MIUR • CONFINDUSTRIA

CONFERENZA NAZIONALE DEI PRESIDI DI SCIENZE

PROGETTO LAUREE SCIENTIFICHE

ABSTRACT

INTERVENTI ALLA PRESENTAZIONE DEL PROGETTO

MONTE PORZIO CATONE (ROMA) - 13 OTTOBRE 2004

CENTRO CONGRESSI E RAPPRESENTANZA VILLA MONDRAGONE

UNIVERSITÀ DEGLI STUDI DI ROMA "TOR VERGATA"

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Miur - Confindustria - Conferenza Nazionale dei Presidi di Scienze

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Scientific Degrees Project
English Version

The Crisis in Scientific Vocations in Italy

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Origins and size of the problem

Young people's interest in studying science began to decline in the early 1980s when it was noted for the first time in the USA which, nevertheless, managed to compensate for this for many years by opening up American universities to young people from the emerging countries, especially China.[1] This trend continued throughout the 1990s in all the industrialised countries[2] such that the interested international organisations became aware of the problem (see the following report of Dr. F. Sgard, the OECD delegate). In Italy, the *Permanent National Conference of Presidents of Science and Technology Faculties* has, for some years now, begun to lobby for action on this problem which today is at the centre of attention in the political, scientific and industrial world.

Let's quantify the size of the problem in Italy with some data. The demographic decline of nineteen year-olds began in the mid-1980s but the reduction of high school graduates began in the mid-1990s. The decline in university enrolments began at the start of the 1990s only beginning to rise again after the reform law of 1999 (Law 509/99) .

Figure 1

The trend in enrolment in different fields of study from 1991 to 2000 is shown in Figure 2 below where we can see that while there is an increase of almost 35% in enrolments in the Arts, there is a definite drop in Sciences.

Figure 2

Perhaps even more striking is the trend for science faculties over the last 50 years which shows that university enrolments in *the scientific field* has fallen from 16% to 10% of the total.

Table 1

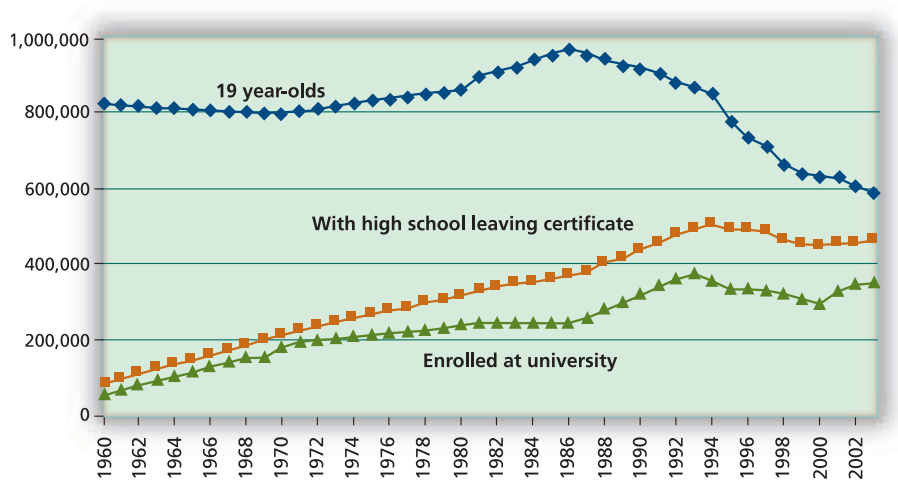

Figure 1 **Population of 19 year-olds, high school graduates and enrolled at university in Italy from 1960 to 2003** *(source: CNVSU)*

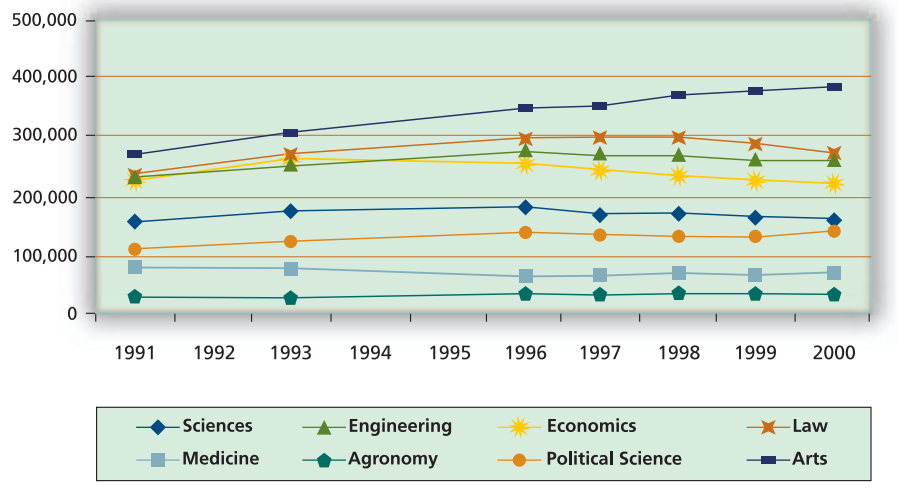

Figure 2 **Trend in enrolments by field of study source**
(source: Elaboration of ISTAT and MIUR data - from 1998)

Absolute values	**1951/52**	**1961/62**	**1971/72**	**1981/82**	**1986/87**	**1991/92**	**1996/97**	**2000/01**
Total enrolments in degree courses	*221850*	*280580*	*750293*	*1001570*	*1064481*	*1452669*	*1694433*	*1687237*
All Sciences	**35889**	**37632**	**105338**	**133331**	**130919**	**169966**	**183518**	**173610**
Medicine	34078	25165	98148	168403	114543	78875	72107	101535
Engineering	27923	31690	82823	87073	96237	165434	198873	212119
Agronomy	6991	4815	13882	40469	33508	31323	39803	42017
Total "Sciences"	**104881**	**99302**	**300191**	**429276**	**375207**	**445598**	**494301**	**529281**
Percentage values								
All Sciences	**16,2**	**13,4**	**14,0**	**13,3**	**12,3**	**11,7**	**10,8**	**10,3**
Medicine	15,4	9,0	13,0	16,8	10,8	5,4	4,5	6,0
Engineering	12,6	11,3	11,0	8,7	9,0	11,4	11,7	12,6
Agronomy	3,1	1,7	1,8	4,0	3,1	2,2	2,3	2,5
% Total "Sciences"	**47,3**	**35,4**	**40,0**	**42,9**	**35,2**	**30,7**	**29,2**	**31,4**

Table 1
Enrolments for degree courses in the sciences, absolute and percentage values
fonte
(source: ISTAT)

Table 2

Really, the most alarming results are to be found by looking at each subject area and the individual disciplines within them. Some areas, such as biology and computers, have held up and other new areas have grown rapidly e.g biotechnology which has increased from 48 enrolments in 1994 to over 4200 in 2003. Nevertheless there has been a collapse in the so-called hard sciences (maths, physics and chemistry – which are responsible for the basic training of future scientists and teachers of science) and, to complete this worrying panorama, a drastic fall in geological sciences as well.

The only partially positive note is, as we have already seen, that since the 1999 university reform which coincided with the information campaign of the Conference of Sciences, the number of enrolments in hard science courses is rising even if not enough either to compensate for the losses in the preceding decade or in absolute terms.

There are two different reasons for alarm. On the one hand, it has now been recognised by all the economic indicators and by a very great number of sociological stuies that in the technological knowledge age, a country's well-being and

economic progress are directly related to its ability to carry out advanced research. In quantitative terms, this can be seen in the *Yellow report* CERN 2003-005, September 2003, entitled *Technology transfer and technological learning through CERN's procurement activity* (by Erkko Autio *et al.*).

In qualitative terms, in June 2001 the president of the US National Science Board, Prof Eamon M. Kelly, made the following observationg to the US Senate's Finance Committee by way of example:

❞ *«In a speech before the American Association for the Advancement of Science on May 3, Larry Lindsey stated that "the average annual real rate of return on corporate investment in America is about 9 percent". Compare that to a conservative estimate that the return on Federal investment in basic research is about 30 percent».*

The US Council of Scientific Presidents also made an interesting affirmation in February 1996:

«For each dollar originally invested, federally supported fundamental scientific research repays the economy 20% to 50% annually in each succeeding year. This has been established by more than a dozen independent studies».

(www.mdsg.umces.edu/CSSP/Policy/cssp1p96.pdf).

Table 2
Evolution of enrolments in some scientific degree courses (1989-2004)
(MIUR data)

	1989	1991	1993	1994	1995	1996	1998	2000	2002	2004
Mathematics	4396	4173	4581	3635	3255	2579	1921	1611	1740	1848
Physics	3216	3228	3283	3559	3145	2698	1299	1428	2018	1974
Information Sciences	5295	4868	4166	3350	3795	3325	5603	4562	8543	7861
Biology	7777	7772	10674	10463	10224	7708	6788	7159	8958	10238
Natural Science	2137	2453	3206	3007	2824	2802	2038	1455	2689	2646
Geology	3717	3583	2975	2647	2569	2162	1850	1293	1394	1563
Biotecnology			48	129	362	568	680	1394	4180	4126
Chemistry	2274	2116	2484	2111	2569	2162	XX	1293	1702	1869

Table 3 However the most striking yardstick is provided by looking at the Finnish experiment (and to a slightly lesser extent, but also less publicised the British one) in making heavy investment in high tech since the beginning of the 1990s. The result is particularly noticeable if we compare the growth of GDP in these countries with the situation in Italy.

Figures 3 and 4 In this light, this well-known problem is multiplied by that of the lack of investment in Italy in R&D which involves all public and private areas but which is particularly noticeable in the industrial sector and which is reflected in the previously mentioned difference in GDP growth in Italy and in Finland (demonstrated in detail in Figure 4).

In this regard, it is comforting to know that Confindustria (the Confederation of Italian Industry) has recently made some very important proposals (*The Pistorio Plan*) to promote innovation and high technology in enterprises and in Italy.

The importance of promoting research has been recognised not only in countless statements made by the Minister and important figures in the world of science and economics but also in the words of the Presidents of the Republic, the Chamber of Deputies, the European Community, and Confindustria. There is further confirmation in government guidelines and, more recently, the statement issued by the European Ministers of Education at the Berlin Conference.

