# COMPUTERS FOSTER EDUCATION AND EDUCATION FOSTERS COMPUTER SCIENCE
## *The Politecnico's Approach*

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Abstract: The technical-scientific vocational crisis has become for several years a crucial issue within the scientific community. Nowadays in Italy this worrying matter mostly concerns ICT Universities and Faculties. Starting from the analysis of the situation and identifying some possible reasons, we focus on the vision and the concrete strategies of the Faculty of Information Technology Engineering of Politecnico di Milano. In particular, this paper introduces two kinds of projects: vocational guidance programs and habit change initiatives.

# 1 INTRODUCTION

This paper analyzes the increasing young people's disaffection from scientific studies and careers, with particular emphasis on ICT subjects and curricula. Section 2 describes the current vocational crisis and some of the main causes, according to Italian, European and U.S. statistics. Section 3 introduces the vision of the Faculty of Information Technology Engineering of Politecnico di Milano to curb the problem, focusing both on vocational guidance (section 3.2) and habit change initiatives (section 3.3).

# 2 THE SCIENCE VOCATIONAL CRISIS

"Science and technology play a major role in most aspects of our daily lives both at home and at work. Our industry and thus our national prosperity depend on them." (Bomer, 1985, p.6).

The introductory sentence of "Bodmer Report" (Bodmer 1985) sounds strongly up-to-date nowadays.

This issue seems not to be perceived in Italy, where young people's disaffection from scientific studies and careers is increasingly worrying.

This topic is also part of the wide international debate about the so called Public Understanding of Science, which significantly involves all Western countries. The problem turns out to be even greater in Italy, as we can gather from the discouraging enrollment rate and degrees in technical-scientific courses and from the OECD-PISA[1] performance achieved by our 15-year-old students.

## 2.1 Background Situation

Data from the Department of National Statistics of the Ministry of Education, University and Research (MIUR, 2009) reveal that in Italy students enrolled in scientific-technological degree courses[2] in the academic year 2008/2009, represent 27,04% of all university students (this rate reaches 27,48%, if we consider also the students enrolled at the 1st year for the first time – see Figure 1).

[1]The *Programme for International Student Assessment* (PISA) is an International research supported by the Organisation for Economic Co-operation and Development (OECD) to assess student knowledge and skills in science, mathematics and reading at age 15. Three assessments have so far been carried out, each focusing on a specific area: the first one (PISA 2000) was on reading literacy, in the second one (PISA 2003) the emphasis was on mathematical literacy and problem solving, the third (PISA 2006) was on scientific literacy. 57 countries were involved in PISA 2006.
[2]Scientific-technological degree courses concern Scientific, Engineering, Architecture, Agricultural and geo-biological areas

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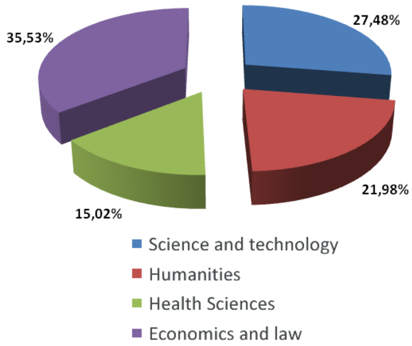


Figure 1: Enrollment rate by area (2008/2009) in Italy.

Despite the last academic years' slight increase (+0,27%)[3], the enrollment rate to the technical-scientific programs are not even comparable with those of the 50's, when about half the university population was registered at the same programs.

The results of OECD-PISA 2006 firms up the wide lack of interest in scientific subjects: the average score of Italian students in their performance on the science literacy is below standard (475), in comparison with the OECD average (500).

The disaffection of young people towards scientific issues is confirmed by other evidences, emphasized in the analytical report *Young people and science* (European Union, 2008).

