NEW MODELS OF COMPUTER-BASED UNIVERSITIES FOR TRAINING THE ENGINEER OF THE THIRD MILLENNIUM

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ABSTRACT

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Abstract — **The overcoming of space and time constraints applicable to the old ways of transmitting knowledge and the multimedia and interactive nature of the new communication tools represent an unprecedented challenge and a precious opportunity for reformulating, from a theoretical perspective, as well as of renewing, in practice, the traditional training procedures of professional profiles in the field of engineering. The specific training required to the engineer-architect that will work in the Third Millennium is involved in a set of parameters very unlike those that are widespread in traditional universities on which nowadays professionals have to rely for their training. The new engineer will have to understand and manage pressing issues such as products and buildings life-cycle issues, environmental sustainability, energy resources sparing and so on in a continuous connection and cultural confrontation with the global network that is ever increasing widespread and puts on the market everybody's skills. The model linked to the micro-territory becomes obsolete and a new futuristic model, already imagined in the previous century takes shape (Beguinot, 1989), as a reference point for today's new dimension. The task of the university is therefore that of coordinating and managing this complex process, leading professional profiles towards a cross-field and at the same time specialised training that makes them actors of global knowledge, without being victims of it, but changing their attitudes towards knowledge into a cultural self-promotion that will not scatter their competencies, but make them essential and indispensable to global development.**

Introduction

The overcoming of space and time constraints applicable to the old ways of transmitting knowledge and the multimedia and interactive nature of the new communication tools represent an unprecedented challenge and a precious opportunity for reformulating, from a theoretical perspective, as well as of renewing, in practice, the traditional training procedures of professional profiles in the field of "polytechnic" professions.

The specific training required to the engineer-architect that will work in the Third Millennium is involved in a set of parameters very unlike those that are widespread in traditional universities on which nowadays professionals have to rely for their training. The new engineer will have to understand and manage pressing issues such as products and buildings life-cycle issues, environmental sustainability, energy resources sparing and so on in a continuous connection and cultural confrontation with the global network that is ever increasing widespread and puts on the market everybody's skills. The model linked to the micro-territory becomes obsolete and a new futuristic model, already imagined in the previous century takes shape (Beguinot, 1989), as a reference point for today's new dimension.

As result, even the way to spread culture changes. Books, ever-increasingly fewer available on paper format, drawings, ever-increasingly "drawn", words, ever-increasingly less direct, but filtered on the global network, commented, justified or criticised by a globalized knowledge. Italian towns, having a huge cultural heritage, are becoming from unreachable sirens in mass knowledge sources: history, art, architecture, construction techniques and engineering become links to the past to which anyone can access, which anyone can appreciate.

Whether this is right or wrong, this is what is going on, to which all professional profiles have to adjust, otherwise fall into anachronism and old-fashion status: a professional who does not use advanced programmes and

who has no managerial imprinting, will not survive competition; however, this same professional, if he lacks a solid educational background, will not be able to cope with the potentials of the new system.

The task of the university is therefore that of coordinating and managing this complex process, leading professional profiles towards a cross-field and at the same time specialised training that makes them actors of global knowledge, without being victims of it, but changing their attitudes towards knowledge into a cultural self-promotion that will not scatter their competencies, but make them essential and indispensable to global development.

The Engineering Faculty of the International Telematic University UNINETTUNO faced this challenge and, starting from a psycho-pedagogic model inspired by connectionist theories (Garito et al., 2006), is experimenting training models that are mainly aimed at enabling students to become active constructors of knowledge. Most specifically, contents can be used through the media (TV, DVD, Internet) generally independent from space-time variable and distributed within multimedia and interactive system where the student can, being guided by his teachers, build a customised learning path, continuously checking his own progress.

This system places at the centre of the cognitive process not the learning object or its usual intermediary, that is the teacher, but the subject of learning, that is the learner, with his interests, his attitudes, his curiosities. Overcoming space-time frontiers involves, among other advantages, a consistent integration of activities taking place in remote places. In the context of a real "Mediterranean" attitude, training is actually delivered in four official languages: Arabic, English, French and Italian with two official branches set up in Cairo, Egypt.