Table 3
GDP growth from 1993 to 2003 and percentage variation in this interval
(ISTAT data)

	ITALY	FINLAND	UNITED KINGDOM
1993	993,4	86,5	963,4
1994	1025,4	100,0	1042,7
1995	1097,2	129,7	1134,9
1996	1232,9	127,7	1190,9
1997	1166,8	122,6	1327,6
1998	1196,7	129,4	1423,3
1999	1180,4	127,8	1462,4
2000	1074,8	119,9	1439,3
2001	1091,8	121,0	1431,0
2002	1184,3	131,5	1564,6
2003	1455,4	158,8	1775,0
Increase %	*+ 46,5*	*+ 83,6*	*+ 84,2*

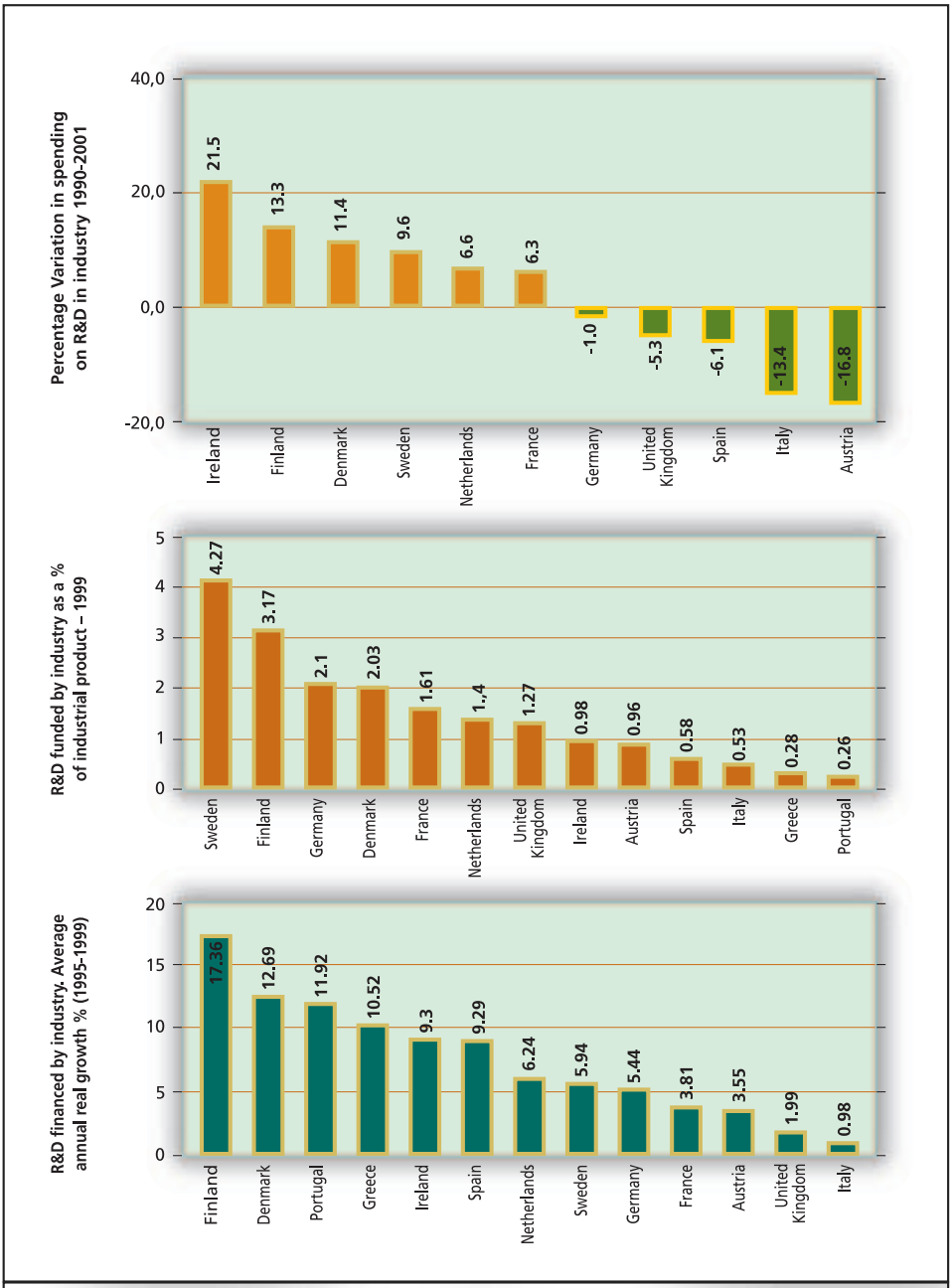

Figure 3 **Comparison of European investment in R&D**

(source: DG Research Key Figures 2002)

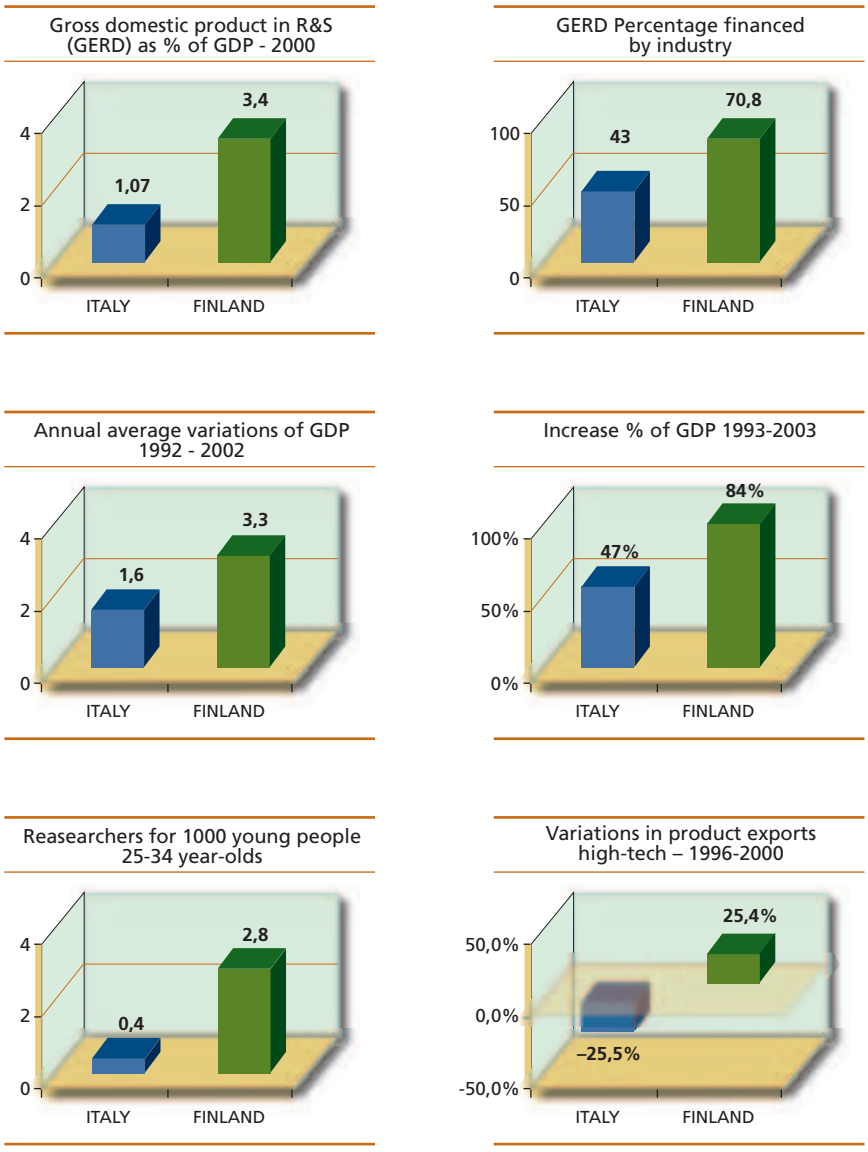

Figure 4 **Comparison between Italy and Finland** *(elaboration by Bordese-Predazzi)*

We must now identify and undertake the first and most urgent steps to remedy an extremely worrying situation. The implementation of the *Scientific Degrees* project presented today at this conference is a first and most important step.

The second reason for concern is the risk of a serious shortage of science teachers (mathematics, physics and the natural sciences in particular) within a very few years. This risk has been reported and documented in the excellent report commissioned by the British government and published in 2003, written by Sir Gareth Roberts who said: *«In mathematics there are insufficient teachers to match the demands of the curriculum in one school in eight, a situation that has deteriorated from the previous year»*. The recommendations of Roberts' Report have been taken up by the British government with the result, according to many experts, that today the U.K (along with Sweden) is a county from which good practices may be learned.

Figures 5, 6 e 7

Table 4

While waiting for the results of the study to be prepared by the OECD, let us conclude these preliminary considerations by showing some data on trends in other countries for the purposes of comparison. For example this table compares (however not complete) enrolments in Physics in some other countries (the data has been slightly adjusted to make them more uniform) which shows how the *trend* in discussion crosses over borders and continents.

Causes and reasons

A lot has been written about the causes and reasons for the decline in interest by young students in science. In a recent meeting, the Steering Committee OCSE commissioned to look at the problem has come up with three points:

a. the image of science and scientists,
b. the difficulty of science subjects compared to the perception of career paths,
c. a lack of national educational systems and poor training of science teachers.

Further to this, it should be added that there is an inade-

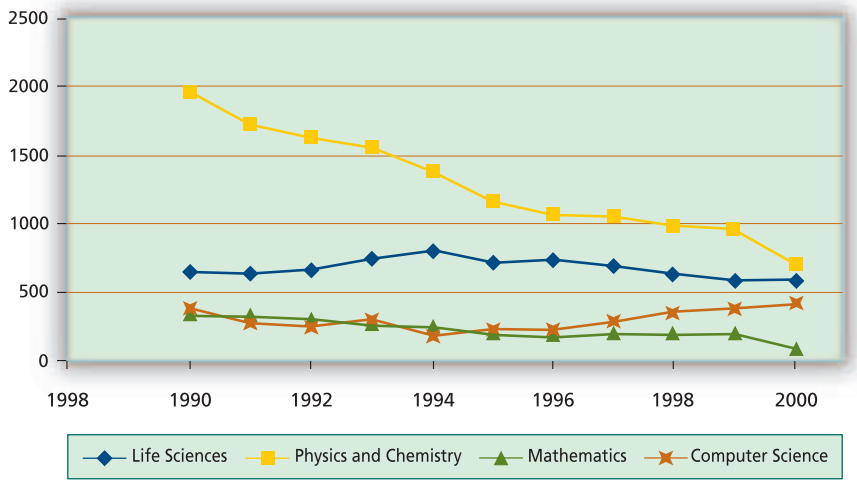

Figure 5 **Students enrolled at university – 1st year** *(source: ANISN)*

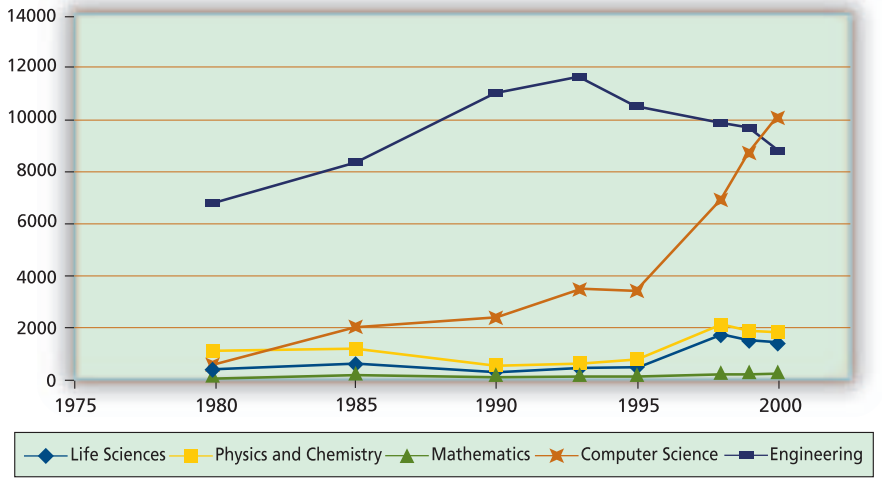

Figure 6 **Students enrolled in university** *(source: ANISN, Ministry of Education, 2001)*

