A proposed model of curricula development based on studies of two Mechanical Engineering Departments in Greece

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To my father

«Καληνύχτα αστέρι να
μου γνέφεις που πάς
να 'σαι πάντα ψηλά φωτεινό
κι από κει να με βλέπεις»

Abstract

This dissertation focuses on existing problem in the Greek state relating to Engineering Education in Universities. The purpose of the research is to evaluate the classic approach of a five years education for engineer and to compare it with the new curricula of a four year education.

The goal of the research is to indentify and define the dimensions affecting the profession of engineer in modern society and therefore to understand and to improve the required education. The dissertation begins with a literature review in the relevant domains. Following a review of the relevant literature, the main problems are identified and research questions are formulated. These are addressed through an interpretive research approach, comparing the curricula of two Greek Engineering Departments, one based on five years of study that is the Mechanical Engineering Department of University of Patras and the other based on four years of study that is the Mechanical Engineering Department of Technological Institute of Patras. The compilation and analysis of the curricula is based on the subjects of engineering and its contents, on the teaching hours, on the number of students and teaching staff and on the level of scientific documentation.

The research develops a conceptual framework for inquiries based on mixed methods for the collection and analysis of the data. The purpose of choosing a combination of methods for the study is to use the results of the quantitative method in the design of the qualitative investigation. It is intended that the qualitative data can then be used to validate the quantitative findings and to provide a more comprehensive description of the phenomenon under investigation. This is a developmental approach, based on the work of Greene, Caracelli and Graham (1989).

The major conclusion of the research is that many differences exist in the way in which the two types of engineers are educated. The critical analysis of international literature and the social experience of the author enabled this work to answer the research questions and to propose a model curriculum which could be adopted by the two engineering departments, fitted to their standards.

Acknowledgements

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Chapter 1: Introduction

1.1. Background

John Seely Brown (Dolence and Norris 1995) defines the value of higher education by the relationship it creates between knowledge, communities, and credentials. Traditionally, the role of education has been to prepare students to live and work within their own society. However the current nature of many jobs in the workplace is constantly changing (Twigg and Oblinger 1996). Two recognised factors contributing to this situation are the increasing globalization of world economies and the introduction of more sophisticated technologies into working environments. Global competition and accelerated change require technologically literate workers who are able to retrain and retool intellectually. Unsolved global problems of energy, poverty, healthcare, and the environment place tremendous pressures on the workforce to become agile, flexible, and globally competitive. Learning becomes a lifelong practice (Dolence and Norris 1995). These serious challenges present a wealth of opportunities to institutions of higher education. Our students must learn to think broadly, compete globally, understand technology, and be ready to serve their immediate communities, states, nations, and the world. All of higher education, and especially engineering education, is being challenged to maintain pace with an external environment whose expectations of content, quality, application, technology, and achievement are rapidly escalating.

Engineering is concerned with transforming the resources of nature, through the application of the principles of science, in a manner considered optimum, into a form suitable for general use and ultimately for human use. In the other words, the business of engineering is to transform things called resources into usable products, while the business of science is to discover things and to create testable, preferably, quantitative relationships among chosen features of things. (Kjersdam. 1994).

Using the results of science in an uncritical way, is the major problem in engineering education. Engineering is basically the application of maths, physics, electronics and technology to finding and solving real-world problems. Engineers create our material world. They apply science to produce 'things'. Engineers design products, processes and systems. Engineering solutions have been developed for the benefit of society. The discipline is underlain by the moral purpose of trying to improve the lives of people. Engineers transfer ideas and things from one context to another. They adapt products produced for one market so that they can be used in another market. Therefore extending the use of something is another dimension of the engineering creative enterprise.

An engineering education is an interactive process between engineering departments and the professional domain of engineer, which means, that it should be adapted to the needs of production.

There is a wide variation between European countries as far as higher education and its relationship to the world of work is concerned. This is due to a diverse range of factors such as the length of higher education programs, vocational versus academic provision, institutional reputation and the extent to which independent learning is encouraged. The relationship between higher education and employment and the type of higher education that is provided varies in most respects more substantially by country than by field of study. This means that there are more "national" cultures than "disciplinary" cultures in the relationships between higher education and the world of work. There are also regional differences within countries. This is greatest in the poorer countries of Western Europe than in the richer ones, thus amplifying the disparities that exist between countries. (New Perspectives for Learning: Higher Education and Employment in Europe).

Tertiary Education in Greece

Higher education in Greece consists of university education and technological education. The Universities together with the Greek Technological Institutions (T.E.I) constitute what is called as Tertiary Sector of Education, a term introduced in Greece by Law 1404 of 1984. The higher education institutions act under the supervision of the State, which finances their operation and determines their status within a legal framework. The duration of the university programs of study is between 4 and 6 years, while that of tertiary technological education is $3\,1/2$ to 4 years. Universities are geared towards academic programs, whereas Technological Institutions offer professional and vocationally orientated programs. (Tsamadias Constantinos 2002).

However, there is a difference between the Universities and the Technological Institutes. The first distinction arises from the constitutional provisions that determine the different mission nature and orientation of two academic units. The University has as mission to produce and transmit knowledge through teaching and research and TEI have as mission to give knowledge with vocational and applied orientation. The second distinction has to do with the quality standards that have existed for a long period in the selection and appointment of the T.E.I's teaching staff which lead to a differentiation of the main teaching staff of the two types of Institution. The majority of teachers in TEI do not possess PhD awards, which is a must for University teachers. The third has to do with the professional prospects of University graduates and T.E.I graduates. Although, the studies result in the attainment of a degree, which permits professional recognition as engineers, T.E.I graduates are not registered in the Technical Chamber of Greece and they do not have the same professional rights with those of the University's graduates. Must be reported also, that the candidates who entrance in TEI are those with the lower grades in Panellenic exams.

In a permanently altered and evolving economic environment, where the competition is always internationalized in a wider and globalized market is judged essential the faculty from part so much the countries as the enterprises to rival in the international setting. The creation of the single market of the European Union, and the fast development of the new technologies impose a requirement upon the Greece to adapt to these requirements.

The requirements of Greek society and Greek industries probably are quite different from the requirements of countries of Western Europe and America. The very small and small to medium-sized enterprises (SME) posses a special role in the economic growth, in the social cohesion, in the production and in the employment of the E.U. It is calculated that the very small enterprises are 92% of total enterprises in the E.U. The corresponding number for Greece (enterprises with 50 maximum workers) touches upon 99,55 % of total enterprises! (http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/)

It is obvious, that at this moment in Greece, very small and small to medium-sized enterprises possess a particular role in the fields of economic development, production and employment. So they are called upon to obtain the ability to assimilate the new technologies and to be adapted in the market conditions. On the other hand, the Greek universities have an obligation to respond to the changes imposed by the global market according to the Bologna Declaration, but adapting them to the Greek situation. Globalization is a reality and the country that insists the challenges change, has no future.

1.2. The aims of the investigation

Society is changing faster than ever. Major factors behind the changes are the development of knowledge and the ability to make knowledge productive. Knowledge is of the greatest value for development and competitiveness today and in the future for as long as we can see. Not only individuals but also education must change to maintain their status. Among the most important challenges confronting engineering education is anticipating the professional skills that graduates will need throughout their careers. Meeting the challenge requires engineering educators to respond to the current and the future needs of the societies in which our graduates will work. To address these needs, we must grasp the salient conditions which characterize technological education within an ever-increasing technological society. (Pledge, 1966).

These characteristics include the following trends:

1. The pace of technological change within professional practice is constantly increasing due to anticipated and unanticipated changes in corporate requirements and societal expectations, as well as in the fundamental technologies. (Schachterle Lance- Vinter Ole. 1996).
2. Industry has 're-engineered' itself often requiring professionals to learn whole new areas of expertise.
3. Globalization of all kinds of professional activities requires as never before that engineers must be able to adopt quickly as never before to working within cultures new to them.
4. Globalization, new technologies, new forms of work, new financial and social environment are some of the new challenges to which companies and organizations are called to respond with inter-complementary approaches giving emphasis to customers needs, to competitive pressures to learning and to the creation of flexible infrastructures.
5. Limited budgets and the general economic recession in many countries force a closer look at the cost- effectiveness of universities (however that might be defined).
6. Technically-oriented higher education is increasingly seen as playing a key role in the economic well-being of society. Developments in the European Union have entailed a renewed interest in questions concerning the compatibility and comparability of university degrees and programs of education.
7. The political changes and the opening of international markets has placed educational institutions in a new and challenging situation. They must "create" educated people, who are able to satisfy modern requirements, taking into account the social and environmental problems if they want to

survive. The quality of education is created in every area of the educational system and in its every process. The main these areas are: studying, teaching, services, management. (McQueen 1994).

Developments in the European Union have entailed renewed interest in questions concerning compatibility and comparability of University degrees and programs.

The requirements of Greek society, and therefore of Greek enterprises are concrete. They want an engineer who from the beginning is informed so that he or she will able to adapt to the production processes and solve the problems. Graduating engineers are, of course, expected to have obtained an understanding of their discipline by the time they graduate. Reports on the state of engineering education suggest that students are not able to perform the relevant professional activities upon graduation. (Self-Evaluation Report of University of Patras, 1999).

It is widely agreed that industry has a very large requirement for engineering technicians, 'practical' engineers and 'theoretical' engineers. (Agogino 1992). In many countries industry employees a greater number of 'practical' than the 'theoretical' engineers. In regard to this point we have an obligation to see the roles that are played by the Greek engineer and the Engineering Higher Education, putting the question of which type of engineers the Greek society needs, at this time in vocational and working life. The MPhil program has to therefore answer to the following questions:

- Does the Greek market need both practical and theoretical graduate engineers?

- What is the most appropriate duration an engineering studies curriculum- 4 or 5 years?

- What are the suitable curricula for Greek engineering departments so that the students can successfully participate in engineering activities upon graduation taking into account the social demands and needs?

The aim of this project is therefore to research, analyze and validate the possible implementation of quality tools and techniques for the creation of an approximate model of comparison between the curricula of two or more educational departments. The investigation was focused upon techniques for comparing (quantitative and qualitative) curricula of two Greek Engineering

Departments (the Mechanical Engineering Department of the University of Patras and the Mechanical Engineering Department of the Technological Institute of Patras).

The objectives of the project that met the overall aim are identified as:

- Perform a thorough literature review in the following domains :

a. Recent approaches in quality Management.

b. Quality in Educational Organizations.

c. Engineering Education.

- Analyze existing data, derived from the adopted curricula, from a survey of the two Greek engineering Departments.
- Develop a model of general curricula for Engineering study in Greece.
- Validate the above model using appropriate criteria.
- Critically evaluate the project and suggest further and alternative areas of research.