For each of the fields of study listed in the survey, only a minority of young EU citizens considered studying scientific subjects. Young people were most inclined towards social sciences, followed closely by economics or business studies, while mathematics was selected by the smallest group of respondents. While almost 4 out of 10 young people said they would definitely or probably consider studying social sciences (39%) or economics (36%), less than a third of respondents showed an interest in each of the other fields of study listed: 31% considered biology or medicine, 28% engineering, 25% natural sciences and just 21% mathematics.

In the majority of the countries, at least half of the respondents said they would definitely not consider studying engineering. In Italy almost six out of 10 young people would definitely not be studying engineering.

The most worrying result is that only 42.2% of Europeans agree that this lack of scientific vocation would constitute "a threat for future socio-economic development". This figure falls further to 34.7% in the subsample of Italians. For 54.9% of respondents, moreover, the industry sector "will always find the skilled personnel it needs."

A particular attention in the context of scientific vocational crisis should be drawn to ICT sector. After the well-known boom of 2000, due to the so called "dot-com bubble" and the related grow of interest in technological subjects (Computer Science and Telecommunications above all), there has been an inexorable decline.

Figure 2 shows how since 2000 the Engineering enrollments in Italy and at Politecnico di Milano have remained almost steady and have absorbed the fall of enrollments occurred between 2004 and 2005, while enrollments in Information Technology Engineering at Politecnico di Milano have suffered a fall of 50%.

## 2.2 Public (Mis)Understanding of Science or Lack of Information in Schools?

Nowadays just a few researches investigate systematically the reasons for witch young people turn away from technical and scientific studies. According to some surveys by European Union (2005), it is possible to identify four main causes perceived by young people as responsible for the disaffection from scientific studies and careers:

- poor image of science and scientists in society
- lack of appeal of scientific subjects and studies
- difficulty of scientific subjects in comparison with the career prospects
- lack of schools and of talented motivated and well trained teachers to teach and promote science and technology.

Regarding the first two reasons, it is clear that today a paradoxical opinion of science prevails. Scientific has become synonym for exasperating rationalism, for engineering narrow mind - incapable of understanding the complex nuances of the world, for unimaginative technicality and not for techne[4].

On the other hand science is the main way to hunt for answers, minding the complexity of issues and rejecting default patterns. Thanks to complexity analysis, science investigates theoretically and performs pragmatically in very different contexts.

In addition, over the years a real gap between humanistic and scientific knowledge (always seen as conflicting, and inevitably separated) has been dug.

[3]A significant increase, in contrast with the general decrease of university enrollments (-3,13%).

[4]**Techne**, or **techné**, is etymologically derived from the Greek word *τέχνη*, which is related to *craftsmanship*, *craft*, or *art*. It is the rational method involved in producing an object or accomplishing a goal or objective.

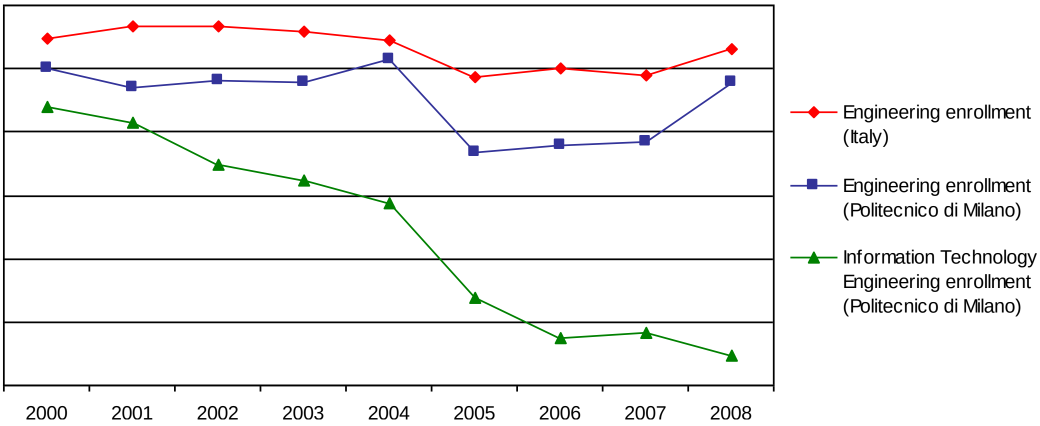


Figure 2: Engineering enrollment (2000-2008).