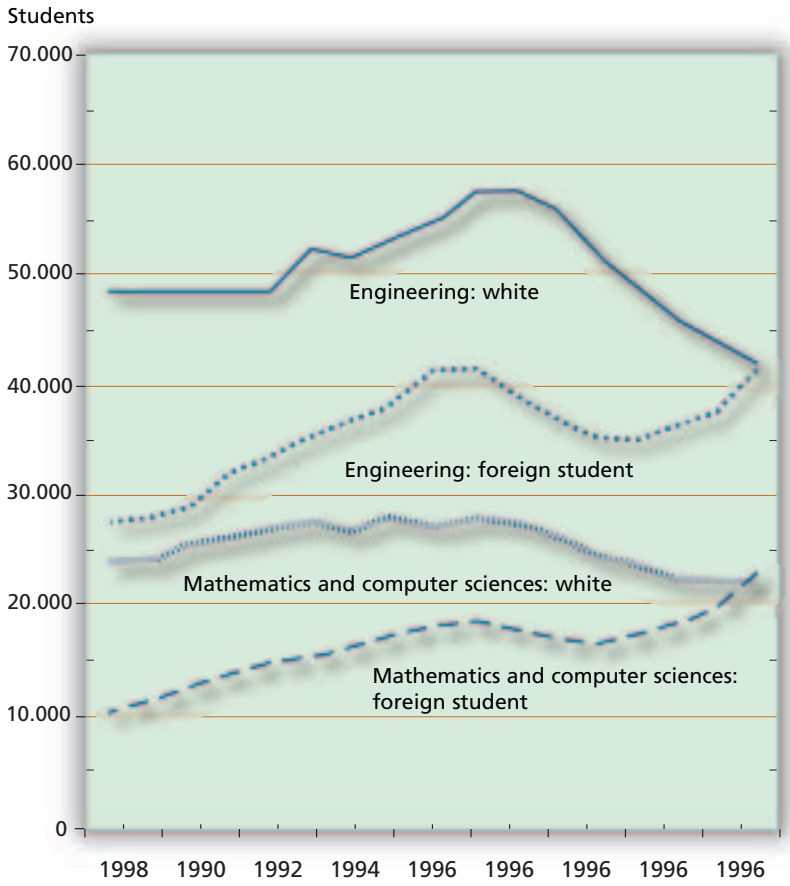

Figure 7 **2nd level enrolments in Engineering, Mathematics and Computer Science**
(source: ANISN)

Table 4
Enrolments in Physics in different countries

	1990	2000	2003
Italy	~3300	1428	1974
The Netherlands	1953	683	
Argentina	3065	2738	
France	~17000	8612	

quate awareness of science, in Italy prevalence is given to humanisitic knowlegdge which is often seen in opposition to science. Corollary there is a tendency to look at the supernatural, where the confines between magic and science, between astrology and astronomy are dangerously mixed.
The first point is perhaps the the most delicate. The image of science has slowly lost its lustre and has passed from being seen as a remedy for all to being a source of great suspicion. There are many examples which show the negative reactions, where science is mixed up with its technological applications leaving discussion to reactions which may seem out of place. Here are some examples, a nuclear power station that a madman has brought to a chain reaction in order to test the security system generates collective hysteria and so the nuclear power industry is dismantled. Paradoxically we do however continue to import nuclear energy from abroad, so creating a three-way negative result, the first is that there is no control on its security, the second is that it is more expensive and the third is that we depend totally on a very polluting source of energy. OGMs are seen to be very dangerous innovations which need to be stopped apriori, this rather than trying to understand their potential, while in many other countries their development continues rapidly (as underscored both by the Minister for Health Sirchia, and the ex-Minister Veronesi).
The examples could very well multiply. This type of attitude helps us to forget that it is thanks to science that human lifespans have doubled in little over a century, that famine has been wiped out where man has truly made an effort to do so, that many diseases have been put under control and so on. The result is that instead of trying to keep tabs on technological development and expand scientific enquiry, the tendency is to demonize it and view it as something malignant.
The second point, i.e., (the difficulty of science subjects) is for its main part a consequence of the third and further contradicted by statistics that relate to other career propects. It is however drammatically true when considering data regarding other countries. The career of a researcher is long,

difficult, filled with practical difficulties and in Italy with very low pay when compared to many other countries of the OCSE. The result of this is that our young people do become researchers but go elsewhere to work because salaries outside Italy are more appealing. This represents the worst type of draining (i.e., brain-drain) that our country can do to itself , much, much worse than when it exported unqualified manpower.

Figure 8

Finally, schools have a great need for revitalization. Careers in schools have for a long time been seen as limited or subsidiary with detrimental results on the teaching of Mathematics and Physics (this topic would obviously need much more discussion than just two lines en passant). Even here comparing Italy to other countries shows how far behind it is.

Solutions

The OCSE has set up a team who within a year will provide the government with recommendations on the more urgent

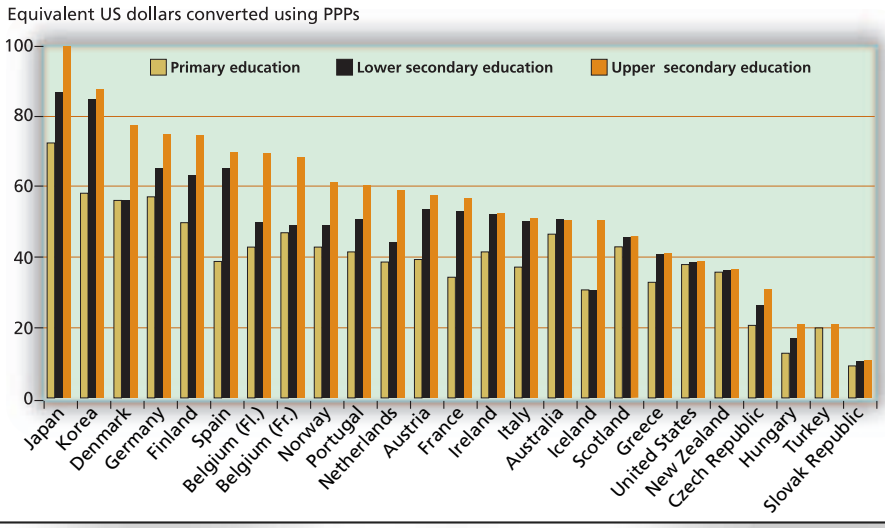

Figura 8 **Hourly pay per hour of teaching according to the level of education**
(source: OECD, Organisation for Economic Cooperation and Development)

measures to be taken. It is however evident that the most important step to take is that of revitalising schools, and such revitalisation must start with primary schools right through to forming well-prepared teachers, who are motivated and well-paid. Moreover, a precise plan of action is needed which will throw light on careers regarding research in order to attract the most brillant people, (above all Italian but also foreign).

The 'Scientific Degrees Project' more than anything stems from the close collaboration of the government with the university world and industry. This project has all the elements for an excellent platform from which to start. This opportunity should not be wasted and should be put into practice with great vigour, while waiting for proposals which may require a longer period of time.

Concluding Comments

Minister, while taking this opportunity to thank you for your concrete attention to the themes of this seminar and confirming the interest that the National Conference of Science and Technology Faculty Chairs has towards the strategy that you yourself have undertaken, I would like to point out the most urgent priorities necessary for any long term strategy that wishes to deal with the emergencies outlined above.

- Means should be established which will favour research in Italy. If we create valid researchers but let others take them away with better offers, the problem will never be solved. Italy lacks the breeding ground which would expand research. Every researcher who emigrates to look for better conditions, will have cost no less than 250,000 euro for his schooling and scientific training and will cost an enormous amount for his future. It is indispensable to begin giving competitive salaries and suitable means to our researchers. The topic of discussion regarding the necessary steps to take would have no end, but certainly one could start by abolishing the taxes on Phd fellowhips, research grants, researchers' salaries and finally research should be exempt from taxes.

- Urgent intervention and a programme to investigate the politics regarding the education system is needed, as well as a clear objective to expand the training of teachers in the scientific field and moreover to make people in our country more aware of scientific subjects.

[1] While it is true that USA has been able to deal with the fall in science students with their *appeal* training which traditionally has always lured a great number of brains (and whose effect has never been estimated but has to do with the enormous development of the country), this effect is now starting to slow down due to various resons. To start with terrorism and the restrictive measures of giving out visas (in 2001 USA gave out 160,000 visas for scientific purposes, while in 2002 this dropped to 70,000 visas). Another cause seems to be the line of politics in the American Administration favouring traditional industry rather than *high tech*.

[2] Developing countries for the moment remain out of the declining trend for science, in primis, India *and* Pakistan (big exporters of engineers, physicists, mathematicians and so on). This is not the place to go into this apparent social dichotomy but one could ask if the fact (according to *Almalaurea*) that the majority of students in Italy who enrol in science subjects come from less well-to-do classes has the same origin.

OECD Global Science Forum

Activity on Declining Interest in Science Studies among Young People

Frédéric Sgard

The development of human resources in science and technology is an acknowledged priority for countries that seek to advance science and technology as major driving forces of the increasingly globalised economy. Concordant observations suggest an apparent decline in interest in science and engineering studies in a number of OECD countries. This apparent decrease in student enrolment at various level of the educational system varies from country to country in the OECD area. It affects mathematics, physics and chemistry, and, to a lesser extent, the life sciences at both undergraduate and graduate levels, although this may be sometimes hidden by influx of foreign students in some countries.

The actual effect of such disinterest on the workforce has not been assessed precisely, but some countries report difficulties to recruit properly trained students to fill vacancies for scientific jobs and are concerned about the impact on competitiveness and productivity.

Several reasons have been put forward to explain such decline of interest in scientific studies. At the educational level, possible explanations include the lack of interest of science teaching, perceived difficulty of science courses and traditional orientation of girls and of some ethnic minorities towards non-scientific curricula. Career aspects are also important as scientific careers both in public and private sectors may be perceived as less rewarding than that of finance or management for a similar investment. Finally, a general concern about public perception of science has emerged which evolve towards more distrust for science and may influence education choices.

Faced with convergent studies, a number of countries have realised the importance of the problem and started to address it through recommendations and a variety of measures. Such initiatives are however still in their infancy and no real evaluation of their impact has been carried out. In addition, there has been little co-operation between OECD countries to confront their national situation and share experiences on the benefit of ad hoc solutions undertaken.

