 was responsible of an on-line mathematics first-year course for the Degree in Computer Engineering; we understood this direction can be equally fascinating, but decided that we were more interested in e-learning technologies which are not a substitution but an integration to classroom teaching.

In the end, following the suggestions of A.S.I.T., the Department that deals with web-learning technologies in Università Bocconi, our workgroup decided to utilise *Learning Space* (3.5 version) as an integration to traditional courses.

We organised five different web courses:

1) A complete course, dedicated to students with poor performances in mathematics (a better definition is the following: all students registered at Università Bocconi since more than three years, who have not succeeded in giving the first-year mathematics exam); this course concerns approximately 100 students, and we will refer to it with its code number 271.

2) A basic course, dedicated to all first-year students in the Business Administration Degree; approximately 1200 students, code number 5015clea.

3) A basic course, dedicated to all second-year and third-year students in the Business Administration Degree; approximately 300 students, code number 4009clea.

4) A complete course, dedicated to first-year students who are particularly interested in technological innovations (students belonging to a brand new degree called Economics of International Markets and New Technologies); approximately 150 students, code number 5015clemit.

5) A complete course, dedicated to first-year students with a mathematical and quantitative high profile but without particular motivations in technological innovations (students belonging to a degree called Social and Economic Disciplines); approximately 150 students, code number 5015des.

I was in charge of the first three courses, with the help of Giovanni Paolo Crespi and Maria Beatrice Zavelani Rossi; Michele Impedovo was in charge of the fourth one, with the help of Fabrizio Iozzi; Annamaria Squellati was in charge of the last one; Anna Marotta and Marcella Gombos were responsible for the web implementation of the courses; Margherita Cigola contributed to the general framework of the project and to its overall management.

3. The courses

Learning Space (in the 3.5 version) is made up of four main environments: *Schedule*, *Media Center*, *Course Room*, *Assessment Manager*.

The *Schedule* contains the instructions on the available course material, and associates it to the single lessons. The *Media Center* contains the available material, which can be grouped by type or by subject. The *Course Room* is an on-line discussion forum dedicated to all course students and teachers. The *Assessment Manager* allows the construction, distribution, collection and evaluation (either automatic or not) of homework and exams.

As we will see, these four environments have been used in different ways according to each different course.

1. Course 271

The classroom course had the following structure:

a) 80 lesson hours, given by me, on traditional subjects (elementary functions, series, differential calculus, integral calculus, linear algebra, financial mathematics); I rarely used a computer in the classroom, I emphasised on applications to economy and finance.

b) Approximately 80 hours dedicated to *tutoring* and exercises in small groups, partly organised by me and partly by my two colleagues, as a reinforcement to the subjects explained during the lessons.

The on-line course had the following structure:

a) In the period April-September 2001 we built up a large data bank in the *Media Center*, containing all exam papers assigned for that course in the last three years; students have access to the data bank to consult/print complete exam papers or single exercises, recorded under various

keywords (for example: all multiple choice exercises assigned on differential calculus, regarding economic applications).

b) During the course, with the help of some students (to whom the University guaranteed the payment of a small sum), we put in the *Media Center* the slides of all classroom lessons; at the end, in April 2002, the entire course will be on line. After many hesitations we chose to scan the hand-written slides (in fact, we scanned a polished rewriting of the slides effectively used in the classroom), and not to create a *Word* or *Latex* version of them. Students considered this material as very helpful, but I must admit its preparation has taken a lot of time.

c) We put in the *Media Center* the exam program, additional exercises, simulations of exams to come, many *Mathcad* files and other material.

d) Our *Course Room* has been rather lively, although mainly centered on teachers' communications and students' questions; it was not the place in which to pose or discuss interesting additional mathematical problems (I considered the peculiarity of the course, which was intended for students with particularly poor performances in mathematics; they were surely much more interested in 'finally passing this exam' than in 'exploring the infinite beauty of mathematics').

2. Courses 5015clea, 4009clea

These were two identical courses, and we kept them separate for formal reasons only.

The classroom course was similar to that of course 271, although it included less *tutoring* hours.

The on-line course was made up of the *Media Center* only; it contained an analogous data bank on previous exams, and also the exam program, simulations of exams to come, many *Mathcad* files and other material. We did not create slides out of the lessons, we did not use the *Course Room*. It was a basic course, really.