1.3. Ethical issues

In the process of data collection, real people (students and teaching staff) will be involved. All participants will give their approval to the use of their answers in the project. The main ethical considerations of the study research are therefore:

a) Informed consent- all participants were given specific and complete information about the survey and their role in it. They were invited to give their consent to participate in the survey and may withdraw at any time;

b) The confidentiality and anonymity of the participants is especially important in a project of this nature and for this reason the personal details of the participants will not be disclosed;

c) Code of practice- although the project is carried out remotely from Staffordshire University, the normal Staffordshire University Code of Practice relating to research as described in the University's Postgraduate Research Regulations will be followed;

d) A risk analysis exercise was carried out as a part of the RDC1 and Research Proposal submission to idenity and prevent potential harm to the participants in the research.

1.4. Intellectual challenge

The engineering profession has been changed drastically over last decade all around the world.

Globalization of all kinds of professional activities requires that engineers must be able to adapt quickly within cultures that are new to them.

The market requires engineers apart from their core engineer field, to be competent as well in the following:

- The effective use of Information and Communication Technology;
- Design Activities relating to their products and processes;
- Minimising the conception to production time of their products;
- Knowledge Management relating to their discipline, products and processes.

In addition, developments in the European Union have entailed renewed interest in questions concerning compatibility and comparability of University degrees and programs.

The main challenge to modern global reality is the general understanding of the philosophy and the objectives of undergraduate studies. Today, the main task for each program is not to fix rigidly the titles and content of subjects taught, but to identify the knowledge that must be accumulated, the abilities that must be gained, the skills that must be learned and in general the qualifications that must be acquired by students during their studies.

Taking into account all the above and looking at the Greek educational at the status quo (3 and 5 years engineering studies) we are faced with a challenge: to investigate in depth the needs of the Greek situation and the required changes that will lead the future Greek engineers to be more competitive in the globalized market. The proposed research program fulfils the requirements of a Masters degree level (i.e. MPhil) for the following reasons:

a) It is extremely difficult to gather data from many sources as the majority of the Greek Universities strongly believe that a three years program is not suitable for the Greek engineers and therefore a thorough primary research survey is needed;

b) The need for this work is emerged also, from the different way on which the graduates from the two Educational Units are educated. Although Technological Institutions have passed to University status they have not improved the quality and the level of the offered knowledge. So, this creates a social problem as the graduates have not the same professional reasons.

c) It is a very innovative idea and must take in consideration the cultural aspects of the Greek scientific society regarding the engineering curricula. It is notable that there are no publications regarding the design of modern engineering curricula in Greece. The leaders of the Greek Universities strongly believe that the engineering education must stay as it is (5 years duration). The work is therefore original and must be convincing.

d) The proposed curriculum would be under discussion in the Mechanical Engineering dept, which is very keen to modify its curriculum to a modern one. This means that the outcomes of the research will constitute a worthwhile addition to both the academic 'body of knowledge' and to practice in the area.

1.5. Research Program

Qualitative and quantitative methods are used together in this work. Both quantitative and qualitative data have a place if the complexities of the field of quality management are to be fully explored. Rossman and Wilson (1985, 1991) suggest that there are three reasons why quantitative and qualitative methods might both be used in a research design:

a) To enable confirmation or corroboration via triangulation;

b) To elaborate or develop analysis by providing richer detail;

c) To initiate new lines of thinking through attention to surprises to provide fresh insight.

Two engineering departments- the Mechanical Engineering Department of the University of Patras and the Mechanical Engineering Department of the Technological Institute of Patras are compared (using both quantitative and qualitative approaches). The first phase, was the comparison of the curriculum of both the departments, collecting data related to lessons, teaching hours, students- teaching ratio, the duration of studies, the number of students who graduate on time etc. The second step of quantitative research was a statistical analysis of the data collection from the first step. At the same time a qualitative approach was applied to 'enrich' the data through a series of personal interviews with the participants.

The most suitable method for this work was the most common research method, the survey. Three prerequisites to the design of any survey are the specification of the exact purpose of the enquiry, the population on which it is to focus and the resources that are available. (Coleman 2002).

a) The primary and central aim of the survey was to develop a holistic approach to Total Quality Management implementation in an Educational Unit and the main objective of the project was to design a model of curricula, based on quality principles, for Greek Engineering Departments.

b) The access to the students and to the teaching staff was traightforward.

c) Due to the fact that the sample was not large, for practical reasons the expenses of the questionnaire formation and the transportation needed for the interviews was not high.

Questionnaire and interviewing are the selected tools that was been used in this work.

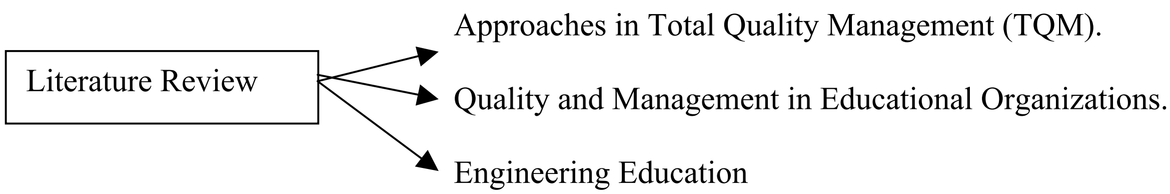
Both of them can serve the follow objectives:

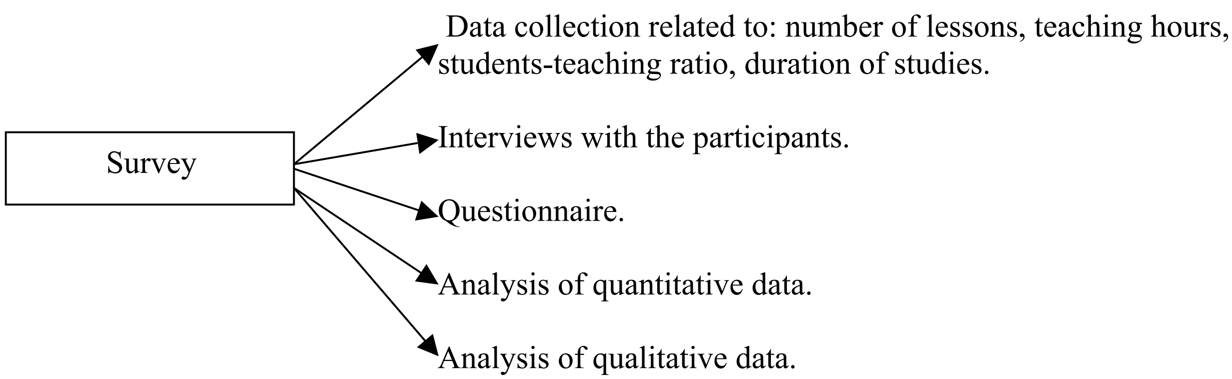
1) They can be used as the main means of collection of information, that has direct relation with the objects of research.

2) They can be used in order to are checked affairs or to indicate new of them.

3) They can be used in combination with other research methods.

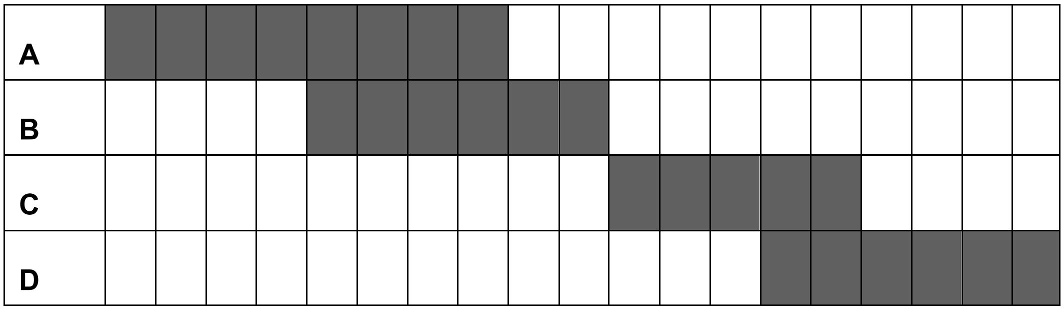
Methodology diagram





As from the above diagram is seemed, my first priority designing my research methods was to explore and analyze the appropriate literature related with the investigated topic. The in-depth study and analysis of this literature research helped to be emerged and be confirmed the research questions of this work. And secondly it was important to me to choose methods of data collection and analysis which will bring to the surface the existing problematic situation. With this criteria in mind, this study is a survey including a combination of qualitative and quantitative methods within an interpretivist research paradigm. I discuss and justify this choice in Chapter 3.

timescale



A. Literature review on following topics: Recently approaches in quality management, Quality and management in Educational Organizations, Engineering Education. Preparation of paper presented at the second Balkan Region Conference on Engineering Education.

(01-10-2005/30-04-2006).

B. Data collection, development of the questionnaire. (15-02-2006/31-06-2007).

C. Interviews. Statistical analysis.(01-09-2007/31-06-2008).

D. Conclusions. Thesis writing. (30-05-2008/30-03-2010).

1.6. Structure of the Dissertation

This MPhil dissertation is structured into five chapters. In this introductory chapter the background information is provided and a rationale for the choice of topic and the research questions is presented. There is also a consideration of the research perspective and a brief summary of the research program.

Chapter Two gives a brief literature review of Engineering Education and quality in Education. Of special interest of this chapter is the impact of culture on Engineering, especially in Greece. From the literature review were emerged and confirmed the research questions related with the existing problems in Greek engineering. Chapter Three describes the problem in detail and gives the results of the primary investigation that led to be answered the research questions and be produced a model of curricula suitable for Greek engineering departments. Chapter Four describes and evaluates the proposed model of curricula for Greek Engineering Departments. Finally, Chapter Five draws some conclusions from the research and makes some recommendations for future work.

1.7 Summary

In this introductive chapter is presented the aim of this work that is the existing problem in Greece relating to Engineering Education in Universities. A brief presentation of the Greek educational system for higher education is shown, where the Universities together with the Greek Technological Institutions (T.E.I) constitute the Tertiary Sector of Education. The existence of two different types of engineers was identified (who claim the same professional rights in the labour market), highlights the great problems of education in both engineering and the Greek society as well.

The intellectual challenges for the choice of topic and the research questions are presented. There is also a brief summary of the research program and methodology followed.