The Global Science Forum (GSF) is a venue for consultations among senior science policy officials of OECD Member countries in the area of international scientific co-operation. It produces findings and action recommendations on high-priority science policy issues requiring international consultations/co-operation, and identifies opportunities for collaboration on major scientific undertakings.
Specifically, the Forum serves its Members in the formulation and implementation of their science policies by: 1) exploring opportunities for new or enhanced international co-operation in selected scientific areas; 2) defining international frameworks for vital national or regional science policy decisions; 3) addressing the scientific dimensions of issues of global concern

The GSF authorised an activity on the issue of declining interest for science studies at its Ninth Meeting in July 2003. This issue was then also highlighted during the ministerial meeting of the OECD Committee for Scientific and Technological Policy in January 2004 as a priority for the OECD Secretariat, among the more general problem of human resources in science and technology, and this GSF activity is therefore taking place within a more general framework of projects within the OECD.
A Steering Committee was first asked to determine a precise goal and programme of work for further activities. A number of conclusions and proposals for further work were presented in a report to the GSF in July 2004 and a Working Group, with participants from 18 countries, has been set up in September to implement these recommendations.

Scope of the activity and programme of work

The questions concerning this complex issue can be divided into four broad areas:

- the amplitude and characteristics of the decline
- the causes of the decline
- the impact of the decline
- what can be done about it

The subject of the impact of the decline on national economies and on society in general was excluded from the study as these issues are addressed by other directorates of the OECD. In addition, a consensus emerged to focus the work especially on young people at the early stages (primary and secondary education level) rather than at the later stages (university studies, career prospects). The issues are more complex at the early stages but understanding them may lead to longer-lasting policy initiatives. The importance of the different steps of the educational process and of the consecutive choices young people (and particularly girls) make towards or away from science studies, was one of the major problems underlined.

The work programme that was proposed contains two main elements:

a. A quantitative analysis of the statistical data and trends in different countries to more precisely define the extent of the problem.
b. A qualitative analysis of the reasons for the decline and a review of the solutions that have been undertaken at national levels, including an analysis of methodologies and evaluation procedures.

The quantitative study

A preliminary study of the statistical data and trends in different countries using comparable information appeared to be a necessary prerequisite to the project. This study would serve as factual background reference to evaluate the quantitative aspect of the decline. The objective is to analyse trends in student's enrolment and choice for science studies by country over a number of years.

The data that were determined to be necessary to analyse

the extent of the decline are:

- the number of high school diplomas with a S&T orientation or equivalent data, relative to the total number of high school diplomas;
- the number of entrants in tertiary education in S&T-related fields, relative to the total number of entrants in tertiary education;
- the number of graduate and Ph.D. diplomas in life sciences, physical sciences, mathematics and statistics, computing, and engineering relative to the total number of diplomas.

Some of these data are not available from international databases, and will therefore require the active participation of the countries involved in the study, but such data are important to provide real information on trends and to assess for instance possible drop-outs at the transition between secondary and tertiary education. This study, which will be carried out by the OECD Secretariat, is expected to provide not only real data on the current extent of the problem in selected countries and on future trends but also to point out countries without problem which could help identify solutions. In addition, it should provide information on methodologies and possible shortfalls in existing data on education.

Qualitative study on causes and solutions

The objective of the Working Group is to find important correlations among existing studies to identify key factors that are behind the decline in enrolment into science studies and practical solutions that can be implemented. Four broad areas of investigation have been identified:

- the image of science and scientists. This includes the effect of role models, the analysis of attitude and motivation surveys, the impact of informal learning (science museum) etc.;
- science and Technology careers. Jobs attractiveness, both in academia and industry, and their perception among students, teachers and parents are important factors of choice;

- science education and curricula. This broad subject includes elements such as innovative ways of teaching S&T (including hands-on practices, intervention of professional scientists in courses, specialised science curriculum, the use of information technologies), a better understanding of the goals the purposes of S&T education (training of future scientists or educating the general population), the relevance of S&T to society, the progressive stages of education and their influence on choices, educational systems and policies, the influence and goals of tests in maths and science, that of career guidance etc.;
- teacher training, qualification, and development. Teachers often play a prominent role in the orientation of students, and their training and attitude towards science are key components.

The issues related to gender and ethnic/cultural minorities as well as to business involvement should also be taken into account but as horizontal issues/opportunities while considering the other topics.
This qualitative analysis will be the core of the Working Group undertaking. Its outcome will be an analysis of the discriminant factors behind the decline of interest for science studies, the identification of potential targets for governments' actions, a sound analysis of the initiatives undertaken in those key areas in terms of results, methodology and evaluation, and recommendation for governmental concrete actions.

Concluding conference

The results of both quantitative and qualitative studies will be presented at a conference that will conclude this Global Science Forum activity. This conference will take place in the Netherlands in November 2005 and consist of:

- the presentation of the work carried out by the Working Group, including the results of the quantitative study undertaken by the OECD secretariat and topical presentations by experts on the key issues selected by the Programme Committee;

- discussions on the policy implications of this study and of possible action plans with governments officials, education and business representatives.

The outcome of the conference will be a concise (15-20 pages) policy-level report which will contain findings and conclusions based on the work of the Working Group and the results of the quantitative study as well as on the presentations and discussions at the conference.

Presentation given at the Seminar on Scientific Degrees Project

Gianfelice Rocca
Confindustria, Vice President for Education

This seminar is an excellent opportunity in which to reflect upon the role of education, in particular careful attention is to be given to the teaching of scientific subjects, and the economic dynamics to be found in our country. Moreover it is with this occasion that the joint initiative MIUR-Confindustria (Confederation of Italian Industry) regarding scientific degrees will be presented to you all.
The Confederation of Italian Industry has as one of its main priorities the teaching of Science and research. It is a concrete initiative for our country as will be shown here today.

Figure 1

Firstly we have to give thought to the Italian situation by looking at it with an international perspective. How will it be possible for Italy to maintain a pro-capita income of $19,000? With which economic model will it be placed with on global competition, considering that developing countries seem to be highly competitive, not only because of low production costs, but also because of their ability to rapidly absorb new technology and launch themselves on international markets.
The Confederation of Italian Industry is the main stakeholder as far as current competition and the future of the country is concerned: in fact, it represents nearly all of the industrial groups. These companies are exposed to global competition and are the main exporters of products (90%) from our country. A rather important share of Italian GDP is derived from exports. Our main competitors, like China for example, are gaining international market shares. Italy on the other hand, in the three-year period 1999-2002 went from 4.3% to 4.0%.

In order to face these challenges, business leaders have as their main objective, investment in education and research. In fact, the most dynamic sectors in the world are tied to techno-scientific knowledge: for example, telecommunications, bio-technology, software, and medicine. These sectors are highly competitive and are characterized by technological innovations. Since a lot of the new technology can be copied and even used in developing countries competition has become global. Likewise, acquiring knowledge (from the market for example) stimulates innovation; that is, the competition that is generated when knowledge is to be gained.

Investments made to expand knowledge and skills create more competition and favor growth. Higher education increases productivity and technological progress, these two elements are fundamental in creating competition in the production process and for the economic growth of our country. Higher education also means an increase in the av-

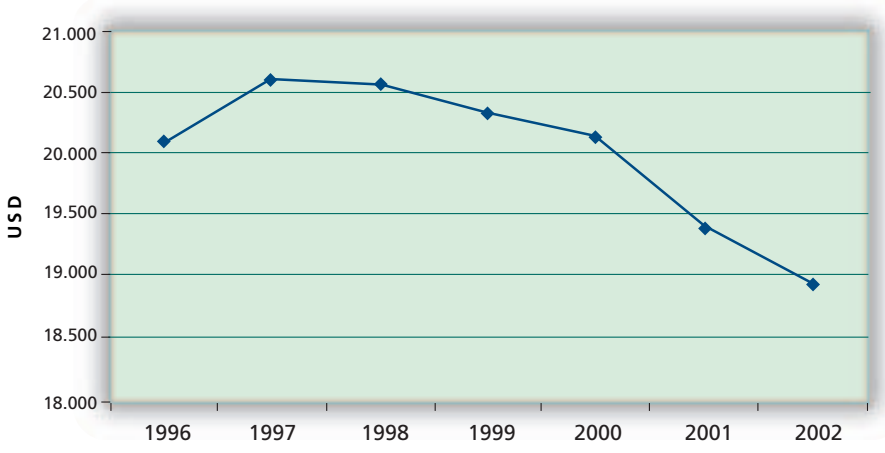

Figure 1 **Pro capite PIL trend (current dollars)** *(source: World Bank).*

erage salary of workers. These aspects will be further enhanced if we increase people's awareness of science and also increase training in the fields of techno-science.
This knowledge is the best type of investment for the individual and permits a country to progress in the most innovative of sectors where competition is global. By investing in both scientific and technological knowledge, we enhance economic growth and standards of living. First place is held by the USA, in Europe Finland is in first place and China and India are growing rapidly.
Technological challenges are coming to Italy not only from advanced countries like the USA or European ones, but rather from India, China and South-East Asia. These countries have invested heavily in techno-scientific training.
Even a small country like Finland has invested heavily in scientific training, research and development (the Scandinavian country has doubled its number of researchers and has increased its number of polytechnics; it has given an important place to science in the curriculum of nine to seventeen year olds; it is at the top of the rankings for the number of patents). In only a few years Finland has reached the highest levels of competitiveness and economic growth, so demonstrating how important and fundamental educational choices are in order to improve the lives of citizens and the performance of a country.
In Italy, the major indicators pertaining to Research and Development, researchers, and the expenditure on innovation are below the OCSE average. Moreover, innovation is concentrated mainly in facilities (50%), much less than that which is spent on research (29%). As such, it is vitally important to improve the links which tie business and research so as to transfer techno-scientific knowledge to the business world, so improving competitiveness. The following citation by Rubbia is emblematic: "applied research does not exist, only applications of research do", it is this application that needs to be implemented.

The link between industry and research is so at the center of the process of innovation. It is necessary to re-launch the ca-

pacity to create innovation and increase the level of scientific knowledge in our country together with the skills that industries can draw from. I believe that it is necessary to 'oil' the mechanisms that link scientific knowledge to industry, that also involve the world of education and research, right up to the training of 'industrial' graduates and PhD students. These people will be the motors that set off science and 'knowledge management'. Indeed for us innovation does not only mean product innovation or technological process, but it also means improvement in the management of companies. All of this also has to involve small and medium sized firms.

The example of PH.D students in research is particularly significant, seeing that in Italy the paths leading to a doctorate are still only viewed as academic research. In Anglo-Saxon countries the demand in companies and in research institutes for doctorate students in research is high and the level of pay is very much higher than in Italy. For example, a Ph. D student in science and technology or in economics in the USA can earn between $70,000 and $90,000 gross for a first job offer, this whether it be academic or in industry.

Furthermore, in Italy the same offer of Ph.D.s in science and technology is modest and needs to be enhanced (every 1000 people in the 25-34 age group. Data 2000). The following data is quite significant and clear:

- the percentage of Ph.D.s conferred in Italy is 0.4 of the population, while there are percentages much higher than 1 in France, Germany, Great Britain and the United States;
- the percentage of Ph.D. foreign students in Italy is 1% as opposed to 20-40% in the United states, Great Britain, Australia, Belgium, Switzerland and 11 % in Spain;
- scientific and technological Ph.D.s in Italy are 0.16, the EU average is 0.56, USA 0.41, UK 0.68, Germany 0.81, Sweden 1.24 (every 1000 persons in the 25-34 age group. Data 2000).