We will develop this course next year; one of the most interesting characteristics of this kind of course is, in fact, the possibility of building and modifying it year by year.

3. Course 5015clemit

This was the most interesting and innovative course of all; it is described in detail in the works of my colleagues Michele Impedovo and Fabrizio Iozzi, which will be presented at this same Conference (see references at the end); thus I will give only a short description of it.

The classroom course had the following structure:

a) Approximately 110 lesson hours, covering a larger program than that of course 271 (for example: many-variables differential calculus and optimisation, dynamic systems, a larger number of topics in financial mathematics); computers were largely used during the lessons, and this fact had a considerable influence not only on the presentation of the subjects but also on the choice of the mathematical contents to privilege.

b) Approximately 25 hours dedicated to computer laboratory activities, essentially centered on the use of *Mathcad* software.

The on-line course had the following structure:

a) The *Schedule* contained detailed instructions on the use of materials connected to each lesson.

b) The *Media Center* contained essentially the large number of *Mathcad* and *Excel* files used during the course. As it is a new course, no data bank of the previous exams has been provided.

c) The *Course Room* has been used in a very active and lively way, with a strong interaction between teachers and students; as my colleagues explain in their papers, they have tried to carry out an instance of *computer-assisted collaborative learning*.

d) They used many of the evaluation instruments (both automatic and non automatic evaluation) provided by the *Assessment Manager* environment.

In this course the evaluation process has greatly involved the use of *Learning Space*, *Mathcad* and computer laboratories; in all other courses, neither *Learning Space* nor any other computer technology has been used in the evaluation process.

4. Course 5015des

The classroom course has followed a program similar, in broad lines, to the program of course 5015clemit. Computers have been rarely used; however, students did some group homework involving the use of *Mathcad*.

The on-line course has been essentially conceived as a notice board; during the course a large number of tests has been proposed as homework in the *Media Center*. They have been evaluated with non-automatic procedures. The *Course Room* has hardly been used.

4. Some conclusions

At the time of writing this paper (end of January 2002) the courses described above are only halfway, therefore we cannot evaluate our results; we will present a first analysis at the Conference. Anyway, let's try to draw some conclusions.

1. We think the integration of on-line technologies in undergraduate traditional courses is a workable, sensible, useful and almost unavoidable way; the quality of our teaching offer has sharply and undoubtedly improved. From the scarce data we have, we got the feeling that those e-learning technologies which try to substitute traditional teaching activities are, at least at the undergraduate level, less interesting; they seem fit to cover a little, important niche sector rather than to expand to a consistent part of undergraduate courses.

2. The choice of how much web technology, of what kind, and how deeply related to the use of computer technology in the classroom is an open question: there are many possibilities, and we do not have a unique recipe at this regard. On the contrary, we think the possibility of different approaches is, at this stage, an essential resource. A lot depends on the kind of students for whom the course is prepared (the courses 5015clemit and 271 are nearly opposite, at this regard!); and a lot depends on the personality and teaching style of each teacher, as it obviously should be.

3. There are more general reasons that lead us to think that the choice of using e-learning technologies is useful and unavoidable, even beyond its effectiveness in strictly educational terms: Universities are investing a lot in these technologies, and our choice contributes to bring us nearer to the center of an important innovative stream.

4. This choice demands a lot of teaching work, there is no doubt; and - frankly speaking – sometimes it is not highly qualified work. A necessary boundary condition seems to be the fact of working in a University where these issues receive appropriate consideration, and where a fair amount of economic and human resources is available; we have been lucky, but this situation may be quite common.

5. Another important condition is the fact that the professors themselves should consider their teaching work as interesting work, strictly connected with their professional and personal growth; in our Italian experience this condition has revealed to be more delicate and difficult to obtain, but the perspectives for the future are encouraging. In fact, we hope that the spirit of the Italian University reform will lead to a reconsideration of the role of University professors, favouring a divarication between the functional profile of the undergraduate professor and that of other

academic categories; and with the acknowledgement of the prominence of teaching activity in the identity of undergraduate professors.

The perspectives for e-learning technologies in mathematics courses in Università Bocconi seem to be very interesting.

Next year we are thinking of extending our e-learning project, at least in a basic version, to all first-year mathematics courses; and we will implement a similar project to some of the second-year mathematics courses (financial mathematics) and to some statistics courses.

REFERENCES

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