The training paradigm of the engineer of the Third Millennium can exploit at its best the possibilities assured by the Didactic Cyberspace, aimed at developing the "five minds for the future" (H.Gartner, 2009). In particular, beside keeping traditional "polytechnic" qualities (hard skills), that is a very good basic methodological and cross-border training, the mastery of the latest and most advanced knowledge and technologies, strong analytical and *problem solving* skills, and also the capacity to work intensively, we aim at developing new qualities (*soft skills*), required by the new socio-economic context, by the new trends (*green engineering, network connectivity*) and by the fast changes taking place in the labour market. For instance, the ability to gather and filter information needed in any context, willingness to learn all lifelong (*learning to learn*) because of the ever-increasingly fast obsolescence of knowledge and to redirect their interests (*adaptability*), tendency to creativity and inductive skills, behavioural skills (making relations, assertiveness, leadership), and "ethical" skills such as multicultural approach and social and environmental awareness.

Production Centre   Technological Pole
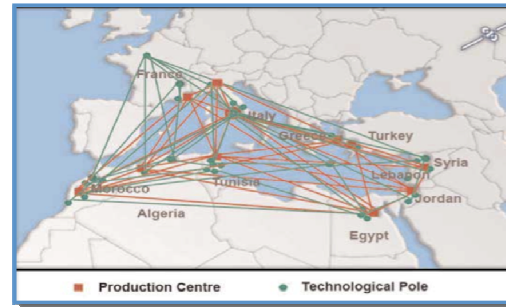
Below we shall try to get an insight into the current socio-economic background in function of the training paradigms and then we shall illustrate the background premises and the model developed for this multimedia "factory of knowledge" that assures excellence-level training and is ambassador of the great tradition of the Italian engineering in the Mediterranean Region.

1. Engineering studies in the 20th Century

Due to the recent development of multimedia and the ensuing change of society, in the current setting, many questions related to the engineer of 2030 are raised – in technical as well as in social terms, in relations to the targets to which the 2030 engineering and engineers' achievements will aim.

The increasing complexity, uncertainty and the interdisciplinary character of the engineering systems, the fast obsolescence of knowledge in all fields of engineering, the increasing rhythm of technological development:

- bio-engineering, biotechnologies and medicine
- energy, resources and environment
- Development of calculation power, telecommunications
- Miniaturisation (MEMS, nano-technology)
- Integration of large-scale complex systems.

Can be listed as *technological drivers of change*. As a result one may question whether the current educational paradigm is suitable or not and the relative answer is supplied by socio-economic analysis:

1.1 Weakening of the work-force

A fourth of the work-force in the sector of engineering and science - whose research and innovation work created the economic boom of the Nineties – is over fifty-year old and will give up work by 2020.

At present, there still is a 21% decrease in the students' population in Europe and in the USA in the fields of engineering and physical sciences and since 1997 there has been a 15% decrease in the number of research doctors (Europe and USA). In spite of this, the demand for work-force in the fields of engineering and technology in general, also in fragile economic settings, will still be high also in the next years.

1.2 World population (CIA, 2001)

A group of 100 people in 2030 will be composed as follows:

- 56 from Asia (and among them 19 from China and 17 from India)
- 13 from the Western hemisphere (and among them 4 from the United States)
- 16 from Africa (and among them 13 from Sub-Saharan Africa)
- 3 from the Middle East
- 7 form the East Europe and former Soviet Union
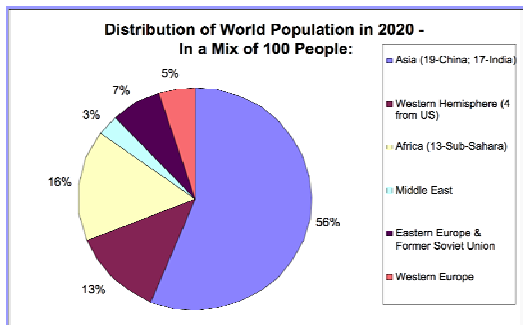- 5 from Western Europe

Figure 2. Faced with the ageing of population in the USA, European and Japan, the most troubled areas of the world will face baby-boom (*youth bulge*).

2. The future socio-professional setting of the engineer's activities

The rhythm of technological innovation will keep on being very high (yet increasing) and the world in which the engineering will work will be deeply and globally interconnected; the people involved at different levels (i.e. designers, producers, distributors and users) in the engineering activities will be ever-increasingly diverse and multi-disciplinary, whereas social, cultural and political forces will keep on determining the fields and the success of technological innovation.