A similar situation exists for data related to researchers.

- researchers (per 1000 employed): in the EU 15.6%, in Italy 3%;

- R&D workers (per 1000 employed): Italy 7, EU 15.11, France 14, Germany 13, Japan 14, Finland 23.

The Confederation of Italy Industry is moving on various fronts to promote objectives related to the promotion of research and the diffusion of scientific knowledge, both of which are necessary in order to re-launch the country. Concretely we sustain:

- the development of a system based on meritocracy, a system where results count and efficiency is used where human resources are concerned;
- the re-launching of research with initiatives which create closer ties between the business world and universities, many of these initiatives have already been launched on a local level;
- an increase in the level of scientific knowledge in general, the 'Scientific Degrees Project' presented here today is an example of this endeavor. Moreover, in this regard various activities have already been implemented, on a national front – *Orientagiovani* – and territorial associations, among which *BergamoScienza*, activities which involve universities- schools- business- culture- institutions, and there is also a website where one can 'talk about science'.

The conference in Lisbon brought out a strategy which has as a main objective that of making Europe a society based on knowledge- that is, a society which bases its competitiveness on knowledge. The conference in Lisbon highlighted two emergencies in our school and training systems which need careful attention and priority, these are, early school withdrawals and the insufficient total number of graduates in Mathematics, Science and Technology. The objective is to increase scientific knowledge by 2010.

Taking act of the impulse given by the heads of State and the Lisbon government, MIUR and the Confederation of Italian Industry have launched the 'Scientific Degrees Project' an important initiative, and totally funded by the State. This project could become a European model of collaboration between universities and the business world, together

with the objectives outlined in Lisbon, which aim at improving scientific 'performance' in Europe.
This project is an experimental one, and outlines four plans of action (Orientation; three-year degree training; Internships; Post-graduate courses), all to be implemented by the Ministry in collaboration with universities and businesses. Along with these plans of action the following numerous activities are also at the forefront, and should be implemented on a national level:

- an analysis of future demand of graduates in scientific areas which will be needed by the private sector, the public sector, the non-profit sector and research;
- a better understanding of demand, especially needed is precise information and an orientation scheme for entrepreneurs; in particular, for small and medium firms. This would let graduates show their scientific skills and potential, so lending themselves to more sectors;
- the participation of entrepreneurs on the planning of training paths which are more in tune with the needs of the production process.

Moreover, the project foresees guidance regarding job offers and training and in particular:

- refresher courses for teachers;
- supplementary courses, alternating between school and work, experimental laboratories, scholarships for students both in Italy and abroad;
- orientation for the young and their families.

The project will designate funding for orientation (orientation for entrepreneurs is also foreseen), it will also provide a right and true path for the 're-construction of scientific knowledge': from the three-year degree course, to university and company internships, both national and international to post-graduate courses (Ph.D.s and mixed training paths; for example, degree in Physics-master in economics-research and internships in foreign institutions and business internships).
Indeed, university training in science gives us all the possibility of investing in basic knowledge, so being able to apply technology to many sectors; from bio-technology (for example, Chemistry and Genetic Engineering), to Telecommuni-

cations (Physics and Informatics) to Finance (Physics and Mathematics).
The recent innovations in university training courses such as the three-year degree courses, and the strengthening of autonomy have favored the implementation of positive actions such as those foreseen by the project.
The real importance of this initiative, the element which gives it a real innovative charge is tied to the origins of the project itself. It came about at the beginning of 2004, at a workshop organized by MIUR/Confindustria and thanks to an excellent working rapport established between the two institutions for some time now, and renewed a few months ago.

Thanks to the collaboration with the National Conference of Science and Technology Faculty Chairs, it has been possible to better 'define' this rather complex project. It will seek to act in a systematic manner in order to introduce structural changes.
The new verve which was mentioned earlier is a three-way proposal. This is to mean that not only is the planning phase an effort made on the part of three institutions, but also that of the implementation of the project will involve all three institutions.
The implementation of this project will take time, for it is also an ambitious venture: each of the three institutions involved in it has taken upon itself the responsibility of doing its part. Each institution will carry out its role with optimism and rationality. In this light, it is also important to implement an exchange which cannot be bi-directional, between the center and the territory, in which different players will be brought together: business associations, companies, research and training institutes, networks of schools and universities. An important element is that a project which comes out of central institutions can only grow thanks to the impulse that comes from the territory and on which it is implemented, collaborating together.
We are proud to give our contribution so that this partnership experience can become a positive model for Europe.

Speech given at the Presentation of "Scientific Degrees Project"

Letizia Moratti
Minister of Education, University and Research

The "Scientific Degrees Project" is the result of work done by the 'Miur-confindustria' technical workshop, set up according to the regulations of the present convention which was recently renewed with the participation of the National Conference of Science and Technology Faculty Chairs.
The project has the aim of finding concrete answers to the present day crisis in scientific vocations, prevailing in nearly all European countries. Enrolments in University degree courses regarding Chemistry, Physics and Mathematics over the last 15 years have registered a downturn of over 50%, with the inevitable result of a loss of international competitiveness in high technology sectors. However, there has been a slight rise in enrolments in the last 3 years in the three-year degree courses in Chemistry, Physics and Mathematics which have shown a constant renewal of interest.
There are various reasons for this phenomenon. In particular, it is unanimously acknowledged that not only should the didactic methods used right from primary school be looked at, but also a series of parallel actions need to be taken which would help students in their choice of university courses, this together with a strategy of endeavouring to render science degree courses more appealing to young students.
The project thus, is an experimental one, giving rise to project paths which for the first time ever bring together different players, universities, business associations and all types and levels of schools.
Miur proposes four plans of action:
1. *pre-university orientation.*
2. *a renewed look at the classes in the degree courses (21, 25 and 32);*

3. *enhancement of internships;*
4. *enhancement of post-graduate training.*

Each of these four actions must be pursued both on a national and international level. This needs to be done by directly involving students and teachers from both schools and universities, as well as the National conference of Science and Technology Faculty Chairs and business associations. Hence, this type of intervention will touch upon the socio-economic and productive levels of our country.

With reference to the local action to be carried out, Miur intends to choose 10 projects which must be presented by universities in collaboration with business associations and schools. These projects will have to proceed with two or more actions and will have to be distributed nationally in order to ensure a balanced distribution of plans of action on a national level. In this regard orientation is an important objective. In fact, the strategy outlined in Lisbon and the resulting five reference parameters have identified early school withdrawal and the insufficient total number of graduates in Mathematics, Science and technology in the European Union as the two main priorities and emergencies facing our education and training systems.

It is unanimously acknowledged that these two drawbacks are directly attributable to the lack of school orientation and pre-university programmes, this being in line with the European objectives stipulated by Law no. 53/2003.The Ministry of Education has consequently programmed a series of actions to promote educational success and complete personal development throughout life.

This entails creating a more effective link between universities, institutions and the world of work. The tool to be used is the National Orientation Plan which involves all the relevant players, whether institutional or otherwise, and which provides an umbrella for sharing the cultural and methodological basics on intervention projects. The plan in fact is to provide the necessary groundwork for the enhancement and support of single activities that each school or university will independently be carrying out to address the needs of their referents in each location.

Consistent with this new approach, the "Scientific Degrees Project" offers the opportunity to test new orientation models and tools that aim at improving student performance in our secondary schools, especially by expanding their competences, both basic and scientific, and to bring changes in teacher training. The planned pilot activities, which will seek to involve schools and school networks already working in this direction, will make it possible to test orientation didactics models that can be put into practice on a daily basis, as well as new training models for teachers.

Among the necessary actions identified, the ones which merit careful attention are those oriented towards giving teachers up-to-date training courses by setting up experimental laboratories in the school environment. The refresher courses will involve around 14,000 teachers in the three-year period destined for the project. The length of the course is 3 days where basic and practical research themes can be exchanged among teachers, university researchers, research institutes and companies.

Moreover, the project outlines further action which will allow for experimenting in schools and universities, with the collaboration of business associations and research institutes, pilot projects prearranged for the organisation of laboratories for the study of chemistry and physics. We are convinced that such initiatives can stimulate student interest in scientific subjects reforming present day teaching methodologies. What's more, at the time of student enrolment universities will take into consideration student participation in these laboratories and so give training credits (Cfu), which will then be tallied their university degree course of study. This endeavour will involve classes in their final years of study (3rd, 4th, 5th years) around 40 units per course.

In the three years of the project around 10,000 students chosen by the schools will take part in the experimental phase of the programme, its success will be evaluated by using accurate indicators given by universities and schools. Similarly, the projects presented could provide supplementary courses in mathematics reserved for students in their final year of study chosen by the school. These courses would

be held in universities with the help of qualified teachers. This type of programme could involve around 1,200 students on a national level, it would be based on the pilot project outlined by Science Faculties and schools.
In addition, the action outlined by the project to enhance internships and trainee courses are a strategic path towards the success of the project. In fact these courses would allow students to enter the world of work and allow them to gain some initial professional work experience with positive effects on their employment opportunities and to transfer know how between the world of work and the university world. Unfortunately, present day internships in Italy are characterized by strong fragmentation. The available services are diversified and are offered by structures which are very different from each other (universities, private companies, institutions). Such fragmentation causes a lot of difficulty for the relevant institutions to closely monitor and guide the phenomenon in terms of the current legislation and agreements stipulated with the same institutions and trade associations.

With the vast number of companies present in Italy a project has been put together which aims at creating a feasible path leading to a universal platform for internships. The data put together by the National Committee for the evaluation of University systems shows that presently there are 140,000 internships on offer: the objective is to set up a national data bank on all internships on offer with a complete map of the system. This platform would unite and integrate all the relevant players presently involved in the promotion of internships; hence providing educational and training institutions and businesses with a better view and better management of internships.
The unifying project could be completed in three years and will give rise to a national electronic data bank where all can converge by comparing needs, offering skills, needs and expectations. This data bank would be user-friendly for students, businesses and educational institutes alike so rendering this linking tool between universities and the world of

work more efficient and manageable. This would give all the opportunity to make choices on a national level and in all professional sectors. Businesses would finally have at their disposal an univocal tool to choose the students who would be placed in company training programmes. Students themselves would also be able to easily identify the training opportunities that businesses put on offer.

Consequently a great 'community on line' would be created, the first real 'community' in which universities and the world of work could meet and communicate on a daily basis.
The ten projects which will be selected will be backed up by suitable resources. Presently the sum of 6.5 million euro has been allocated, coming out of the fund for the organisation of the university system, (period 2004/2006), approved by the decree of August 5th 2004. This resource will be further enhanced by giving teachers the possibility to do refresher courses to update their skills; moreover, the setting up of pilot projects for the setting up of laboratories for Chemistry, Physics and Mathematics (about 2 million euro).
The entire "Scientific Degrees" project is so backed not only by the guidelines already mentioned, but also by financial resources. Such resources will allow for incentives to students enrolled (above all to female students) in degree courses 21, 25 and 32. These incentives would also be extended to students from schools taking part in the pilot projects where the laboratories have been set up.
In particular, a specific plan of action is foreseen for university students in Chemistry, Physics and Mathematics with a total of 150 scholarships offered every year for the three years of the project. The students who win the scholarships will be free to enrol in any university of their choice without any geographic restrictions. The more talented students who have attended the experimental courses with success and who have passed the necessary evaluation tests will be able to go on award trips of at least two weeks in research institutes both public and private, whether Italian or foreign.
At least two hundred students will be able to take part in this opportunity. Similarly, specific incentives will be given

to first year university students, so that they will be able to take up internships or training periods in companies, research institutes (public and private) university centres, whether Italian or foreign.