Chapter 2: Literature review

One of the most important task that a researcher faces, starting his research, is to review the literature relevant to the investigated area. Researcher needs to review the literature relating to his field in order to find out what has been published to date in it. This will help him set the parameters for his research by showing what has yet to be researched. It will also give some indication of the research methods that have been used and it may produce further ideas.
(Lofthouse and Whiteside, 1994). Understanding the structure of literature and being able to indentify what information can be found in specific formats is an extremely important skill for α researcher. Information is available in a variety of formats and from a wide range of sources as: Dictionaries, books, journals, statistical tables, internet web. (Coleman 2002).
Literature searching, as a methodological technique, was useful to the author of this study to identify all those items which deal specifically with investigated topic. The study of literature was an excellent source of knowledge on scientific approaches, strategies and methods that researcher can follow and implement in a particular field of research. It was helpful to break the topic down into its different sections, and to search easier through issues of books, journal titles, journal articles and other sources relevant on the research topic.
The first important section relevant on the research topic was the quality in Higher Education. Quality in education is one of the main problems in all kinds and at all levels of educational institutions. Therefore, among the main tasks of the faculty of any university, is the undertaking to improve the quality of their graduates and the efficiency of the academic system. The quality of education is created in every area of the educational system and in every component of its processes. The second section was the Engineering, Greek Engineering and its culture. The acquired knowledge and information from this section of literature review helped to enhance the existing problems in Greek Universities. And the third investigated area is engineering curricula. The literature research in this topic gives the opportunity as this study propose a curricula model for Greek Engineering Departments, that is the main result of this Mphil research.

2.1 Quality in Higher Education

Defining the quality of engineering education is not easy. Based on the Oxford Dictionary quality is a degree, especially a high degree, of goodness or worth. The Webster's Dictionary defines it as a grade of excellence. Various researchers, however, have put forward their own definitions of engineering education quality. For example, Crosby stated that quality has to be defined as conformance to requirements, not as goodness. (Crosby, 1986).

Others also defined it as fitness for purpose, effectiveness in achieving institutional goals, meeting customers, stated or implied needs, and the degree to which education prepares students to be personally effective and capable within the circumstances of their life and work. (Green, 1994, Stephenson, 1992, Harvey, 1992). There is a lot of discussions among the members of the university communities in applying the philosophy of quality techniques in Higher Education Organizations.

The concept of total quality management (TQM) avoids the direct definition of quality; its focal emphasis is client satisfaction and continuous improvement (Hill, and Howarth, 1999). This, however, leads back to the requirement of defining the clients and their needs. Defining quality as fitness for purpose confuses the term quality with adequacy or even salesmanship Further, Guptal and Rae pointed out that such a definition is limited in practice because of the difficulty of measuring results of higher education with any kind of precision (Gupta, and Rae, 1997). They propose that quality in higher education is possible only if the quality of the following factors is maintained: student intake, staff, teaching, assessment, courses, research, and facilities. They did not, however, define the term 'quality' with regard to any of these mentioned aspects.

Since there is so much difficulty in finding a globally acceptable definition of quality in education, one may ask why we need a definition? The need arises because of the desire to communicate that a particular institution provides a higher quality education with the consequence of attracting more students, more funds, more job offers for the graduates, and more recognition. One may suggest that the assurance of quality can be communicated globally by adopting internationally accepted standards such as the ISO standards. The motivation for industry to accept ISO 9000 standards varies widely and includes the desire to obtain marketing advantage, to improve operations, to create quality assurance systems recognised globally, to improve the quality of products or services, and to satisfy the requirements of major customers.

Some universities and colleges followed the path of industry and adopted the ISO 9000 standards and probably more will follow. The reasons include:

- Increased internationalisation.
- Desire to increase the mobility of students.
- Desire to attract industry, solicit more funds from politicians, and impress society at large.
- Lack of convenient peer-review for new institutions in some countries.
- Discomfort with the current accreditation system.

Nevertheless, several concerns surround the process; these include:

- The possibility of confusing the public; accreditation and conformity with ISO 9000 standards are not the same, nor are they mutually exclusive.
- Forcing the customer model on education.
- Destruction of the traditional meaning of higher education through non-academic strict formalism.
- Creation of a burden on the budget and staff.
- ISO standards need interpretation to be used in education.

Higher education discovered total quality management in the 1980s and quickly became enamored of it. Terms like “customers focus”, “employee empowerment”, “continuous assessment” and “Deming’s 14 principles” started appearing in educational journals in all over the world. Deming himself suggested the linkage between quality management principles and education, claiming that “….improvement of education and the management of education, require application of the same principles that must be used for the improvement of any process, manufacturing or service” (Deming, 1994). Deming also, pointed that universities must be committed to learning and to training if they are to survive.

Quality in education is one of the main problems in all kinds and at all levels of educational institutions. Therefore, among the main tasks of the faculty of any university, is the undertaking to improve the quality of their graduates and the efficiency of the academic system. The quality of education is created in every area of the educational system and in every component of its processes. The main areas and the corresponding processes, that contribute to quality are typically as follows:

a) Studying, which is understood as individual, creative learning;

b) Teaching, which is understood as the activities relating to initiating and supporting the studying process;

c) Services, which is understood as supporting students needs in general;

d) Management, which is understood as investigating the needs, setting goals and constructing forms of teaching and curricula, creating conditions for the effective progress of education;

e) Administering, which is understood as to do management procedures, in accordance with the accepted regulations;

f) Environment, which is understood as the sum of material resources supporting educational process.

A fundamental unit of a university which is highly responsible for the basic educational area, is a department. The main objective for a department, within scope of the mentioned areas of creating quality should be in the following way:

a) Studying.

- Improving of students' ability to study;
- Implementation of teaching evaluation by students.

b) Teaching

- perfecting teaching skills;
- implementation of teaching evaluation by teachers.

c) Management

- Investigating educational needs
- Designing new forms of studying.
- Designing and evaluating new curricula
- Controlling the quality program.

d) Service

Investigating of students needs and introducing new services.

e) Administering

- Improving administrative services for students and external clients.

f) Environment

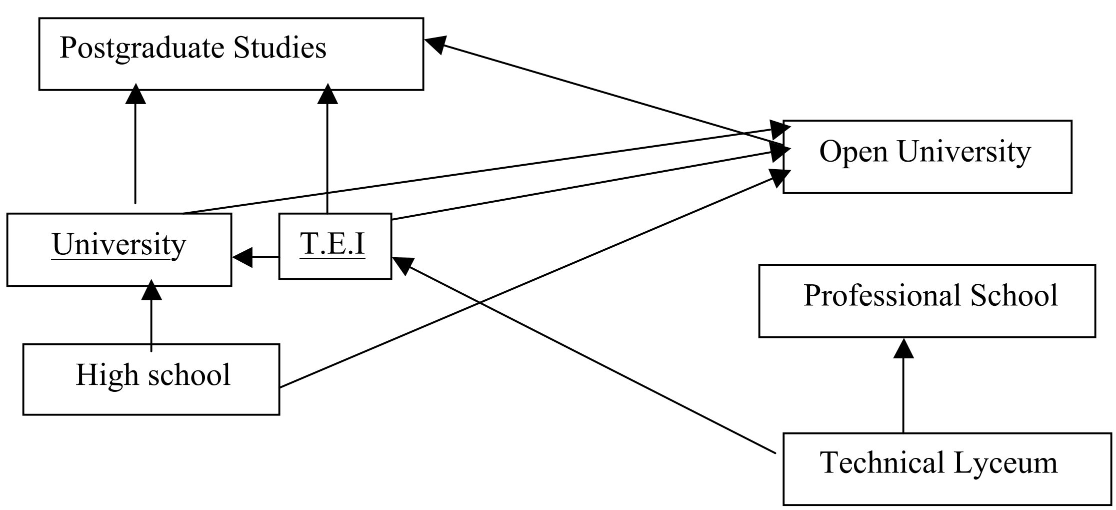
- Modernization of the material educational environment;
- Modernization of the informative environment.

2.2 Higher Education in Greece

2.2a. The major constitutional principles

The University sector in Greece is regulated by article 16 of the Greek Constitution in effect since 1975 and by the Framework Law 1268, passed by the Greek Parliament in 1982. This Framework Law introduced the most significant reforms in Greek Higher Education since 1932 and replaced all previous ones. The Laws which followed did not greatly affect greatly its philosophy and basic principles. However they strengthened the Universities' financial management by making it more flexible and introduced the postgraduate studies. They also provided for the establishment of Research Institutions associated with Universities. The major principles which were reassured by the above mentioned article 16 of the Constitution, were the full autonomy and academic freedom for the Universities. In addition the Constitution provided for the state supervision exercised upon the Universities by the Minister of Education. The need for state control arises mainly from the fact that the Universities are public entities financed entirely by the state. According to the Greek Constitution, University studies are free of charge. This means that students do not pay any fees. The most recent legislation, however, provides for the possibility of fees to be imposed on students studding for a postgraduate degree. As mentioned, the Universities are financed entirely by the state. Especially the state covers directly the needs of the Universities for staff salaries and also provides them with an account of money for investment. In addition Universities can obtain funds either from research projects or from the supply of services to the public or private sectors

Figure 2.1: structure of educational system in Greece.



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After the recent structural reform of 2001, the Greek higher education system consists of two sectors: The university sector, which comprises twenty two (22) Universities (including the Higher School of Fine Arts and the Hellenic Open University), and the technological sector, which comprises fifteen (15) Technological Educational Institutions (TEI). The institutions of the technological sector are considered as being equivalent to the *fachhochschulen* in Germany and the (old) polytechnics in the UK. All higher education institutions in Greece are state run. According to the Greek Constitution, higher education is offered exclusively by the state and, hence, it is prohibited for higher education services to be offered on a private basis.

Three of the above Universities and one of the TEIs were founded during the last three years in the context of the regional development policy followed in higher education by the Greek Government. According to this policy, each Region of the Greek Territory should in general contain a dipole composing of one University and one TEI with complementary functions at the regional level.

There is significant variety with regards to the features of the Greek Universities. There are multi-disciplinary as well as uni-disciplinary or specialised Universities. There are Universities located at one site, but there are also multi-site Universities. There are Universities with huge numbers of active students (e.g. the Aristoteles University of Thessaloniki with 30.000 active students), but there are also very small Universities as well (e.g. the Harokopion University and the Higher School of Fine Arts in Athens with 500 active students each). The technological sector is however much more homogeneous than the university one.

The population of Greece is 10.940.000 habitants. Therefore, the density of Universities in Greece (not including the Hellenic Open University) per one million habitants is about 1,9 and the respective density of the overall higher education institutions is about 3,4. These figures are still somewhat lower than the current EU average.