According to Rashid (2008, p.34), senior vice president for research at Microsoft Corporation, "At the heart of falling interest in computer science are fundamental misconception about the work we do, our ability to make a difference in the world, and the job opportunities our field offers. […] One barrier to interest in computer science is the unfortunate and deeply held stereotype of the solitary male programmer who slaves over a keyboard and subsists on snack food. A majority of young people subscribe to this stereotype and believe the job of the computer scientist consists of endless days spent alone in front of a computer screen."

Scientific studies have always been considered more "difficult" then other curricula (Andriole and Roberts, 2008), as we can infer from the critical statistics on scientific degrees drop-out-rate. This kind of curricula is very selective in the first years (the drop-out-rate at the firs year is 30,6%, against 25% of national average) and it is above average also in the following years (34% of enrolled students slow down in their study path).

Undoubtedly, the perception that scientific studies are difficult stems primarily from misinformation in school: students who are misled about scientific subjects by teachers, loose their motivation when facing the first difficult challenges at university. Just then their performances, and in some cases also the chances of completing the studies, rapidly decrease.

However, figures only partially confirm this representation: the percentage of enrolled students who graduate in technical-scientific faculties (39%) is on the other Italian faculties average (40%).

Another reason why students do not consider technical-scientific enrollment is the bias they will not have a good career prospect. Figures do not confirm this negative perception, emphasizing the good performances of technical-scientific degrees in the labor market and the high level of satisfaction of working graduates. This statement fits particularly to ICT studies: 3 years after degree 88,3% of graduates have open-ended jobs.

According to the U.S. Bureau of Labor Statistics (2009), employment in scientific and technological services will grow by 28,8% and will add 2,1 million new jobs by 2016. Employment growth will be driven by the increasing reliance of businesses on information technology and the continuing importance of maintaining system and network security.

However, the main responsibility for technical-scientific vocational crisis is in the school system, which is not able to motivate and prepare young people to study science. Teachers, who should play a key role in encouraging students to scientific studies, promote too often an idea of uninteresting science disconnected from practical every-day life.

Research in this field (Driver, Leach, Millar and Scott, 1996) evidences that secondary school students tend to have a too "technical-empiric" vision of scientific knowledge, where creativity and analysis depth do not concern scientific professions.

Furthermore, schools uphold the wrong dichotomy between a rigorous science, but difficult to learn, and a more accessible and understandable science, but certainly trivialized. This view does not support an effective process to communicate science and strengthens the previously mentioned concept of "separate science". The idea of a "science for the few" certainly does not help to raise enrollment rates in scientific faculties.

As for ICT, the situation is even more worrying, since a vicious circle has arisen between teachers' negative awareness of science and the uncritical adoption of new technology in schools.

Too often the adoption of ICT has been interpreted as mere digital literacy (e.g. ForTic for teachers or ECDL for students) or as a required acquisition of hardware, achieving paradoxically negative results. Teachers are supposed to undergo technology passively (the computer is seen as a tool to perform tedious tasks). As a result they have a dichotomous vision of ICT and culture, which they convey to their students, in reason of their privileged position (ex-cathedra).

For these reasons, the main activities to promote science and technical-scientific culture must necessarily concern schools (of any level) and act not only as academic guidance but also and especially as a stimulus to a deeper change of Weltanschauung.

# 3 THE FACULTY VISION

## 3.1 Background Settings

In view of the situation outlined above, the Faculty of Information Technology Engineering (ITE Faculty from now on) of Politecnico di Milano[5] launched several initiatives[6] addressed to the world of primary and secondary school, in order to change the public perception of science.