This project will be completed with a network of actions together with the constitution of a data bank regarding internships, these actions are as follows:

a. the current revision of classes in the courses which were initiated by Ministerial Decree of 17.07.04 (amendment to regulation no.509/99), will allow to re-design science courses to better meet the needs proposed by companies and public and private research institutes.
b. a detailed booklet will be commissioned to give information on the university courses (classes 21, 25 and 32) which will be distributed to all students in schools.
c. Science Faculties will seek to establish appropriate courses (master level I and II) for refresher courses for school teachers teaching scientific subjects.

The last point in particular, that is the implementation of master courses is of great strategic value in the panorama of university training, this because it is to be done in collaboration with business associations, regional boards, local authorities, professional bodies and public and private bodies. These courses will allow for both refresher courses and for continuing training based on EU principles and recommendations of 'long life learning'. The "Scientific Degrees" project underscores the importance of this much awaited tool as well as aiming to bring together universities and businesses; furthermore, Level 1 Proficiency Courses are the ideal tool in the transition from the basic and methodological training of the three-year degree to a highly professional form of training that aims to develop a clear professional model.
The advantages of all of the above are:

- orientation towards the world of work;
- involvement of teachers from the business world in the training process;
- creation of closer ties between universities and companies.

Proficiency courses of this kind are also fundamental in:

- updating 'old' graduates in the spirit of ongoing training in fields that have undergone considerable changes in the way they are applied to high technology, and clearly these fields especially (but not exclusively) include Chemistry, Physics and Mathematics.
- enhancement of the interdisciplinary aspects that characterise the new fields of application;
- making refresher courses specific to their fields available to teachers at secondary schools.

In the same spirit and with the same objective, financial incentives are foreseen for universities working together with schools and business associations to set up Level I and II Master courses for teachers who wish to carry out a period of study whether to refresh their knowledge or to specialise.

The Scientific Degrees Project

Programmatic Document of 17 june 2004

edited by **Miur – Confindustria – National Conference of Presidents of Science and Technology Faculties**

1. INTRODUCTION

For a number of years now, young people's growing disaffection towards scientific subjects has been apparent in the obvious and constant reduction in enrolment in scientific university degree programmes.[1] The extent of this phenomenon is shown by the fact that the percentage of students enrolled in scientific degree programmes in Italy was about 50% in the '51-'52 academic year and was only 30% in '00-'01.

This has happened despite the fact that science graduates are amongst the highest in demand in our labour market,[2] which mirrors the same trend as many other international markets. National[1] and international[2] statistics confirm this observation, supporting it with studies and comparisons that all point to the same issue: meeting the growing requirements that arise from current demand and that could set in motion a positive cycle of growth in independent research and technological innovation.

If our country is to grow, we urgently need to renew interest in the sciences and strengthen high tech investments, which are unanimously acknowledged to be the key to international competitiveness. The countries that have invested the most in high tech, such as Finland, have nearly dou-

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[1] Istat-Miur Report on university education, various years [3], National Committee to evaluate the university system [4], Fourth Report on the state of the university system [5].

[2] OECD [6], Economic Outlook [7], Education at a Glance [8], OECD indicators [9].

bled their GDP in the last 10 years [10]. Italy has fallen considerably in this sort of ranking and decisive action must now be taken in the form of a coordinated effort on the part of those who potentially have most to gain: institutional bodies, schools, universities and businesses.
Consequently, a series of proposals must be identified that can renew the study and application of scientific subjects. This can be done through structural steps that aim to: 1) stimulate young people's interest in studying these fields; 2) provide a better education in the base sciences right from the secondary school level; 3) reinforce the interface between universities and businesses in order to encourage the placement of our best students in the high tech market. The "Scientific Degrees" Project is seen as the first step in this strategy.
This document is divided as follows. Section 2 provides a brief analysis of statistical data and then outlines the objectives of the "Scientific Degrees" project. The sections that follow (3,4,5,6, and 7) identify: i) steps to be taken; ii) implementation timeframes, methods and costs; iii) who would be responsible for each of the action described. Section 8 discusses the project's time requirements and the organizational approach to be used in the short-term. Finally, Section 9 looks at the overall resources needed to carry out the project and the methods to be used to implement the various actions identified herein. In this document the abbreviation ***Con.Scienze*** stands for "Conferenza Nazionale dei Presidi delle Facoltà di Scienze e Tecnologie" [National Conference of Science and Technology Faculty Chairs].

2. OBJECTIVES

As mentioned earlier, the crisis in scientific vocations is a phenomenon typical of many countries in the world, but especially the most developed ones, as shown by OECD figures. The states of the European Union have continued to ponder the causes of this loss. As a result they have decided that an explicit goal of the VI Framework Programme on Research [11] and of the "Science and Society" programme

[12] will be to provide an analytical report on the phenomenon and its possible causes and propose concrete solutions. A break-down of the phenomenon shows that in Italy in recent years Chemistry, Physics and Mathematics have been the subject areas least chosen by young people starting their university careers (see Figure 1). Specifically, the number of Chemistry students went from 2274 (in 1989) to 1293 (in 2000), for a 43.1% drop, those in Physics from 3216 (in 1989) to 1428 (in 2000), a 55.6% drop, and those in Mathematics from 4396 (in 1989) to 1611 (in 2000), a drop of 63.3% [13].
These figures are worrying for at least three reasons. First of all, it will be difficult to face the rising demand within businesses for researchers and technicians with high-level scientific qualifications, which will inevitably lead to decreased international competitiveness in high technology sectors. Furthermore, there is the problem of decreasing numbers in universities due to generational turnover. Unless an appropriate recruitment plan is introduced, this fact will have a negative impact on the entire university system, with its older and most experienced staff being halved by 2010 [14,15]. Finally, it will become difficult to find enough qualified teaching staff in the scientific subjects in schools of all levels and kind (our secondary school students are now at the bottom of European rankings as regards basic training in physics and mathematics) [16].

Given these points, there is no doubt whatsoever that decisive action is needed, without delay, to support the so-called "hard sciences", namely Chemistry, Physics and Mathematics. An initial and very interesting step has already been taken with the approval of DM (Ministerial Decree) no. 198/2003. Article 4 of this decree sets out the first direct incentives to stimulate the enrolment of young people in certain degree programmes, including precisely 21, 25 and 32. The "Scientific Degrees" project aims to follow the same planning direction, by setting itself the following **objectives**:
• ***to increase the number of students enrolled in the***

degree courses of Classes 21, 25 and 32, while maintaining a high student quality standard;

- ***to increase the number of graduates in Classes 21, 25 and 32 and to enhance their placement in the labour market.***

These objectives could be reached by way of steps aiming to: 1) develop pre-university orientation for secondary school students; 2) better synchronise university students' three-year training with the needs of the working world; 3) develop and encourage company internship programmes for students in Classes 21, 25 and 32; 4) develop the post-graduate offerings for graduates from Classes 21, 25 and 32; 5) finalize a detailed communications plan.

It is worth underscoring that many of the steps that will be discussed in the following sections of this document are of a general nature, precisely because they aim to strengthen basic education in scientific subjects. This makes the steps

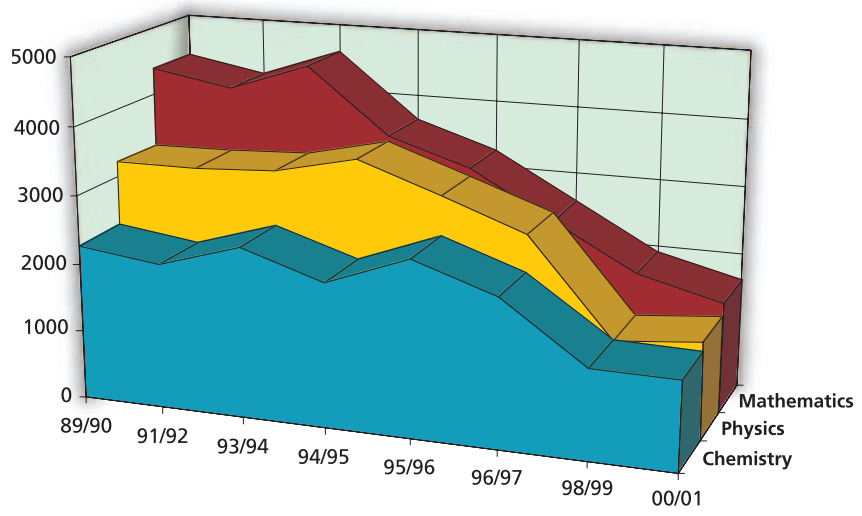

Figure 1 **Students enrolled in Degree Courses in Chemistry, Physics and Mathematics[13]**

outlined in the "Scientific Degrees" Project interesting in and of themselves, beyond the fact they are being presented here and discussed in regard to degree classes 21, 25 and 32.

3. PRE-UNIVERSITY ORIENTATION

The strategy outlined in Lisbon and the resulting five reference parameters identify early school withdrawals and the insufficient total number of graduates in mathematics, science and technology in the European Union as the two main priorities and emergencies facing our education and training systems. In line with European Union objectives and in order to implement Law no. 53/2003, the Ministry of Education has planned a series of steps to promote educational success and complete personal development throughout life. This entails creating a more effective link between schools, universities, other bodies and institutions and the world of work. The tool to be used is the National Orientation Plan, which involves all the relevant players, whether institutional or otherwise, and which provides an umbrella for sharing the cultural and methodological basics of intervention projects. The Plan creates the groundwork for the enhancement and support of the single activities that each school or university will independently be carrying out to address the needs of their referents in each location.

The orientation of students in Italian secondary schools in regard to university didactic programmes is of great importance and urgency. Pre-university orientation activities on various levels and using different approaches have to cover the last three years of secondary school. It is simply not enough to present the university degree courses to those already at the end of their secondary schooling. Moreover, it is precisely because orientation must comprise all three aspects – training, research and the world of work – that it is absolutely necessary to promote orientation activities in synergy between secondary schools, universities and businesses.

Consistent with this new approach, the "Scientific Degrees" Project offers the opportunity to test new orientation models and tools that aim to improve student performance in

our secondary schools, especially by expanding their competences, both basic and scientific, and to change the training of teachers. The planned pilot activities, which seek to involve schools and school networks already working in this direction, will make it possible to test orientation didactics models that can be put into practice on a daily basis, as well as new training models for teachers.
The "Scientific Degrees" Project seeks to concentrate on a certain number of specific steps that will be discussed in detail below, providing implementation timeframes, methods and costs, in addition to explaining which players will be responsible for each of these activities.