The total number of active students in Greece is estimated to 360.000 (200.000 in the Universities and 160.000 in the TEIs). The number of students in Greece has almost doubled since 1996, as a result of a policy which combined on the one hand the increase of the number of the new entrants in higher education every academic year until 2001, and on the other hand the establishment of new higher education institutions, mostly on a regional basis, and new Faculties in the already existing institutions. As a result of this policy, Greece has now one of the highest participation ratios in higher education in Europe. Indeed, the percentage of young people in the age cohort between 18 and 21 years registered in higher education institutions in Greece now exceeds 58%, but only 50% of these receive their diploma.

2.2b: **The University Sector**

The existing Framework Law regulating Greek Universities provides four distinct levels of institutional structure. These four levels are as follows: (www.minedu.gov.gr)

Institution;
School;
Department;
Sector.

Departments correspond to a University discipline area and are the principal academic units in each University. They are divided into sectors corresponding to smaller and distinct parts of the major scientific discipline.Departments covering relative disciplines areas constitute a School. The University staff consists of the three following categories:

The teaching staff;
The special administrative and technical staff;
The administrative staff.
The teaching staff consists of the following categories:

The main teaching staff (professor, associate professor, assistant professor, lecturer);
The visiting professors;
The assistant teaching staff;
The special teaching staff (special subjects).

The academic year is divided into two semesters. The courses of the undergraduate study programs are organized on a semester-basis.The responsibility for study programs belongs entirely to the Departments, without any supervision on control either at Institutional or Governmental level.

This responsibility concerns the establishment of course curriculum, credit units and distribution of teaching load among the teaching staff. Studies leading to a first degree in the Greek Universities have minimum duration as follows:

Four years for the majority of disciplines and five years for the:

a. engineering
b. a number of applied disciplines (agriculture, forestry, dentistry)

c. for disciplines of art

Six years for medicine

Access to Higher Education in Greece is through competitive entrance examinations conducted every May by the Central Committee of Entrance Examination. The number of new entrances to be accepted by the Departments of the universities is determined by the Minister of Education and is about 40.000 students every year. The success of candidates and their entrance to the universities departments depends on the grades that they succeed in examinations, the number of places available and their preference.

2.2c: **The Technological Sector**

With Law 1404/1983 stopped to exist the Technological and Professional Schools ceased to exist and were founded the Technological Educational Institutions (T.E.I.) were founded. These institutes were concentrated on the local needs for applied technology. In June 2001 the Law 2916 was passed in application, according to which the status of the T.E.I. was transformed to University status. T.E.I are therefore governed in terms of their organization and their operation by the same constitutional provisions that are also in effect for the Universities. Each Technological Institute comprises of at least two faculties or schools which are further sub-divided into departments. The faculties of the T.E.I focus on applied technology, management and administration, agricultural technology, health care professions, food technology, graphic arts and graphic design. The number of student entrances in the 176 departments is about 43.000 every year. (www.minedu.gov.gr)

2.3. Quality in Greek Universities

Quality assessment in Greek universities is at a very primitive stage and is currently far from systematic. In 1992 the Ministry of Education established for the first time an evaluation procedure for higher education institutions (Self-Evaluation Report of University of Patras, 1999). The responsibility for this evaluation belonged to a national committee, which was never formed and the details concerning the whole evaluation procedure were never determined. Three years later another evaluation mechanism was set up through the National Council of Education which was legislated in June 1995.The review process was completed in 1996 and was received negatively by the unions of students, and by the unions of teachers on all educational levels. Some of the Greek universities have initiated a limited number of quality assessment efforts.

- Two academic departments, one belonging to the Technical University of Athens and the other belonging to the Technological Institute of Patras, participated in the pilot project for quality evaluation in higher education established by the Commission of the European Union during 1994-1995;

- Economic University of Athens and the Technological Institute of Patras participated in the project of the IMHE (Institutional Management in Higher Education) on quality management, quality assessment and the decision-making process. The two higher education institutions prepared and submitted their studies in 1966;

- The Democritus University participated in the institutional evaluation program of CRE during the academic year 1996-97;

- The University of Patras participated in the institutional program of CRE during the academic year 1998-99.

Today, in Greece, it is certain that the conditions are more mature for the activation of processes of evaluation of quality in systematic base. The legislation of National System of Evaluation of quality of Higher Education, today, constitutes an obvious necessity for Greece. This necessity arises from the fact that in all almost the European countries proportional systems of evaluation functioning many years ago. Also, as has been reported, during the last years many educational institutions have participated in processes of evaluation. The Ministry of Education has an intention to advance in legislative regulations corresponding in the above necessities and challenges. The establishment of a National System of Evaluation of Quality in Higher Education, has as its aim the continuous improvement of quality of the work and generally of the operation of universities. The processes of evaluation will cover the total activities of the Universities, that is the educational and inquiring work, the benefit of services and the effectiveness of the administrative mechanism. (www.minedu.gov.gr)

2.4 Engineering in Greece

As stated by Fung,

"Engineering is quite different from science. Scientists try to understand nature. Engineers try to make things that do not exist in nature. Engineers stress invention. To embody an invention the engineer must put his idea in concrete terms, and design something that people can use. That something can be a device, a gadget, a material, a method, a computing program, an innovative experiment, a new solution to a problem, or an improvement on what is existing.

Since a design has to be concrete, it must have its geometry, dimensions, and characteristic numbers. Almost all engineers working on new designs find that they do not have all the needed information. Most often, they are limited by insufficient scientific knowledge. Thus they study mathematics, physics, chemistry, biology and mechanics. Often they have to add to the sciences relevant to their profession. Thus engineering sciences are born." (Mebrahtu. 1984)

Engineering is the design, analysis and/or construction of works for practical purposes. The American Engineer's Council for Professional Development, also known as ECPD, defines Engineering as:

"The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property". (Wikipedia)

Engineering education takes place in the context of training students to practice as professional engineers, whose work involves living with compromise, and optimizing within constraints with rarely one "right" answer. In contrast as an academic discipline engineering education has been identified us using an engineering approach, which is positivist and looks for theoretical answers from "bounded questions". (Becher 1981) Historically, science as an activity for bringing intellectual order into the bewildering variety of events and things in the natural and man-made world had come into existence before the recognition of engineering as a discipline. Science takes a detached investigative attitude to things. Its interest is to gain knowledge through suggesting generalizations. It concentrates on very specific aspects of things, posing problems that generally lead to a unique solution. Engineering is interested in many aspects of things, posing problems that usually seek a number of solutions guided by optimality, performance and other value concepts. It is known that engineering has benefited from science through the adoption of the results of work of scientists. Engineering is concerned with transforming the resources of nature, through the application of the principles of science, in a manner considered optimum, to a form suitable for use in general and ultimately human use.

Engineering studies in Greece were formed at the beginning of the twentieth century based on the German model –that was based on five years worth of studies -due to the political connection between Greece and Germany. After the second World War even though the bonds between the two countries had been loosened, the model of engineering studies remained the same. So the new Technical Universities, followed the German model (based on five years of studies), have independent developed each one different character (theoretical, practical, different programs of study) depending on the local conditions, the international effects but also depending on the origin and the scientific origin of teaching staff. (Self Evaluation Report of University of Parts 1999). The duration of studies (five years) allowed the recognized professional lines. In Greece in order to be member of the professional body of engineers (Technical Chamber of Greece) the students must have followed five years studies.

In 1972 the Greek government supported by the World Bank fund created the Technological Educational Institutes (T.E.I). These institutes were concentrated on the local needs for applied technology. The duration of the studies primarily was two years. In 2002 the status of T.E.I was transformed to University status, that is:

- Duration of studies four years;
- Research orientation (supported by Governmental Organizations);
- The management of T.E.I is more independent.

This process is similar to what took place in the UK, in the transition from Polytechnics to Universities. Six Technical Universities exist in the Greek state, which each year accept about 3 thousands students. After five years studies the Technical Universities grant their graduates a Diploma of Engineer in the follow areas of Engineering: Technology, electrology, computing, civil, environment, chemical, telecommunication, architecture, naval-architecture. Also, as it is reported, in the T.E.I function the corresponding engineering departments. The duration of studies is, in this case, four years and the graduates obtain a degree as Technologists. Although, Universities and T.E.I are subjected to the same constitutional provisions, they have some distinctions. These arise not only from the different T.E.I's constitution or the different mission and orientation but also from more profound academic and professional reasons. The first main distinction has to do with the lower quality standards existing in the selection and appointment of the T.E.I’s teaching staff, which leads to a qualitative differentiation of the main teaching staff between the two Institutions. The second difference has to do with the professional prospects of University graduates and T.E.I graduates. Although, the studies result in the attainment of a degree, which permits professional recognition as engineers, T.E.I graduates are no registered in the Technical Chamber of Greece and they do not have the same professional rights as University graduates. This is because, in order to be a member of the professional body of engineers (Technical Chamber of Greece) in Greece, a five years study program should be followed.

2.5. Engineering Culture

The word culture stems from the Latin "colere", translatable as to build on, to cultivate, to foster. Leibnitz, Voltaire, Hegel, Kant, Freud,….. all have reflected on the meaning of the word in different versions of its use. Since the 18th century, the word culture emerged more in the sense of "products that are worthy". This definition of culture is still vivid and was used to describe Elite and high-culture concepts, particularly in continental Europe. (Dahl: http://stephan.dahl.at/).

The classic definition of culture was provided by the 19th-century English anthropologist Edward Burnett Taylor in the first paragraph of his Primitive Culture (1871): Culture is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society. Another view of culture, focuses of culture as a set of values and attributes of a given group, and the relation of the individual to the culture. Fisher defines culture as: "It is shared behavior, which is important because it systematizes the way people do things, thus avoiding confusion and allowing co-operation so that groups of people can accomplish what no single individual could do alone. And it is behavior imposed by sanctions, rewards and punishments for those who are part of the group" (Fisher 1988). So, we can understand culture as the totality of the following attributes of a given group: shared values, believes and basic assumptions, as well as any behavior arising from those, of a given group. Also, culture is understood, as a collectively held set of attributes, which is dynamic and changing over time. The relationship between individual and the culture in which he lives is a complex set of relationships. The individual determines its culture and in turn the factors relating to the individual are determined by its culture.

Every state has its distinctive culture, which plays an important role in shaping its social, economical and political system. However, there are many outside influences that also play a significant role in shaping the social, economical and political culture of states. There was a time when states used to make policies according to their own cultural trends. These cultural trends altogether include; language, history, race, and religion as well as social, economical and political system of the states. However, the present trend of international relations has changed the traditional concepts of culture and also influenced the prevailing social, economical and political system of various states of the world. Nonetheless, culture also includes the various social, economic and political trends in any society. For instance, the culture of education in the western societies or the developed part of the globe is more or less the same. Similarly the various cultural trends in the developing countries regarding educational development if not in the same but it varies from the least developed country to the developing country according to their level of development. However, all these cultural trends are rooted in the global cultural trends. Education has always been a major influence on the cultural trends of various societies. For instance during the Great World Wars, during the Cold War and the era after the Cold War all countries witnessed different aspects of social and economical cultures that were influenced by the political culture. All these cultural trends play a very important role in educating children. At the same time these cultural trends have played significant and influential roles in the education sector of children and young adults. At the same time, educational development is considered to be the pillar of any developed society. Therefore, education plays a very constructive role in all the departments of the state. Since children are the future of any country, therefore they need to be educated as a priority of any society.