These activities do not act only on students, but also on the whole school system and, in perspective, on society.

The vision of the Faculty is to emphasize and promote a strong integration between the humanistic-social culture and the technical-scientific one.

[5]The Faculty of Information Technology Engineering (Ingegneria dell'Informazione) includes the following programs (Bachelor of Science and Master of Science): Automation Engineering, Computer Engineering, Electronic Engineering, Telecommunications Engineering and Information Technology Engineering (the last one in collaboration with Politecnico di Torino and Tonji University, China).

[6]All the initiative described in this paper (except ICT Engineering lessons) are carried out by HOC-LAB, (Hypermedia Open Centre), a laboratory of the Electronic and Information Department of Politecnico di Milano, founded and coordinated by Prof. Paolo Paolini. Its interests focus on the Web, multi-media applications, design methodologies, "net-society" applications and innovative computer mediated communication (CMC). Its applications' domains span from electronic commerce to cultural heritage, from e-learning to advanced educational 3D environments. The laboratory is "open" in that it gathers a multidisciplinary team of research, not strictly coming from the academic world. All HOC activities addressed to schools are part of PoliScuola, an integrated program whose aim is to conduct researches and activities in the field of ICT-enhanced didactics.

The junction between cultures is represented by ICT, which is often erroneously perceived as mere detached tool. On the one hand ICT can be exploited as useful tool to carry out specific tasks and satisfy requirements (e.g. to speed up work or to widen audience and geographical boundaries), on the other ICT can - and should - be seen as integral and significant part of culture.

In this sense the use of ICT in school can have two beneficial effects:

- At the first level technology is presented as a sort of trick box: teachers and students use technological tools for their educational purposes without focusing on the working process. They insert contents into the trick box, the trick box processes them and returns an output that is more than the sum of the parts.
- At the second level students and teachers use the trick box and wonder how it works. This attitude creates curiosity concerning ICT culture and develops interest in technical-scientific methodologies.

The actions of ITE Faculty aim to develop both levels of ICT conception. In fact the first level of perception can be supported both involving all school levels (from kindergarten to higher education) and concerning all cultures (e.g. all subjects taught at school).

Promoting the use of technology to the first level increases the chance for students and teachers to approach the second level.

## 3.2 Vocational Guidance Initiatives

In this section some educational projects, carried out by ITE Faculty, which aim to improve the attitude and awareness of students from secondary schools towards Politecnico di Milano will be described. These projects, together with other initiatives of Politecnico di Milano[7] (Open Days, Summer School, University Explorer Game, etc..), play a significant role in the effort to open the University to schools.

### 3.2.1 Hi-Tec

Hi-Tec (Marini and Torrebruno, 2006) is an innovative experience which is based on an active vocational guidance for talented students selected from the fourth year of secondary school.

Hi-Tec's aim is to lead students through a three-phases process which consists of:

[7]For information see http://www.orientamento.polimi.it

- contextualization of the problem and its theoretical implications;
- definition of the main task and its reference frames (prerequisites, timing, work methodologies, tools) and work in groups to solve the problem;
- evaluation and sharing of the results with the other workgroups.

Hi-Tec involves many university departments, each with a different program: Architecture Science, Product Design, Environmental Engineering, Management Engineering, Physics Engineering, Chemical Engineering, Electrical Engineering, Information Technology Engineering, Mechanical Engineering.

Hi-Tec promotes a blended learning methodology: the first phase (30 hours, online) aims to introduce the students to the subject of the specific program; the second phase – the core of the project – carried out in one week (32 hours, in presence) involves the pupils in a collaborative activity, enhanced by theoretical lessons and supported by workshops. The aim of this phase is to design and develop high quality projects.