3.1 "Scientific Degrees" Project Open Day

An open day would be organized in all secondary schools to publicise the implementation of the "Scientific Degrees" project. In particular, the Science Faculties and the world of work would present the opportunities offered by DM 509/99 to both students and teachers at secondary schools in terms of the didactic programmes available in the Science Faculties in addition to the professional outlets in the world of work and high tech for students graduating from Classes 21, 25 and 32. Individual student counselling events could also be organized.

3.2 Orientation for the "Orientators"

The orientation activities carried out by universities and the world of work in secondary schools are now of a sporadic and unstructured nature. In contrast, orientation should be carried out in a uniform manner during the last three years of secondary schooling. Science (Chemistry, Physics and Mathematics) teachers consequently need to be involved and they should be provided with training and information as well as the means and tools required. The 'Scientific Degrees" Project seeks to provide training as a service to teachers in order to achieve a didactic style that offers a range of intellectual, disciplinary and methodological approaches and stimuli. In particular, the "Scientific Degrees" Project proposes the following:

3.2.1 Refresher Course for Chemistry Teachers

On an annual basis a refresher course would be organized for teachers of Chemistry in Italian secondary schools. The course, which would be organized by the Science Faculties (separately or jointly) along with the world of work, will have the following aims:

- provide an update on the latest research, both applied and basic, carried out in universities, public and private research bodies, industries and enterprises;
- have teachers participate actively in carrying out certain experiments, thereby providing them with ideas to reproduce these experiments in class with their own students;
- have teachers participate actively in working groups to compare experiences and discuss possible didactic innovations in Chemistry in secondary schools;
- present DM 509/99, its implementation on a national level regarding Degree Class 21, and, above all, provide information on the professional outlets of those graduating from Classes 21, 25 and 32 in the world of work and high tech.

It is estimated that, to be truly effective, these courses should be attended by 100 teachers at most. The typical length of a course of this kind is three full days. It would be best to create incentives for teachers to participate in courses of this kind both in terms of career ranking points and financial aid (expense refunds, where appropriate). The opportunity to have course members from various areas of the country could be an enriching factor and be intellectually stimulating.

3.2.2 Refresher Course for Physics Teachers

On an annual basis a refresher course would be organized for teachers of Physics in Italian secondary schools. The course, which would be organized by the Science Faculties (separately or jointly) along with the world of work and possibly with the INFN, will have the following aims:

- provide an update on the latest research, both applied and basic, carried out in universities, public and private research bodies, industries and enterprises;
- have teachers participate actively in carrying out certain

experiments, thereby providing them with the material needed to reproduce these experiments in class with their own students (this is one of the aims of the course);
- have teachers participate actively in working groups to compare experiences and discuss possible didactic innovations in Physics in secondary schools;
- present DM 509/99, its implementation on a national level regarding Degree Class 25, and, above all, provide information on the professional outlets of those graduating from Classes 21, 25 and 32 in the world of work and high tech.

It is estimated that, to be truly effective, these courses should be attended by 150 teachers at most. The typical length of a course of this kind is three full days. It would be best to create incentives for teachers to participate in courses of this kind both in terms of career ranking points and financial aid (expense refunds, where appropriate). The opportunity to have course members from various areas of the country could be an enriching factor and be intellectually stimulating.

3.2.3 Refresher Course for Mathematics Teachers

On an annual basis a refresher course would be organized for teachers of Mathematics in Italian secondary schools. The course, which would be organized by the Science Faculties (separately or jointly) along with the world of work and possibly with the INFN, will have the following aims:
- provide an update on the latest research, both applied and basic, carried out in universities, public and private research bodies, industries and enterprises;
- have teachers participate actively in working groups to compare experiences and discuss possible didactic innovations in Mathematics in secondary schools;
- present DM 509/99, its implementation on a national level regarding Degree Class 32, and, above all, provide information on the professional outlets of those graduating from Classes 21, 25 and 32 in the work of work and high tech.

It is estimated that, to be truly effective, these courses

should be attended by 150 teachers at most. The typical length of a course of this kind is three full days. It would be best to create incentives for teachers to participate in courses of this kind both in terms of career ranking points and financial aid (expense refunds, where appropriate). The opportunity to have course members from various areas of the country could be an enriching factor and be intellectually stimulating.

3.3 Psychological-aptitude test and self-evaluation test

The ultimate goal of all orientation activities is that of allowing students to acquire awareness of their own inclinations and become confident with their own choices before leaving secondary school. This objective can be reached in two ways. The first is an aptitude test to identify the student's inclination towards studies of a scientific kind. Secondly, a self-evaluation test can check what level has been reached in base science subjects. The self-evaluation tests will be of the kind normally administered by Science Faculties to incoming students. Students can therefore check whether, during their last year of secondary school, they have the minimum knowledge level that can lead to a more fruitful performance in first-year courses in the degree programmes of Classes 21, 25 and 32.

The "Scientific Degrees" Project proposes that Con.Scienze be commissioned to create a web site by that allows students to do both an on-line aptitude test and a self-evaluation test.

3.4 Course Presentation Booklet for Classes 21, 25 and 32

Having appropriate information on the job prospects of university graduates from the scientific subjects can be a decisive factor when making an well-informed post-secondary school choice. The Eurobarometer survey has indeed demonstrated that one factor in the declining number of "scientific vocations" is the perception that adequate income and good job prospects would be hard to achieve. On the contrary, the most recent ISTAT [Italian Statistics Institute] study ("University and work", 2004) shows that, in general,

degrees in technical-scientific subjects, in the broadest sense, produce a good "yield" on the labour market. Three years after graduating, 75% of "scientific" graduates had found ongoing employment. Consequently, at least in terms of their chances of finding work, the negative perception young people have towards scientific degree courses is not supported by data. There is a perception gap between the prevailing negative social representation of science courses and the actual facts.

In order to close this gap, the "Scientific Degrees" Project aims to commission the creation, on the part of Con.Scienze, of a booklet presenting the degree courses implemented for Classes 21, 25 and 32. The goal is to spread this information throughout the nation. This booklet will use an approach that is straightforward and easily understood by third-year secondary school students, to outline the following:

- professional outlets, both the traditional ones and those more closely related to the latest developments in the world of work and high technology, and how they arise from the education received;
- the employment rates and work experience of students graduating from the degree programmes of Classes 21, 25 and 32;
- the average amount of time required to find work;
- the kind and essential amount of knowledge required to undertake one of these three degree programmes.

The first three points, in particular, will require an *ad hoc* statistical study (see also step 4.3). This is essential in order to demonstrate the level and quality of work – both in business and research – that is available to those holding degrees from Classes 21, 25 and 32. This statistical research also provides the advantage of building an up-to-date database that can fill the current void in knowledge regarding the level of national demand for graduates in these disciplines. Consequently, this step should include plans to upgrade and upkeep the database in preparation for future updates of the materials gathered in the booklet.

3.5 The countless jobs of the chemist, physicist and mathematician

The demands of the labour market give priority to the need to create professionals that are different than those now familiar. They need to have a strong multi-disciplinary background. In contemporary society, technological innovations, economic development, cultural changes, ease of access to knowledge and its rapid distribution have produced a constantly changing scenario in which the various members of the social system are forced to re-consider their duties and prerogatives.

Solid training in Chemistry, Physics and Mathematics guarantees exactly the very foundations of this multi-disciplinary education, allowing individuals to "read" the technological and scientific objects that surround them in their everyday lives and, above all, be among those who know how to interact with and transform them.

The "Scientific Degrees" project will commission the planning, creation and maintenance of specific sites to explain the "countless jobs of the chemist, physicist and mathematician", to be done by Con.Scienze, possibly in conjunction with National Institutes such as those of Higher Mathematics (INDAM) and of Nuclear Physics (INFN). The advantage of sites of this kind would be that elementary and secondary school students could access information and easily use links to surf to the sites of the organizations involved. This would facilitate the "orientation" even of the very young, long before they need to choose university, and at the same time it would raise consciousness of the importance of investing in research and high technology. Last but not least, students need to learn that undertaking a scientific career also means learning to interact with others, become part of a work group and be a team player.

3.6 Orientagiovani 2004 and Scientific Culture Week 2005

Orientagiovani [Orienting youth] is the name of the day traditionally organized by Confindustria [the industrial sector association] every year to help students evaluate and com-

pare the growing opportunities in the world of training, university and work. The Orientagiovani 2004 event, scheduled for next autumn in Milan, can be the first special event for orientation regarding degrees in Classes 21, 25 and 32. This could be coupled with the events Industrial Associations organize on a local level with schools and universities, which are normally held on a range of different dates.
The *Scientific Culture Weeks* were started by MURST/MIUR to encourage widespread acquisition of a solid technical-scientific culture and to facilitate effective communication exchanges between society in general (and schools in particular) on one side and the research system (universities, research bodies, both public and private, companies, etc.) on the other. Keeping in mind that next year will be the Year of Physics, our proposal is to include Chemistry, Physics and Mathematics amongst the main themes of Science Week in 2005. It is also proposed that Science Week should include specific orientation activities regarding the degree courses of Classes 21, 25 and 32.

3.7 Chemistry Lab Experiment Courses

Secondary school students do not always have an opportunity to systematically familiarise with Chemistry laboratories and actively participate in experiments. In order to overcome this problem it is proposed that Science Faculties, along with schools and, if possible, with the world of work, should organise pilot projects to set up Chemistry lab experiment courses for certain types of secondary schools (for example, in scientific secondary schools, but also in classical studies secondary schools) in order to stimulate students' interest in scientific subjects and provide them with the basics of scientific method.
These courses will be carried out by Science Faculties and be held within the faculties for groups of students selected from various schools, up to a maximum of 40 per course. These courses will be started in the second half of the school year for students in their 4^{th} year and in the first half of the year for those in their 5^{th} year of secondary school. After attending these courses, students will prepare a brief lab re-

port. Graduating student reports will be recognised by universities as training credits.

3.8 Physics Lab Experiment Courses

Secondary school students do not always have an opportunity to systematically familiarise with Physics laboratories and actively participate in experiments. In order to overcome this problem it is proposed that Science Faculties, along with schools and, if possible, with the world of work, should organise pilot projects to set up Physics lab experiment courses for certain types of secondary schools (for example, in scientific secondary schools, but also in classical studies secondary schools) in order to stimulate students' interest in scientific subjects and provide them with the basics of scientific method. These courses will be carried out by Science Faculties and be held within the faculties for groups of students selected from various schools, up to a maximum of 40 per course. These courses will be started in the second half of the school year for students in their 4^{th} year and in the first half of the year for those in their 5^{th} year. After attending these courses, students will prepare a brief lab report. Graduating student reports will be recognised by universities as training credits.

3.9 Supplementary Mathematics Courses

Most withdrawals from Scientific degree courses are due to the inadequate basic training students have in Mathematics. In order to overcome this problem, it is proposed that Science Faculties, along with schools and, if possible, with the world of work, should organise pilot projects to set up supplementary mathematics courses for certain types of secondary schools (for example, classics secondary schools) in order to acquire the minimum amount of basic knowledge considered necessary for a student to integrate effectively in a degree course in classes 21, 25 and 32. These supplementary courses will be carried out by Science Faculties and be held within the faculties for groups of students volunteering from various schools, selected up to a maximum of 40 per course. These courses (which could also become topic-based

once the programme is underway) will be started in the second half of the school year for students in their 4th year and in the first half of the year for those in their 5th year of secondary school. Universities will recognise training credits for students taking these courses, as long as the courses are supplementary to the normal course load and that pertinent progress tests are passed.