Science, Culture and Engineering Education

Human life is social and there is no science that is not in some way social science, because it develops and happens into a physical and time space; it processes in the world, in the rational and empirical world that is mixed. History has demonstrated facts in which Science has had an important cultural influence because it has been the creating agent of the deepest changes in human thoughts. An example is the contribution of Biological Science in the comprehension of nature and its developing mechanisms, which makes us think about our behaving in relation to the environment, the value and the importance of the existence of the several species to the planet's equilibrium and the preservation of life. The comprehension of this value, the universal aspect of life it is due to the Science, because Science is a process of creation of new concepts elaborated by the observation and quantifying the phenomena - concepts that unify our comprehension of the world.

The relationship between science and engineering is a well discussed topic. Often, engineering is argued by outsiders as distinct from science – even subordinate to science (Layton, 1971). From within the profession, however, engineers see themselves as scientists; as Florman (1987) contends, "In seeking the essence of the engineering view it seems appropriate to begin with the scientific view. All contemporary engineers enter their profession by passing through the portals of science".

As a result of responding to doubts from outside the subject area as to whether engineering is really a science, passion for engineering as a science has become even more meaningful. The entrenchment of engineering as a science has had an important consequence for engineering culture in that it has posited the engineer as en expert. Sociologists of knowledge (see for example Knorr Cetina, 1999) have discussed the close relationship between scientific knowledge and the ability to claim expertise. The globalization of the Economy was possible because of the technological advances based in electronic communications and computing. The development of a network of instant communication comprising the entire planet and the economical integration between countries, regions and continents, commanded by big corporations and international enterprises. What made it all possible was Engineering which developed the Science and the Technology to the level that has been achieved and the changes that have been seen, not only in the achievement of new machines, drugs and materials but also of new values. Across a wide variety of literatures sources, researchers consistently identify similar values and practices that characterize an "engineering culture." Engineers themselves are aware that they belong to a professional culture that sets explicit guidelines for what it means to be an engineer. (Brooks, 1982; Florman, 1987; Hacker, 1981; Kunda, 1992; McIlwee & Robinson, 1992). Research on engineers by social scientists and engineers themselves acknowledges that engineers do believe in a uniform engineering culture.

In a well cited study, McIlwee and Robinson (1992) contend that this engineering culture consists of three main components that are recognized by most engineers:

a) An ideology that stresses the centrality of technology, and of engineers as producers of technology;

b) The acquisition of organizational power as the base of engineering success;

c) A self-centered "macho" belief in the value of engineers.

Numerous studies of engineers in the workplace and in educational settings agree that engineers understand these characteristics to be key features of engineering culture. Setting aside the question of whether this depiction is accurate, the concept or the metaphor of engineering culture is amazingly coherent. Across a wide variety of literatures sources, scholars consistently identify similar values and practices of engineering culture. Regardless of its truth, engineering culture is a pervasive and persistent concept.

Professional engineering associations and engineering scholars have pointed to the importance of group work in the field of engineering and have suggested that engineers are not adequately prepared to work well with others. As Barley (1996) contends, the nature of work is changing dramatically and the most serious barriers to adapting successfully to these changes are likely to be cultural. Moreover, recently engineering scholars have suggested that the culture of engineering may have impeded the collaborative process of a team (Ingram & Parker, 2002). Although engineering culture is said to give preference to individuality and lack of communication, every major professional engineering association now says that engineers must learn how to work effectively with one another, and from all corners the call is being made to engineering schools to teach students how to interact in teams. Additionally, the literature on engineering management says that whether engineers like it or not, the need for group work and team based assignments will continue to grow more common in the workplace (Carlson, 2001; Hilburn & Humphrey, 2002; Lovgren & Racer, 2000; Workman, 1995). In organizations that employ engineers, teamwork is on the rise because of its ability to help spark innovative ideas and allow participants to produce higher quality projects (Ancona & Caldwell, 1992; Jassawalla & Sashittal, 1999; LaFasto & Larson, 2001 Humphrey, 2002; Lovgren & Racer, 2000; Workman, 1995).

Engineering Culture as Organizational Culture

Just as countries and organizations have their own culture, so too do occupational communities (Van Maanen & Barley, 1984). Although engineers often have varied orientations and work with distinct technical and analytical tools, scholars have argued about the importance that "engineering culture" plays in the formation and maintenance of engineering practices and values (Hacker, 1981; Kunda, 1992; McIlwee & Robinson, 1992; Sharp, Robinson, & Woodman, 2000). The idea of engineering culture is important because most engineers orient their identities and careers to their occupation rather than to their organizational communities (Whalley & Barley, 1997). As a community of practitioners, engineers activate a repetitive series of interlocked behaviours and, in so doing, form a collective structure. Occupational communities, such as engineering, represent bounded work cultures populated by people who share similar identities and values that transcend specific "organizational" settings (Van Maanen & Barley, 1984). From their first days in an engineering school, engineers are indoctrinated with the values and beliefs of the engineering community. They are taught how to work and think as an engineer (Bucciarelli & Kuhn, 1997). As they move into the world of professional practice their identity as engineers is continually shaped by the culture of the occupation.

Culture of Greek education system

At a national level, the Greek educational system has presented the following characteristics:

a) a lack of a national strategic plan, only good intentions;

b) a lack of continuity in the education programs and strategies;

c) focus on political interests;

d) a contradiction between the plans and the actions developed;

e) teachers have the central role in the education process at school;

f) Greek intellectuals, politicians and technocrats play a protagonist role.

In the traditional educational model the teachers' exposition is the main didactic technique. Teachers answer students' questions encourage students' participation by questioning them and by giving them some assignments and projects to be developed inside or outside the classroom and individually or as a team. The students concentrate on note-taking, reflect on what the teacher says, participate in group discussions and ask the teacher to clarify the concepts that they do not understand. This traditional education system has been effective for many professors through the years, and has responded to society's requirements at that given time. Additionally, the traditional education model is not explicitly stated; therefore the abilities, values and attitudes to be developed by the students are not planned in advance. Thus, students might or might not develop their optimal capabilities. In this situation it is not common for the teacher to clarify the methods for measuring the development of the students' values, abilities and attitudes. In this education model the professor takes the central role in the learning process. He or she decides what should be learned by the students and the way in which it will be assessed. Throughout history, Greek teachers have played a central function in the education process without giving the students their place in the learning process. It is important to underline that this scheme of education still exists in many private and public schools in Greece.

2.6. Engineering curricula- demands for change

As the world becomes a more competitive place there is a pressing need for organizations to be more creative with the ability to generate new products and processes to survive and prosper. The global economy has created new perspectives for organizations: a greater number of rivals but also a greater potential market. This requires the development of more abilities from organizations' staff. The new management philosophy, which is centered on the process and the growth of knowledge, requires the engineers to have not only scientific and technological knowledge but also public relations abilities. So, the increased level of globalization of engineering education has placed academic institutions in a new and challenging situation. To prepare engineers for a global arena, it is not sufficient to educate students in basic sciences, engineering and technology. Therefore, an important aim which should be taken into account in modern engineering education curricula, is to create an engineering graduate with the most appropriate professional profile. It may be said that curricula act as an interface between external demands and the internal process in a particular place of learning. A well-designed curricula must take social demands into account, not only those of the present but those of the future.

The engineering profession is still grappling with the basic definition of an engineer and has failed to change the community's perception of what the role and social responsibilities should be. Considerable debate has been going on in various countries, concerning the formation of future engineers for a global arena. The European approach seems to suggest the creation of a European citizen who should demonstrate the so-called "three cultures" which would encompass the mathematical, scientific and technological culture, the humanities and the economic and social issues. This approach is oriented towards developing qualities in the context the regional needs.

Increased knowledge, new technologies, and expanding regulatory standards affirm the need to significantly restructure the traditional engineering curriculum. It is simply impossible to "add" new courses and requirement with the advent of each new development. Schools are faced with the need to establish a system for continuously updating the curriculum, re-assessing the 'basics' versus the 'specialty' subjects, updating applications and case studies, updating their own technologies, and ensuring opportunities for the professoriate to maintain currency in their expertise. Globalization brings a whole new set of variables. Engineering students will enter an employment world which is characterized by multi-national standards and applications as well as increasing numbers of international regulatory requirements. Like other professions, engineers now find themselves having to apply their trade in a multifaceted environment with increased responsibility. There is growing pressure from employers to improve students interpersonal and communication skills, increase their knowledge of related fields and integrated applications, and to significantly increase their 'creative' abilities. Normally, these would all require additional courses and time spent on such tasks, but now schools are faced with 'integrating' these new requirements into a traditional curriculum. The challenge is how to design an engineering curriculum that is flexible, resilient, and responsive while maintaining the quality of education which has been the hallmark of the university.

The pressure of global markets and increased competition suggest that engineering education must and will be transformed. It is inappropriate, inefficient, and impractical to leave this change solely to the markets or to governments. The challenge for universities is to confront this changing world with the honesty and intellectual integrity that have long been their hallmark, even if this process reveals the inescapable need for far reaching institutional transformation. Finally, every nation which strives to maintain pace with the pressures of global impacts must ultimately focus on the effectiveness of its primary and secondary education system. High levels of mathematics and science achievement must be our goal for 'each and every' child. This will ultimately determine the success of our engineering schools, our universities, and indeed, our economic security in a global market. The "Global economy" has brought about the issue of the internationalization of education, and has proposed the task for engineering education to fit in with globalization well. The important change is that concepts of engineering (and engineers) has been greatly changed. Engineering is turning to huge projects, and coordinated and multinational engineering projects are coming into being in this new century.