For instance, in Hi-Tec 2009, a group of 20 students enrolled in the Computer Science program, were asked to develop real videogames using Scratch (http://scratch.mit.edu), the well-known easy-programming language developed by MIT. Without any programming background, they were trained and tutored throughout the development of sport simulations and classical arcade games. One of the goals they were supposed to reach was the implementation of Physics laws into realistic videogames. Videogames produced by Hi-Tec students in 2009 are available at this web page: http://scratch.mit.edu/users/hitec-2009.

During this week students live and work together, sharing their activities in an atmosphere of socialization and mutual acquaintance.
Hi-Tec has now come to its fifth edition and involved more than 600 selected students, out of more than 1500 applicants. The selection of the participants is carried out starting from their school reports and their personal motivation.

The constant monitoring of the project, reveals how the initiative satisfies the expectations of its participants and achieves its primary goal: to represent a precious vocational guidance for students (see Figure 3).

One of the main reasons of the experience success is the promotion of creativity and development of interdisciplinary skills (collaboration, project management, communication within groups, problem solving, etc.). As we can read on the surveys, students involved in Hi-Tec acquire a deeper understanding of the university world and learn the importance to combine culture and technological education. In the last edition, according to surveys results, 67,6% of students changed their perspective about Politecnico di Milano and 64,7% of students modified their point of view about Engineers (Previously I thought that the Engineer was a very competent person, but strictly constrained by requirements, Hi-Tec made me understand the value of personal creativity and group working[8]).

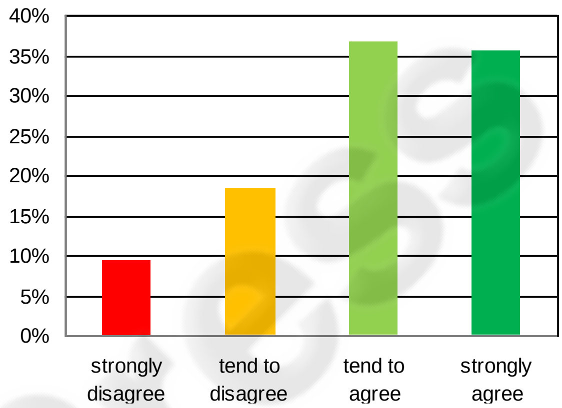


Figure 3: Has HI-TEC influenced your University choice?

### 3.2.2 Computer Science Engineering Lessons

The Faculty teachers offer lessons for free in the secondary schools that expressed their interest with the goal of bringing the Computer Science and Engineering subjects closer to the students, and to arouse their curiosity for ICT.

The project is now in its fourth year; and offers lessons to 4th and 5th year high school students (usually 50-100 students per school); such lessons cover a wide range of topics, typical of the programs of the Faculty of Information Technology Engineering: it ranges from robot playing football to the relationship between computer science and philosophy, from the evolution of the Web to micro and nano-technologies[9].

Besides these "thematic lessons" there are also some introductory lectures about the specific programs of the Faculty and the study paths.

Computer Science Engineers, and immediately

[8]Statement of a student from Hi-Tec 2009.
[9]The full list is available online (in Italian): http://www.inginf.polimi.it/servizi/inclasse/generale.php?id_nav=3004

find out that all these issues (even the farthest from their everyday life!) have actually immediate effects on our lives.

This initiative has not only the aim to convey vocational guidelines to students but has also, and above all, a cultural nature: it promotes among students a habit change about their opinion of science and scientists.

The initiative deserves a wider spreading as the required effort to visit schools is too high.

In order to face this problem a further exploitation of ICT technologies has been planned: precisely, two new changes will be introduced next year:

The use of a videoconferencing system, to deliver online synchronous lessons. This device allows the faculty to widen the catchment area and reduce massively the overhead.

Production of video's to deliver asynchronous lessons, directly available on the Politecnico's website. Last year three video-lessons have been created and published, and we plan to increase this number.

Using well-known technological systems (every teenager knows youtube!) to teach technology means to explore a sort of "metadisclourse" to ICT.