Everyday technology will get ever-increasingly "transparent", intangible and indispensable as ever; therefore consumers' needs will increase: higher quality and reliability, customisation of the product etc.

2.1 Social/technical changes

Social and technical changes will mainly involve relocating the employment of engineers from large companies to medium/small companies – entrepreneurship, increase of employment in non-traditional and less technical sectors (i.e. management, finance, marketing, communication etc…)

The imperative of "sustainability" facing the growth of global population, industrialisation/urbanisation and the environmental pollution get pressing questions; the increasing awareness of social implications of an uncontrolled technological progress result in socio-political conflicts in a globalised world: 16% of the wealthiest world consumes 80% of natural resources. By 2030 there will be 8 billions of people that will create political unbalances because they will want to access natural resources (water) and energy, if this inequality persists (CIA).

It is unavoidable to increasingly focus on risks control in a perspective of security (*safety, security and privacy*); in this respect the following charts give an answer to specific questions:
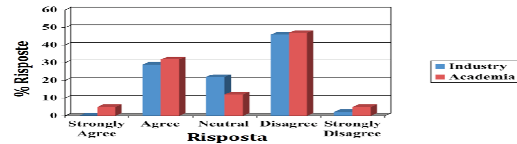

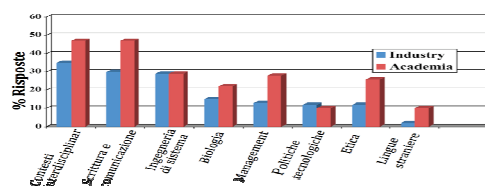Figure 3. Is current education flexible enough to meet the Third Millennium needs?

Figure 4. Which issues should be more widely developed in engineering curricula?

2.2 New skills

The need to enhance the qualities that traditionally characterise the "technician", such as very good basic, methodological and cross-field training, mastery of the latest and most advanced technologies, analytical and deductive skills, problem-solving capacities, ability to work hard and support intensive work rhythms, "resilience" (deriving from a nautical term indicating the ability to get back onto a capsized boat) makes education competitive and specialised (hard skills or technical competences).

However, at the same time, the relational approach requires qualities to be developed, required by the situation: ability to obtain and filter information in any situation, willingness to learn always (learning to learn – obsolescence of knowledge) and to turn one's own interests (adaptability), creativity, curiosity and inductive skills; interest in complexity, capacity of adopt the "life cycle assessment" approach in all engineering activities (design, planning, building and casting-off), behavioural capacities: managerial skills, assertively, team working, leadership, "ethical" and multicultural skills, integrity and social and environmental awareness (soft skills or cross-field skills). Team-work represents a resource and interaction with a group is an indispensable tool.

Therefore, the new graduates should be able to adapt to the social and working environment; they have to be able to communicate, work in ever-less structured professional settings, to be able to manage one's own time at best, to be able to face stressing situations, being able to synthesise and to adapt and above all they should be able to quickly understand whether their professional profile can be included into a specific working environment.
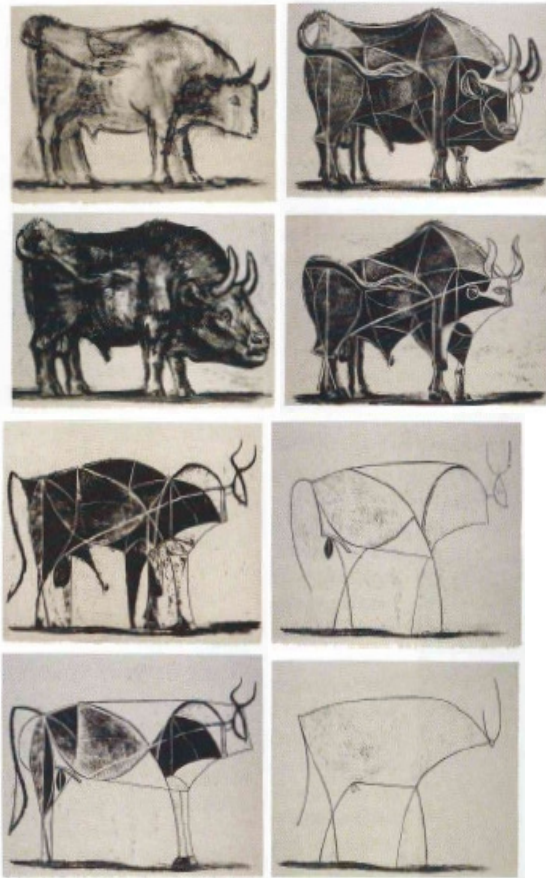
Figure 5. Modelling capacity. Picasso, Huit etates du Taureaux, 1945-1946 *"Simplicity is complexity being solved"*

3. How to keep on thinking as craftsmen using technology in an appropriate way

As always, the answers come from an advancement that is based on the knowledge of the past, on the analysis and respect of this last one and from there it sets off to go on in knowledge and technology.