Engineers have now got themselves away from the narrow division of labour of technical engineers, research and development engineers, designing engineers, management engineers, etc. Now, the emphasis is placed on comprehensive qualities in an all-round way for engineers on the basis of labour division, and new requirements have been proposed. Among these changes, the most important is the change in the educational ideology which is brought about under the global economy. Therefore, the above-mentioned changes should be taken into consideration for the assessment of engineers' qualifications, and related engineering education. So, the development of engineering curricula, should be based on techniques that must determine the tasks, skills and attitudes needed. In other words, designing a curricula that is demonstrated as "learning outcomes" must be taken into account. Learning outcomes are the knowledge, skills and competences achieved by the learner through the learning process. Adopting a learning outcomes approach developing curricula, valuing what a learner knows, is an active way to promote learning and teaching. For employers, outcome-oriented curricula can offer a valuable platform for bridging the worlds of education, training and work, providing a common language between competences acquired in learning and the needs of occupations and the labour market. For teachers a curricula built on knowledge skills and competences that learners can acquire, gives them the opportunity to design learning programmes with more flexibility applying new teaching methods (work-based learning, problem-based, action learning) and valuate them effectively. And for learners an outcome based curricula is a user-friendly approach giving them more opportunities for active learning and training. It is easer to them to know what they have to learn and for what end. (European Centre for the Development of Vocational Training**:** http://www.cedefop.europa.eu/EN/). Therefore an examination of the existing system is the first step on which the development of engineering curricula should be based.

Globalization of Engineering Education –Engineering education in Europe – The Bologna Declaration

The world has become a "global village" where trade, design, quality and other factors no longer recognize boundaries and cross-cultural barriers have been broken down. The world community provides more scope for peace, international trade and development. There are more opportunities for young engineering graduates in the global arena. Large international companies recruit foreign engineers to assist in development projects in their own countries. Many engineers themselves now seek employment abroad. This requires not only traditional engineering skills but also the appropriate language skills, the understanding of cultural differences and the knowledge of specific national and international standards of practice and business practices. Recent political changes and the opening of international markets have made it possible to establish closer economic, industrial and business relationships between individual countries.

The increased level of globalization of engineering education has placed academic institutions in a new and challenging situation. To prepare engineers for the global arena, educate students in basic sciences, engineering and technology. The process of putting in place a system of education to produce engineers in Europe, was first established in the French Ecoles Politechniques and the Ecole Centrale des Arts et Manufacture, following the French

Revolution over two hundred years ago. The process included competitive entry by examination, a strong foundation in science and mathematics, mastery of the engineering sciences, the art and practice of current technologies and finally their application to engineering design. New institutions were created and developed in engineering education and gradually departments of engineering were established in many European universities. In Greece the first engineering school was established in Athens in 1836.

The continental European model of engineering Education that evolved from the French schools was used in France, Germany, Greece and many other countries. It is a process traditionally influenced by research activity. The engineer should be exposed to scientific ideas and have the skills necessary to carry out research. Thus in this model the students spent sometimes 7 or 8 years studying for this engineering degree. Strong links developed between these technical universities and industry, which used research results from these universities. At the beginning of the 1970's in Germany, Netherlands and some other counties "short-cycle" engineering diploma programs were developed in institutions such as *Fachhochschulen* in order to respond to the needs of industry. These engineering diploma programs of 3 or 4 years duration, have an "applied" profile, focusing more on the immediate requirements of industry by placing a heavy emphasis on the study of technology. It is widely agreed that industry has a very large requirement for engineering technicians, "practical" engineers and "theoretical" engineers. In many countries industry employs a greater number of "practical" engineers than "theoretical" engineers. (Agogino 1992).

Program providers in engineering education are struggling to respond to these demands. The most concrete demands stem from the Bologna Process, which started with 6 "lines of action" as stated in the Bologna Declaration of 1999, signed by Ministers of Education and Science of 26 European countries. Four other measures or "lines of action" have been discussed and added during the Bologna- follow- up Conferences at Prague (2001) and Berlin (2003) and signed by 45 countries. The Conference at Bergen, Norway, in May 2005 confirmed the general aim to create a European Higher Education Area by 2010, increased the number of signatory countries to 45 and concentrated on the implementation of the Bologna system of three consecutive cycles and on issues of quality assurance including the decision on an European Higher Education Qualifications Framework and guidelines for internal and external quality assurance.

The 10 “lines of action” agreed on by the conferences of Ministers responsible for Higher Education at Bologna, Prague and Berlin are:

1. Adoption of a system of easily readable and comparable degrees;
2. Adoption of a system essentially based on two main cycles;
3. Establishment of a system of credits, favorably the European Credit Transfer System (ECTS);
4. Promotion of mobility;
5. Promotion of European cooperation in quality assurance;
6. Promotion of a European dimension in Higher Education;
7. Inclusion and development of Lifelong Learning;
8. Involvement of the Higher Education Institutes and the students;
9. Promotion of the attractiveness of the European Higher Education Area. (EHEA);
10. Linking the EHEA to the European Research Area (ERA);

(European Journal of Engineering Education: December 2005, Vol.30).

Greece joined the Bologna Process from the very beginning in 1999. During the last years the government tried to implement the Bologna Declaration through massive reforms. But this action led the reactions from almost all the academic community. So the reforms are blocked.

Greek educational community is opposed to the Bologna Process no in the totality of it, but mainly in two but important points. The first is the reduction of time study, because is considered that reduces the basic theoretical background of graduates and leads to the obsolescence of the degrees. And the second has to do with the change of the Constitutional article that prohibits the existence of private Universities in Greece. As government to overcome all the obstacles to full implement the Bologna Declaration must impose fees, that is in contrast with common sense of Greek society, which considers that education is a public commodity.

The accepted points are: [(http:/www.eurydice.org). Focus on Higher Education in Europe 2010. The impact of the Bologna Process].

Credit Transfer System: is fully implemented. All programs are linked with ECTS.

Mobility policy: Greek students and teaching staff have accepted it and they participate to the mobility through programs as ERASMUS, TEMPUS and they realize different projects in collaboration with other Universities of the European Union.

Life Long Learning: is a recognized mission from all Institutions and has been established by law in 2005. Hellenic Open University serves this purpose having a large number of candidates. Furthermore each Educational Unit may establish a lifelong learning institute which offers learning opportunities to graduates.

Quality Assurance Agency: a National system has been established by law in 2005. The majority of the Universities participate to this process of evaluation.

Quality Assurance Agency of the European Association for Quality Assurance: this is improvement oriented by government but this one of the points on which Academy community has contradictions related with independence of these Agencies.

2.7. Greek Engineering curricula -University and Technological sectors

The curriculum of each department is determined by presidential decree issued on the proposal of the Ministry of Education and Religious, on the proposal of the department, which is based on a decision of the general meeting of the department. The curriculum and the content of the courses is reviewed every three student years. There is a possibility by law that the curriculum be reviewed within one academic year if necessary. But in practice, although many attempts to revise the programs of both two departments are made, the relevant proposals are not produced.
The curriculum of Mechanical Engineering Department of the University of Patras has the following objectives:

a) The high level of modern scientific training, emphasising on basic knowledge of science of Mechanical Engineering and while offering the ability to adapt and assimilate the constantly evolving technology;

b) The development of capacity for analysis and synthesis that allow the creative use of scientific knowledge and modern technology, on understanding and solving problems of industrial action;

c) The promotion of innovation for the design and development of new products and services;

d) To promote and support initiatives, but also the ability of students to participate and work in teams working in Greece and abroad;

e) The systematic laboratory education and practical training of students to link sufficiently the theoretical training with applications and learn about the environment in which they move professionally.

The system of organisation of the curriculum of TEI is based on specific needs and specificities of TEI, which has a clear Technology orientation. The purpose of the program is:

a) The sufficient theoretical training of students;

b) The acquisition of practical spirit and experience;

c) The consolidation of methodology for the immediate and pragmatic solutions for the problems.

The two departments are among the first Greek higher education institutions to have accepted the challenge and implemented the system of transferring credits (ECTS), in collaboration with other educational institutions of the European Union. The mobility of both teaching staff and students significantly affected the educational progress of departments. The contact of the teaching staff with colleagues from the European Universities resulted in the creation of scientific and friendly relations with a view to joint action. Through the programs ERASMUS, COMMET, and TEMPUS students were put in touch with students from European universities working on joint projects. In the Mechanical Engineering Department of TEI, appeared for the first time the concept of quality associated with both the curriculum and the assessment of learning students. As a result, the evaluation of students not only based on written and oral examinations, but also on projects, which in many cases are the main agent of evaluation.

2.8 **Summary**

As the research questions of this work encompass the fields of quality in higher Education, Engineering culture and Engineering curricula, requiring the study to be informed by a wide ranging research literature, in this chapter an in depth study and analysis of this literature is described. This led to a confirmation of the research questions which have to do with the existing problems in Greek Engineering Education.

In the first section of the chapter is justified that Quality in education is one of the main problems in all kinds and at all levels of educational institutions. So, the main tasks of the faculty of any university, is the undertaking to improve the quality of their graduates and the efficiency of the academic system. The quality of education is created in every area of the educational system and in every component of its processes.

In the second section is reviewed the literature relating the engineering education and its culture. Is reported the assumption that engineering education has a recognisable culture that influences it as a professional academic discipline.

In the last section of the chapter is reported the demands for change in engineering education, regarding the engineering curricula in a 'modern society' determining this term. The globalization, the new forms of work, the pressure of global markets and the increased competition suggest that engineering education must and will be transformed. So, the development of engineering curricula should be based on techniques that must determine the tasks, skills and attitudes needed, as the future engineers be able to meet all the above challenges.

The findings and the acquired knowledge from this section helped to enhance the existing problem in Greek Universities and gave the opportunity as this work produce the proposed curricula for Greek Engineering Departments described in chapter four.

Chapter 3: Methodology and Analysis

In this chapter the methods used for the collection and analysis of the data are outlined. As described in Chapter 1, one of the main purposes of this study was to develop an approximate model of comparison between the curricula of two Greek Engineering Departments. The chapter begins by outlining the arguments that underpin an approach combining qualitative and quantitative data collection. The various techniques and instruments used in this study are also identified.

3.1 Research Approach

The author's understanding of knowledge and its acquisition as well as an understanding of the world have led to an adoption of a theoretical framework which fits within an interpretive constructivist epistemological belief system. Constructivist epistemology is an epistemological perspective in philosophy about the nature of scientific knowledge held by many philosophers of science. Constructivists maintain that scientific knowledge is constructed by scientists and not discovered from the world through strict scientific methods. Opposition of positivism to states that scientific knowledge comes from positive affirmation of theories through strict scientific methods: in other words, quantitative research. Constructivism believes that there is no single valid methodology and there are other methodologies for social science known as qualitative research.