Furthermore, we are planning to open the access to University's laboratories to the students of secondary school, and to deliver lessons within these buildings. Participating directly to a "real lesson" (e.g., seeing robots in action rather than hearing about them) would easily reduce the gap between University and young people.

## 3.3 Habit Change Initiatives

Besides the "vocational projects", the ITE Faculty promotes activities aimed to affect in depth school and society.

Concerning ICT, the Italian school system has drifted away from society, for several well-known reasons:

- the average teachers' age is still too high, and turnover is insufficient;
- teachers usually shows adverse attitude towards ICT;
- structural deficiencies of schools;
- lack of adequate training on ICT;
- restrictive awareness of technology: it is taught as a subject on its own and not considered as a "cross over" teaching tool.

The following projects aim to fill this gap, improving teachers' background and qualification, and stimulating their interest in technology.

### 3.3.1 PoliCultura

PoliCultura (Torrebruno, Paolini, Garzotto, Di Blas, Bolchini and Poggi, 2008; Paolini, Di Blas and Torrebruno, 2009) aims to foster the adoption of ICT technology in Italian schools and to promote a "polycultural" approach to education in which technology and humanities are smoothly and synergistically combined. PoliCultura is also a national competition where participants are requested to create a full "hyperstory" on a cultural theme at choice, using a special tool developed by Politecnico di Milano: 1001Stories. This tool supports the process of translating conceptual narrative structures into a suitable interactive digital format; filling them with multimedia contents, and delivering the resulting hyperstory on different channels (CD-ROM, Website, Videopodcast). The tool is fast to learn, quick in enabling the delivery of a complete multimedia hyperstory, and easy to use, hiding the complexity of the implementation underlying the tool. In this way the whole production process of multimedia artifacts turns out to be simple, cheap and fast (a perfect trick box as introduced in section 3.1).

During its three editions, nearly 480 teachers, 860 classes, 10.000 students from schools located in all Italian regions took part in PoliCultura competition.

Among all works submitted to the competition[10] we can mention one of the winners of the ITE Faculty special award: *Interview to History: who invented the numbers?*[11], by the primary school children of Istituto Comprensivo A. Manzoni, Capriate San Gervasio (BG, Lombardy). Led by their teachers, 8-9 year-old children conducted an imaginary interview to ancient peoples (such as Egyptians, Greeks, Romans, etc.), to find out how the need of counting was born and how each people found solutions to this need.

According to the teachers, this work revealed surprising educational benefits: beyond motivational goals, throughout hard working the children achieved advanced communicational skills and multidisciplinary competences. Both children and students show their enthusiasm for the experience also during PoliCultura Awards, when all finalists have been celebrated at Politecnico di Milano.

Besides the educational benefits, 90,1% of inter-

[10]A selection of hyperstories (in Italian) can be visited on Policultura website (www.policultura.it).
[11]*Intervista alla storia: chi ha inventato i numeri?* http://www.1001storia.polimi.it/meusGEN/meuslive.php?public=1&projectid=356 (in Italian)

viewed teachers reported that, using 1001Stories, students have acquired or improved their technical competencies. PoliCultura inclines students towards ICT in a playful way and can be considered a useful experience to build up a scientific consciousness in young people, even – and perhaps mostly - when 1001Stories is used to build hypermedia on a non-technological topic, such as history or literature.

### 3.3.2 Diploma On Line

Diploma On Line (DOL) for ICT-enhanced teaching (Torrebruno and Marini, 2005; Marini and Torrebruno, 2007) is a two-year specializing master for teachers of any school grade. DOL aims at developing and enhancing the use of New Technologies in didactics. Besides theory and methodological contents, it offers practical activities, case-studies and meta-reflections, to promote the use of ICTs into "traditional" didactical contexts.