Some working, even though highly technological, in the engineering field, cannot be carried on without taking into account these parameters; most specifically, in the approach to the conservation of cultural heritage (a currently pressing issue in the light of recent natural catastrophes), the global knowledge of a construction, the analysis of its typology complexity and the compliance with the rules used at the time to build it, are the bases for an efficient work of structural consolidation (Figure 6).
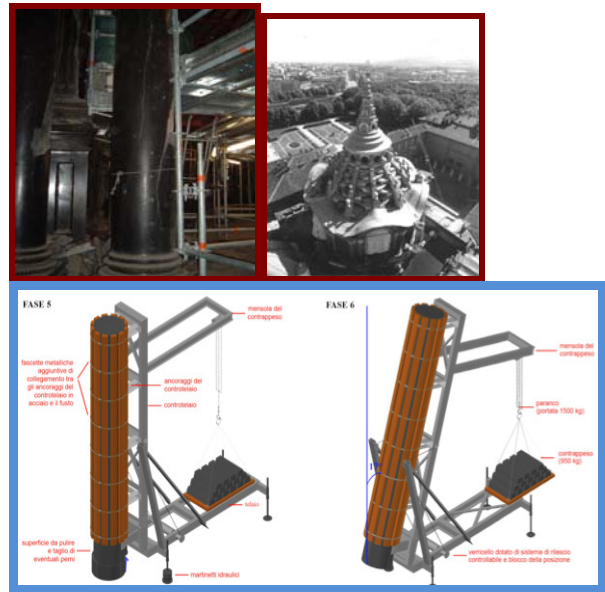

Figure 6. Turin, 2009. Building design for the restoration of the Holy Shroud Chapel (G. Guarini): removal of main columns

Since ever man has inspired himself from the past to build the future and the achievements of the "great innovators" of humanism (Figure 7), show the same matrix of those of the great, new contemporary innovators (Figure 8).
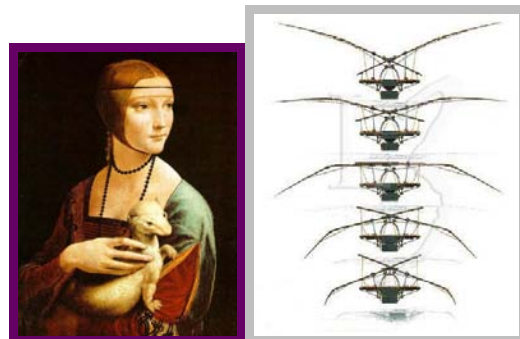

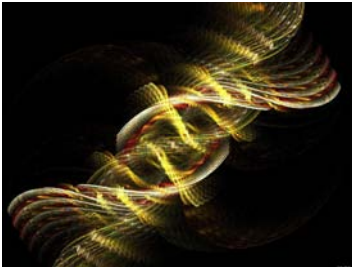Figure 7. Leonardo Da Vinci. a) woman with ermine b) machine for flying.

Figure 8. a) Bernini, St. Peter (Rome, 1623) b) Spiral structure of DNA (W&C,Cambridge, 1953)

To sum up, new knowledge requires a new way of learning and training. Future mind will have to be trained as follows (Five Minds for the Future, E. Gartner):

• disciplined (classical)
• synthetic
• creative
• respectful
• ethical

And success will result from the following three "Ts" (I Fattori del Successo, R. Florida):

•Talents
•Technology
•Tolerance

4. The UTIU's model

Most likely the challenge facing the University of the Future is distance education. It is e-learning which enables to use a virtual space for actual learning. As a result: the *triad of winning features in a creative place can be cyberspace*?

The psycho-pedagogic model of the International Telematic University UNINETTUNO is the outcome of over 20 years of international research work and experimentation in distance education carried on by Prof. Garito's team.