Constructivism proposes new definitions for knowledge and truth that forms a new paradigm, based on inter-subjectivity instead of the classical objectivity and viability instead of truth. For Hein, constructivism, although it appears radical on an everyday level, is a position which has been frequently adopted ever since people began to ponder epistemology (Wikipedia). According to Hein, if we align ourselves with constructivist theory, which means we are willing to follow in the footsteps of Dewey, Piaget and Vygotsky, among others, then we have to run counter to Platonic views of epistemology. We have to recognize that knowledge is not 'out there,' independent of the knower, but knowledge is what we construct for ourselves as we learn. Besides, we have to concede that learning is not tantamount to understanding the "true" nature of things, nor is it (as Plato suggested) akin to remembering perfect ideas, 'but rather a personal and social construction of meaning out of the bewildering array of sensations which have no order or structure besides the explanations…which we fabricate for them'. (Patton M 1990).

This study is therefore a survey. Although, the most common method of data collection in a survey is the questionnaire, conceptual framework for mixed method inquiries has been developed, for the collection and analysis of the data. The purpose of choosing a combination of methods for the study was to use the results of the quantitative method in the design of the qualitative investigation. It was intended that the qualitative data could then be used to validate the quantitative findings and provide a more comprehensive description of the phenomenon under investigation. This was a developmental approach, according to Greene, Caracelli and Graham (1989). Such an approach requires both methods to be used so as to examine overlapping phenomena or different aspects of the same phenomenon. Furthermore, when interpretative qualitative elements are combined with quantitative content analysis, findings are of high conceptual validity and generalizability. Rossman and Wilson (1985, 1991) suggest that there are three reasons why quantitative and qualitative methods might both be used in a research design;

a) To enable confirmation or corroboration via triangulation;
b) To elaborate or develop analysis by providing richer detail;
c) To initiate new lines of thinking through attention to surprises to provide fresh insight.

There are several considerations to be made when deciding to adopt a qualitative research methodology. Strauss and Corbin (1990) claim that qualitative methods can be used to better understand any phenomenon about which little is yet known. They can also be used to gain new perspectives on things about which much is already known, or to gain more in-depth information that may be difficult to convey quantitatively. Thus, qualitative methods are appropriate in situations where one needs to first identify the variables that might later be tested quantitatively, or where the researcher has determined that quantitative measures cannot adequately describe or interpret a situation.

One of the main purposes of this research was the creation of an approximate model of comparison between the curricula of two Greek Engineering Departments. The chosen departments were the Mechanical Engineering Department of the University of Patras and the Mechanical Engineering Department of the Technological Institute of Patras.

This model was to be derived empirically from data collected across the departments as well as from practical and theoretical bases from the literature. The most suitable method for this work was the most common research method, which is (as has mentioned) the survey. Three prerequisites for the design of any survey are the specification of the exact purpose of the enquiry, the population on which it is to focus and the resources that are available. (Coleman 2002).

- The primary central aim of my survey was to develop a holistic approach to Total Quality Management implementation in an Educational Unit and the main objective of the project was to design a model of curricula, based on quality's principles, for Greek Engineering Departments;
- The access to the students and to the teaching staff was almost easy;
- Due to the fact that the sample was not large, the expenses for the questionnaire's formation and for the transportation needed for interviews was not high.

Appropriate and relevant electronic databases were searched applying the following key words in various combinations: Quality in Higher Education, Engineering Education, Engineering curricula, Changes in Higher Education, The impact of culture in Higher Education. (this literature is described in Chapter 2 'Literature Review').

The nature of the study and the combination of qualitative and quantitative approaches necessitated an investigation being conducted in two phases. The first phase of the investigation intended to produce quantitative data, which could be utilized in validating of the existing problem in investigated area. The first set of data was collected from documents across the two departments. Then a questionnaire, as a quantitative instrument, for students and teaching staff was developed. The second phase of the investigation intended to gather data through an interview program. This was to be designed around the objectives of the study which could not be addressed by quantitative methods.

3.2 Main study Procedure

3.2.1 Data collection and Analysis

In this paragraph are presented and analyzed the data collected from documents across the two Greek Engineering departments. The data collected are related to the structure of the two departments, the number and content of courses taught, and the teaching hours.

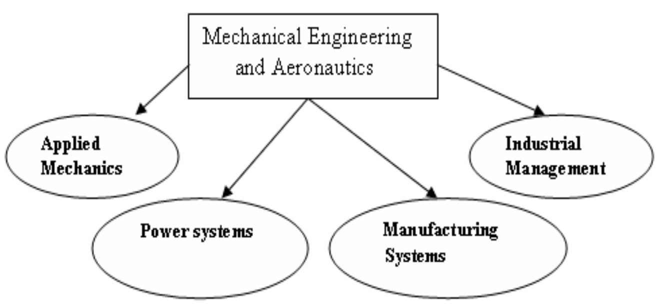
Mechanical Engineering Department of the University of Patras

According to the Greek Constitution the University sector in Greece has as mission the follow principles:

a) To produce and transmit the knowledge through teaching and research;
b) To formulate people who have scientific, social, cultural and political conscience;
c) To contribute in solving major regional, social, national and even international problems.

The Mechanical Engineering and Aeronautics Department of the University of Patras was founded in 1972 based on five years worth of studies which still remain in valid. In the Mechanical Engineering Department of the University also includes the Aeronautical Engineering School. It is the only such department in Greece, so the survey has focused exclusively on the Mechanical Engineering sector.

Figure 3.1: The sectors of Mechanical Engineering Department of the University of Patras.



The duration of the courses, as has been reported, is five years and organized in 58 obligatory subjects. 28 out of 58 are pure theoretical and 30 of them are theoretical and practical as well. (Figure 3.2).

In the first four semester the students from all sectors attend 26 obligatory basic infrastructure lessons. In the 5^{th}, 6^{th} and 7^{th} semester they attend 18 specific infrastructure lessons. In the 7^{th} semester the students are obliged to produce a project with 30 ECTS.

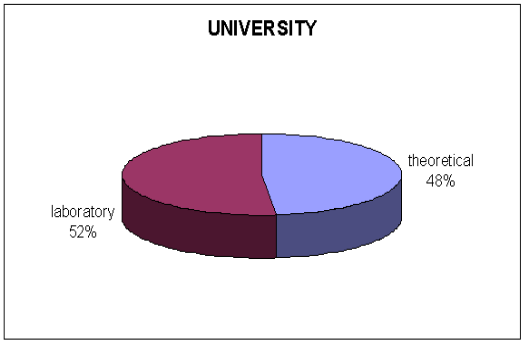


Figure 3.2: Theoretical and practical subjects in University

In the 8th, 9th and 10th semesters each student chooses 14 subjects out of a package of 86 specialized subjects for each individual sector.

The next table shows the lessons and the teaching hours in total.

Table 3.1: Number of lessons and teaching hours.

	theoretical	laboratory	theoretical and practical	teaching hours	ECTS
Basic infrastucture	**10**	**0**	**13**	**112***	**108**
Humanities	**3**			**9**	**9**
Specific infrastucture	**8**	**0**	**10**	**80****	**66**
Specialized lessons	**14**	**0**	**0**	**33**	**33**

* Theory: 89 hours

Laboratory: 23 hours

** Theory: 65 hours

Laboratory: 15 hours

Mechanical Engineering of T.E.I

According to the Greek Constitution the Technological sector in Greece has as mission the following:

a) To give sufficient theoretical and practical knowledge with mostly vocational and applied orientation;

b) To formulate responsible people, who are able as technicians to offer their knowledge in social, cultural and economic life of the state.

In 1972 founded the Technological Educational Institute of Patras was founded that included the Mechanical engineering department based of two years studies. Later on it offered three years worth of studies and in 1983 three years worth of studies plus six months of industrial placement. In 2002 the status of TEI was promoted to that of the highest tertiary level, therefore the duration of the courses were increased from three to four years. The program of studies is determined by Presidential decree following the recommendation of the Ministry Education and Religion based on proposals submitted by the responsible committee.

The students of TEI follow a total of 40 obligatory subjects for their degree. From these subjects 9 are theoretical, 2 laboratory and 29 are theoretical and practical. Figure 4 : lessons of T.E.I This figure saws that the 72% of total lessons is the theoretical and practical lessons, the 23% is the theoretical and the 5% is only laboratory lessons.

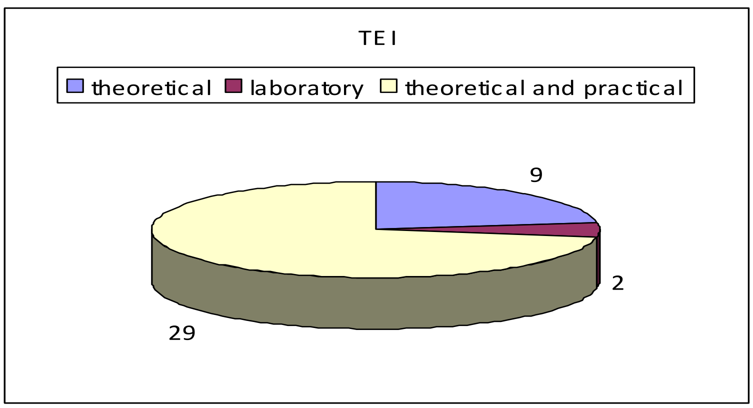


Figure 3.3: The lessons of T.E.I

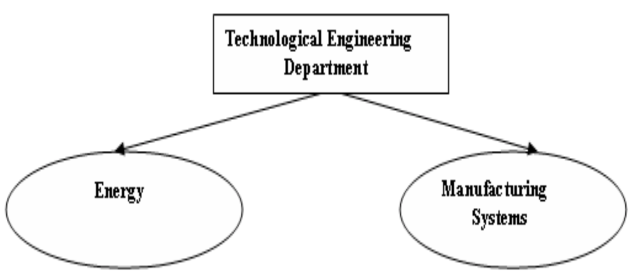


Figure 3.4: The sectors of Technological Engineering Department.

In the first four semesters the students attend 22 obligatory lessons common to both sectors. (Table 3.2). In the 5th, 6th and 7th semesters the students attend 9 obligatory lessons common to both sectors and 9 obligatory lessons per sector. From the 1st until 7th semester the students of the Technological Institution have 24-27 teaching hours per week. In the 8th semester there are no teaching hours. In this semester the students are solely occupied with their dissertation and their practical work.

Table 3.2: The total number of lessons in the first four semesters-T.E.I.

	theoretical	laboratory	theoretical and practical
Basic infrastructure	**3**	**1**	**5**
Specific infrastructure	**1**	**0**	**8**
Specialization	**0**	**1**	**2**
Humanities	**1**	**0**	**0**

The T.E.I students are obliged to produce a dissertation on a subject that is related to the real problems of production and services. This is done by using the equipment and space provided and with financial support. The dissertation can also be realized through different organizations, services or private corporations. On completion of the dissertation it is presented to a committee of three members from the department. The procedure of preparing the dissertation can begin during the 5th or 6th semester. The 8th semester is set aside for practical work in production (at home or abroad).