3.10 "Alternating" School-Work Paths

Another direction to be sought regards the idea of "alternating" school-work paths. In this respect, experimental courses should be created in conjunction with businesses. The aim of these courses will be to:

- stimulate students' interest in scientific subjects, especially those for Classes 21, 25 and 32;
- supply students with useful information to better manage their transition into the working work
- better guide their university choices, especially in terms of the degree courses for Classes 21, 25 and 32.

These courses will be designed and carried out in conjunction with schools, businesses and universities. Universities will recognise training credits for graduating students attending these courses.

3.11 Student incentives

Universities will recognise training credits for students attending the courses described under points 3.7, 3.8, 3.9 and 3.10, provided that these courses are in addition to the usual course load and that all progress tests are passed. Since this is an additional course load, it will be useful to create incentives for students to participate in the courses described under points 3.7, 3.8, 3.9 and 3.10. by way of specific measures. It should be underscored that whereas the crisis in "scientific vocations" underscores the fact that a low percentage of students choose degree courses for classes 21, 25 and 32, the actions taken as part of the "Scientific Degrees" Project consistently aim to emphasise quality over quantity. Specifically, the "Scientific Degrees" Project proposes the following actions.

3.11.1 Award Trips

Incentives to participate in the courses described under points 3.7, 3.8, 3.9 and 3.10 can be award trips of at least two weeks for the two top-ranking students in each course. These award trips will be offered during the summer at

- public and private research facilities, either Italian or foreign;
- certified English-language schools.

Ideal would be two award trips per course, each of about a month, with one being abroad and the other in Italy. Obviously, agreement is required from European research bodies, both public (CERN, ESA, ESO, etc) and private to offer internships to the best students.

3.11.2 Students Grants

In order to strengthen enrolment of the best students in the degree courses for classes 21, 25 and 32, it is proposed that a suitable number of annual student grants be introduced, to be assigned on a merit basis following a national competitive exam for each of the three classes. The students winning the grants will be free to enrol at any university of their choosing, without any geographic limitations.

The "Scientific Degrees" Project seeks to introduce 50 grants for each of the three classes – 21, 25 and 32.

3.11.3 Encouraging Female Enrolment

In Italy, as in the rest of Europe, female students are more numerous in general than male students and they seem to achieve better marks than there male classmates. Nonetheless, young women continue to choose scientific subjects less frequently. As a matter of fact, out of every 100 young women enrolling in university degree courses, only 10 choose scientific-technological areas. Promoting the participation of females in scientific careers is consequently considered of great importance.

The "Scientific Degrees" Project thus seeks to create incentives towards female student enrolment (especially in classes 21 and 25) through the careful use of student grants, in addition to those mentioned under point 3.11.2, and of academic awards.

4. THREE-YEAR TRAINING

The enactment of Ministry Decree (DM) 509/99 has required universities to exert a great organizational effort to modify their rules and regulations, objectives, methods and the content of their degree courses. They have had to introduce a module-based didactic system with a credit system and overall their system of progress examinations, in addition to introducing on-the-job training courses and laboratories. Having reached the end of the experimental three-year DM 509/99 programme and in preparation for changes to it, it is now useful to examine – in conjunction with productive forces and the professional world – the training paths created by the various universities (especially for Classes 21, 25 and 32, but not exclusively) and the degree to which consultation with stakeholders took place during planning. Moreover, it would be opportune to design, where necessary and, again, in conjunction with productive forces and the professional world, new curricular paths more directly oriented to the world of work and high tech. To this end, the "Scientific Degrees" Project seeks to take the following steps:

4.1 Monitoring progress on reform

It is proposed that the Con.Scienze be commissioned to monitor nation-wide progress on the reform plan, with specific reference to

- the phenomenon of early withdrawal, identifying the specific causes by way of a random telephone survey;
- the rate at which prescribed CFUs are acquired;
- completion of the three-year degree within the standard timeframe

for the degree courses related to classes 21, 25 and 32. These will be used to spread the "best practices" of each location to the entire nation.

4.2 Study of trends in high-tech market evolution

It is proposed that Confindustria be commissioned to carry out a study of trends in the evolution of the labour market and high tech regarding graduates from classes 21, 25 and 32, in order to have a clear picture of the relationship be-

tween the supply of and demand for graduates from these Classes.

4.3 Study of the flow of graduates towards the labour market

In order to compare the professional profiles of three-year degree holders with the true needs of businesses, it is proposed that a specialised firm, identified by Con.Scienze and Confindustria, be commissioned to monitor the flow of three-year degree graduates from Classes 21, 25 and 32 towards the market in the three-year period 2004-2007. This data will provide a standard nation-wide tool to evaluate and optimise the professional education delivered in the degree courses for Classes 21, 25 and 32 throughout the country.

4.4 Assessment of DM 509/99 implementation

DM (Ministry Decree) 509/99 expects universities to establish new and more focussed contacts with productive forces, public institutions and the world of professionals, but it should be underscored that "consultation" has not always been carried out in the best manner possible. Consequently, given its importance, it is proposed that Con.Scienze and Confindustria be commissioned to do a study that analyses the "best practices" observed throughout Italy in order to adapt the existing "Protocol" and identify the specific better procedures for consultation between universities and businesses on the programmes of degree courses 21, 25 and 32 (though not exclusively).

4.5 Orientation of entrepreneurs

DM (Ministry Decree) 509/99 has profoundly renewed the cycle of university studies through the so-called pro "3+2" system. A student who receives a degree in Classes 21, 25 and 32 acquires well defined methodological and base knowledge. Universities teach a way of reasoning, a method, that is not simply the traditional scientific method but also the ability to verify and address the constantly increasing number of factors in the real world and make a system out of them. Enterprises still are not fully familiar with the abil-

ities of a graduate from Classes 21, 25 and 32, nor the potential opportunities to apply them. The "Scientific Degrees" project seeks to provide focussed information and orientation to entrepreneurs in order to raise awareness of the characteristics of a graduate from Classes 21, 25 and 32, and to better direct communications. These steps could produce extremely interesting results under points 4.2 and 4.3 as well.

5. INTERNSHIPS

The didactic programmes of the degree courses for classes 21, 25 and 32 foresee internship activities so that students (and recent graduates) can join the world of work with some initial professional work experience and transfer know-how between the world of work and the university world.
Having reached the end of the experimental three-year DM 509/99 programme and in preparation for changes to it, it is now useful to reconsider – in conjunction with productive forces and the professional world – the value of internships as foreseen in the training paths created by the various universities for the scientific classes involved. The "Scientific Degrees" project seeks to carry out the following:

5.1 Enhancing internships

It is proposed that Con.Scienze be commissioned to do a study that, after reviewing existing projects, can identify specific ways to enhance internships in companies, as foreseen by the didactic programmes of classes 21, 25 and 32. This is especially useful in preparation for the revision of DM 509/99, in order to make internships more in tune with the world of work and high tech.

5.2 Incentives for internships

It is evident that the use and utility of an internship depends to a great extent on the local context. Given the low number of students enrolled in degree courses in Chemistry, Physics and Mathematics, it is considered useful to take specific steps in this regard (in an experimental way, for students in degree courses for Classes 21, 25 and 32).

Consequently, it is proposed that Con.Scienze and Confindustria be commissioned to create a free-access database to extend nation-wide demand (from students) and supply (from companies) for internships and on-the-job training in Chemistry, Physics and Mathematics.
Moreover, incentives should be based on merit (through the awarding of ad hoc student grants), thereby encouraging the careers of students enrolled in degree programmes for Classes 21, 25 and 32 who want to take advantage of training internships in the most strategically important research bodies and companies, whether national or international. It should therefore be possible to combine these grants with those of the Leonardo Project of Europe-wide industrial internships.

6. POST-GRADUATE TRAINING

The Level 1 Proficiency Courses are the ideal tool (alternative and complementary to that of the Specialisation Degree) in the transition from university training to the world of work. Nonetheless, this tool does not seem to be extensively used for graduates from classes 21, 25 and 32. If universities and businesses work together on a well-focussed design for Level 1 Proficiency Courses, they could be the foundation for a smoother transition from the basic and methodological training of the three-year degree to a highly professional form of training that aims to develop clear professional models. The advantages of all of the above are:

- orientation towards the world of work;
- involvement of teachers from the business world in the training process;
- creation of closer ties between universities and companies.

Proficiency courses of this kind are also fundamental in:

- updating "old" graduates, in the spirit of ongoing training, in fields that have undergone considerable changes in the way they are applied to high technology, and clearly these fields especially (but not exclusively) include Chemistry, Physics and Mathematics;
- enhancement of the interdisciplinary aspects that characterise the new fields of application;

- making refresher courses specific to their fields available to teachers at secondary schools.

The same spirit and the same objectives lie behind incentives to encourage those who already have other degrees under the old degree programme and who wish to carry out a period of study – whether to refresh their knowledge or to specialise – to enrol in individual courses within undergraduate degree programmes, specialisation degree programmes and doctorate programmes. The "Scientific Degrees" Project will commission a study by Con.Scienze and Confindustria to identify proposals to set up Level 1 Proficiency Courses oriented to the world of work and high technology for the scientific disciplines and work environments specific to Chemistry, Physics and Mathematics.

7. COMMUNICATIONS

If the "Scientific Degrees" Project is approved, the project should be outlined at a day-long meeting at the "Villa Mondragone" Congress Centre of the "Tor Vergata" University of Rome in September 2004. The Minister, CRUI, Con.Scienze and Confindustria would be invited to this meeting.

This working day would aim to:

- present the project as a whole and the individual steps involved, in addition to effects in the medium- to long-term;
- summarise the issues and work routes to be followed in the short- to medium-term;
- discuss the supply of Level I, II and III scientific training provided nation-wide for Classes 21, 25 and 32.

8. ORGANISATIONAL TIMEFRAMES & METHODS

It is believed that the steps described in this document can be completed within the next three years. Specifically, we propose to:

- begin activities starting in the 2004-05 academic year;
- verify the effectiveness of pilot activities year by year and,

in any case, at the end of the three-year period, i.e. in 2007;
- based on the above verification process, make plans for orientation activities in the subsequent three-year period, in order to achieve European Union parameters by 2010.

Steps considered useful in implementing the project include the establishment of a ***Steering Committee*** limited to the members behind the initiative, namely MIUR, Con.Scienze and Confindustria. The Steering Committee will have the following duties:
- supervising the methods of implementing and carrying out the steps described above;
- collecting, analysing and publishing data;
- planning, directing and verifying new steps that may become necessary during the three years of the "Scientific Degrees" Project;
- coordinating four ***Working Groups.***

Each Working Group will be in charge of following and verifying the steps proposed in Sections 3, 4, 5 and 6, respectively.

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