Every year Diploma On Line trains more than 200 teachers from all over Italy (see Figure 4), with successful results both in relation to its didactic objectives and to students ' satisfaction: its low dropout rate, the positive results of the online surveys, the high-quality outputs, the high amount of favorable evaluations and appreciating comments expressed by students represent the highest stimulus to widen the didactic proposal and expand the target.

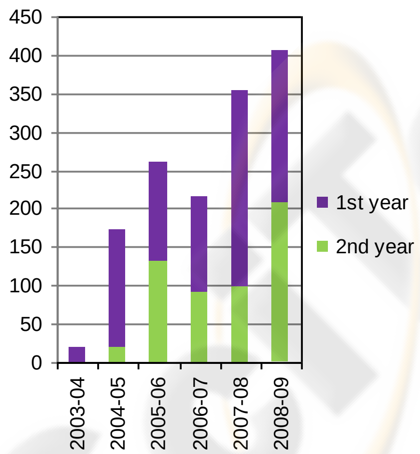


Figure 4: DOL enrolled students (years 2003-2009).

In order to achieve such positive results the course is carefully planned and organized on a solid structure: every year the wide group of enrolled students is divided into classes of 20 people, each supervised by one tutor.

Students carry out all activities and discussions using an asynchronous Learning Management System and a webconference system, sharing knowledge, skills, and materials in a constructive atmosphere.

Studying contents related to ICTs and using them into didactics, learning online, sharing experiences with peers and building online relationships are the key values of DOL. Figure 5 illustrates students' satisfaction, as for contents, activities, webconferences, interaction, relevance (that is how contents can be spent into teachers' school contexts) and tutoring.

DOL is the project of ITE Faculty which mostly influences the school system, both for the wide number of involved students, and for its high-quality educational route.

## 4 CONCLUSIONS

As a ICT faculty in a technological University, we think that it is up to us to show students how exciting is working in a field where we have the opportunity to advance science, develop new ideas and create solutions to difficult everyday challenges.

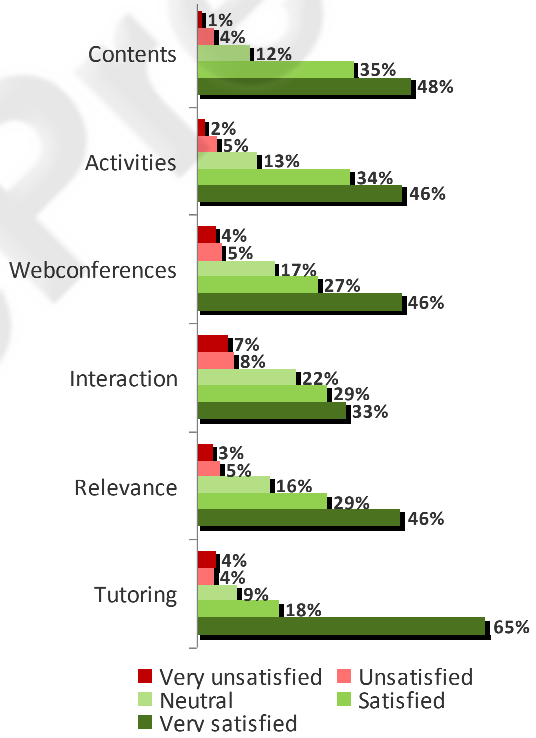


Figure 5: DOL students' satisfaction (a. y. 2008/2009).

Changing the bias and misconceptions of people who have the greatest influence on young people, is the most effective way to increase the interest for scientific studies and careers. The whole process must necessarily start from the first levels of education and involve teachers and peers.

That's why ITE Faculty is targeting schools and interacts with teachers and students, in order to convey the real meaning of science and technology. Only by giving teachers and students a more correct view of science and technology, we can show them the opportunity to play a key role in a world of innovation and progress.

Although the above mentioned initiatives promise significant and measurable results only in the long term, the first outcomes are with no doubt encouraging.

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