Most specifically, the psycho-pedagogic model of the Engineering Faculty envisages the highest degree of flexibility for the student's benefit. The student can build his own learning path in function of this training needs and of his skill level. The learning environment supplies dynamic contents that can be enriched by other contents available on the Web.

The new psycho-pedagogic model is characterised by the shift:

■ From the professor's central role to the student's central role,
■ From knowledge transfer to knowledge creation;
■ From separation to the integration between theory and practice;
■ From a passive and competitive learning to an active and collaborative learning.

The cognitive and connectionist theories are the theoretical basis upon which the whole teaching and learning process in the "Didactic Cyberspace" takes place; it is the only one worldwide designed in four languages: Italian, English, French and Arabic.

In the Didactic Cyberspace it is implemented a synchronic teaching/learning environment where there is unity of time, but not of space in the teaching and learning process and a diachronic one, where the educational and training process is no longer linked to the unity of time and space.

The Cyberspace is an open and flexible learning environment that enables to:

■ End up the one-way communication of knowledge and start a new line of communication that allows the Engineering student to access dynamic knowledge that can enriched made available for other people ;
■ Use the PC, with Internet also via satellite, as the focus of a system where different contributions from different media converge to allow the creation of a truly integrated and "open" multimedia model. The PC allows transmitting directly from the University to the student's desktop lessons, multimedia products, databases, tutorials, practice work, assessment and self-assessment systems.

The learning environments of the didactic cyberspace allow:

■ Organising and deliver educational contents in a pre-planned, structured and consequential way;
■ Adapting the educational process to the needs of the individual student;
■ Supplying the training tools capable of transforming theoretical knowledge into practical abilities and therefore into professional skills;
■ Monitoring the student's learning progress through continuous assessments whose results can be consulted by the student himself in order auto-assess his own learning process;
■ Bringing together the protagonists of the learning process: students, professors and tutors in open and flexible learning environments.

Conceptual map
The students learning process is carried on starting from the Conceptual Map of the module from where the student can get an overview of the contents structuring and of the training materials available to develop self-learning.

The conceptual map enables the student to plan his own learning path in an hypertextual and multimedia way.

Digitised videolessons

The main features of the videolessons of the Engineering Faculty are:

- contents modularity that allows the student to access to specific level of competence;
- indexing of the subjects that favours hypertextual navigation; indexing will also play the role of a cognitive map showing the student the different training paths;
- bookmarks that play an essential role: they are graphical icons that will blink and turn on during the lesson to lead the student in an hypertextual way.

the student will be able to develop hypertextual and multimedia learning processes that will allow to enrich and improve the meta-cognitive strategies, thus promoting the customisation of the learning process,

Virtual Laboratories

Virtual laboratories allow for the development of a very effective distance teaching model. Virtual reality develops new learning models that tend to shift human cognitive activities at all levels: form the symbolic-reconstructive mode to that perceptive-motor one and to make accessible for perceptive-motor activity fields of knowledge that before where accessible only to the symbolic-reconstructive activity.

A new model of student

In the new Internet-based learning models the student carries on tasks and functions that are different from those of the traditional student; he becomes the true "manager" of his own learning process in terms of space and time and acts as member of virtual learning community:

- Implements appropriate self-learning and cooperative and cooperative learning strategies;
- Learns how to interact with individuals having a different culture and a different social and political experience;
- Learns how to transform theoretical notions into practical abilities;
- Becomes an active builder of knowledge and solver of complex problems

A new model of professor

This new model involves a change of university professors' traditional competencies. They have to learn how to use the new languages:

- Deliver courses on television
- Design multimedia products
- Use online exercises and training materials
- Use virtual laboratories
- Interact through chats, forums and virtual classrooms
- Use Web 2.0 in an interactive way

The professor has to:

- Play the role of "professor-director" that designs learning scenarios and who, later on, cooperates with his "students" to create and educational path that should take into account different styles of learning;
- Supply the students not only with theoretical and conceptual tools, but also tools that could allow them to transform knowledge into practical abilities, then into professional skills;
- Promote, thanks to the "virtual laboratories", the integration between knowing and being able to do;
- Develop models of sharing knowledge with the other users of the Network promoting collaborative learning processes;
- Play the role of somebody who orientates and facilitates and give everybody the necessary tools to help the student find the information he needs on the Net and avoid his getting lost in the Web Hyperspace;
- Promote socialization models on the Net

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