The following table is a comprehensive table that shows the existing differences in the both Mechanical Engineering departments. It can be observed the differences on the sectors of the departments, on the number of the teaching staff and students and on the number of the obliged subjects. It can also be observed the difference on the number of subjects with different structure (theoretical, laboratory, basic Infrastructure, specific Infrastructure, specialization).

	UNIVERSITY	TEI
Title of studies	Degree of Mechanical and Aeronautical Engineering	Degree of Technological Mechanical Engineering
Sectors of Department	4	2
Duration of studies	5 years	4 years
Teaching staff	45	18
Support staff	24	9
Student number	800 (160/ year)	800 (200/ year)
Obligatory lessons	58	40
• theoretical	28	9
• laboratory	-	2
• theoretical and practical	30	29
basic Infrastructure	26	9
specific Infrastructure	14	13
specialization	14	14
humanities	4	4
prerequisite lessons	NO	YES
project	YES	-
dissertation	YES	YES
Practical work	*	YES

*optional when funds are available.

Table 3.3: Comprehensive table for the two Engineering Departments.

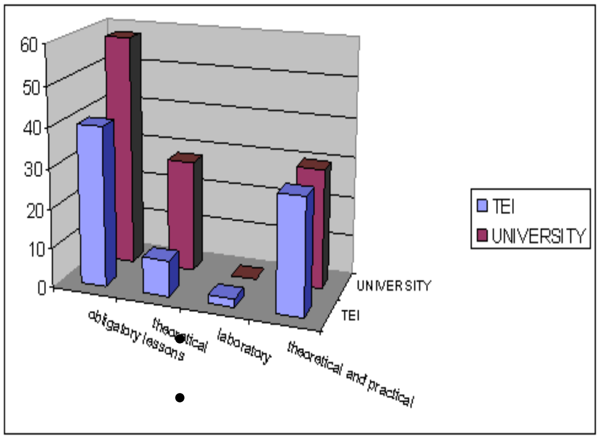


Figure 3.5: The existing differences of the structure of the lessons.

- The number of the subjects offered by the Mechanical Engineering Department of the University is higher than from the respective T.E.I. It concerns the basic infrastructure subjects that are taught in the early years studies. This constitutes a significant diversification between the two departments. In contrast the number of the specialized lessons is almost the same.

Four subjects have been selected (2 basic infrastructure, 1 special infrastructure and 1 specialization) and have been compared in sectors of: teaching hours, content and level of scientific documentation. The results are seen as follow.

1. MATHEMATICS : lesson of general infrastructure in both two departments. The students of the Technological Institution attend 2 semesters totaling 165 teaching hours, in contrast with the students of the University who attend 4 semesters totaling 234 teaching hours. It seems from one point of view, that the student of the University works more intensive than the student of the Technological Institution. Studying the content of subject we see that in Mechanical Engineering Department of the University there is an extensive and in depth study of Mathematical concepts.

Table 3.4: Differences of teaching hours on Mathematics.

T.E.I	UNIVERSITY
2 semesters x 15 weeks x 5.5 hours = 165 hours	4 semesters x 13 weeks x 4,5 hours = 234 hours

Difference : a = 23,33% a : (U – T / U) X100

2. PHYSICS : lesson of general infrastructure. The students of the T.E.I. have to attend 1 semester totaling of 75 teaching hours, whilst the students of the University attend 1 semester totaling 78 teaching hours.

Table 3.5: Differences of teaching hours on Physics.

T.E.I	UNIVERSITY
1 semesters x 15 weeks x 5 hours =75 hours	1 semesters x 13 weeks x 6 hours =78 hours

Difference : a= 0,77%

3. FLUID MECHANICS : lesson of special infrastructure.

Table 3.6: Differences of teaching hours on Fluid Mechanics.

T.E.I	UNIVERSITY
2 semesters x15 weeks x 5 hours =150 hours	2 semesters x13 weeks x 6 hours = 156 hours

Difference : a = 1,55 %

4. WIND and STEAM TURBINES : lesson of specialization.

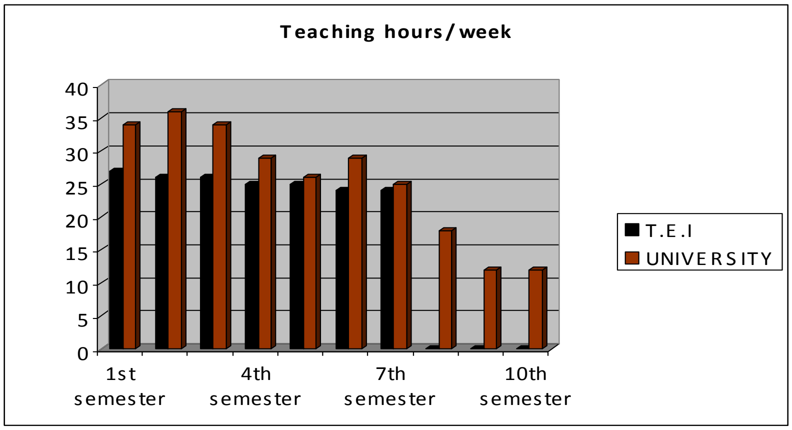
Table 3.7: Differences of teaching hours on Wind and Steam Turbines.

T.E.I	UNIVERSITY
1 semester x15 weeks x 5 hours =75 hours	1 semester x13 weeks x 6 hours = 78 hours

Difference : a: 0,77%

The follow Figure 3.6 shows the existing difference about teaching hours in both departments.

Figure 3.6: teaching hours per week in the both departments.



- The teaching hours per week (Figure 3.6) are in total more in the University than the T.E.I. At first sight it appears that the students from the University work more than their counterparts from the T.E.I. This is not necessarily true because there is a difference of perception in the structure of the courses. This arises from the Greek Legislation which defines the purpose of each Educational Institution.

- The number of the laboratory subjects at the University is low in comparison with the total number of subjects (52%), whilst that of T.E.I. is higher (77.5%). (Figure 3.8). In contrast, the number of theoretical subjects at the University comprises the 48% of total subjects and that of T.E.I is a very low percentage (22,5%) in comparison with the total subjects. (Figure 3.7).

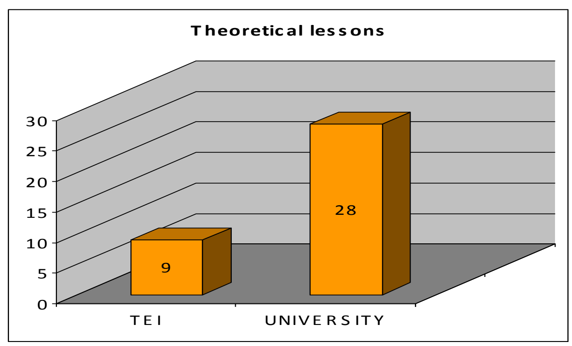


Figure 3.7: Theoretical lessons

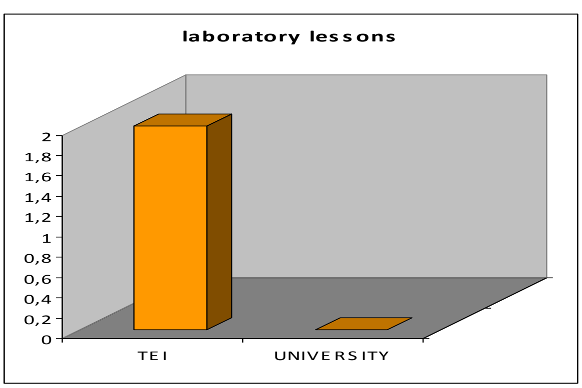


Figure 3.8: Laboratory lessons

The orientation of the subjects of both institutions is mainly analytical. To some extent this is positive, because the students obtain a solid sustainable background. However, this acts against the development of composite skills of the students. This is demonstrated by the absence of projects, especially in the early years, where all the subjects have an absolutely analytically direction. Although, the coursework project, that has been legislatively instituted in the University and the dissertation in T.E.I., requires a composite project, it is not certain that the appropriate direction is realized.

- In the department of T.E.I. practical work is integral to the course. In the respective department of the University, this does not exist. It does, however, exist with support of the European Union. There have been programs where students were employed by industry.

3.2.2 Interviewing teaching staff and students

a. Interviewing teaching staff

Teachers of Mathematics, Physics, Fluid-Mechanics and Wind and Steam turbines of both departments were interviewed. They answered the questions with regard to: the necessity of the teaching material and the respective teaching hours, the scientific documentation and the combination with the lessons of specialization, the degree of participation of the students and the need for curriculum change. The first communication with teachers was by telephone, where it was established that the purpose of the interview was important. The response was positive and the time of the meeting was fixed. The meetings were in the teachers' offices and the duration of the meetings was from 30 to 45 minutes each. The interviews, as reported, were semi-structured interviews, which allowed the extension of the debate into matters other than those mentioned above.

A summary of the opinions of teachers on the issues surveyed follows:

Mathematician (University): "The level of teaching material is high and has to remain so. Is unacceptable an engineer who has not the necessary theoretical background. The teaching hours fulfill the demands to provide the students with the knowledge which will form a fundamental basis for specialization subjects and is vital for further scientific and professional progress. The degree of attendance is satisfactory. I don't believe that we need any change with regard to mathematics.

Mathematician (T.E.I.): " Whilst the subject matter of mathematics is not dealt with in depth, the required knowledge is obtained so as to cover the requirements of the corresponding subjects. The teaching hours are ample for this purpose. The attendance and the interest of the students are moderate".

Fluid Mechanics (University): "… the engineers must have a high theoretical background of knowledge, so the level of teaching matter is corresponded on this direction. However, the existing teaching hours are many and so a big charge of work has to be faced the students. At my opinion, it should exist reduction of teaching hours, incorporating the matter, without exists change in the high level of teaching. In the begin of the semester the attendance and the interest of the students are in high level (70-80%) but this percentage is decreased in 40-50% in the end of the semester".

Fluid Mechanics (T.E.I.): "The material is taught in depth and at a high scientific level. However, owing to the fact that the students lack a satisfactory level of mathematical background, problems are created in the attainment of a clear and comprehensive understanding of the subject matter. There should be better cooperation between the teaching staff to ensure that each unit will provide the appropriate foundation of the other units. In order to be able to say that the Technological Institutions can be considered as University, many things should be changed"

Physician (University): "… teaching covers four chapters of Physics. Thus, the subject is not studied in all its extent but is studied in depth and in high scientific level. Theory is studied thoroughly and is applied in many exercises. Unfortunately, the last three years the physics laboratories do not function and this is a big problem. Students show interest and attendance is in a satisfactory level. Teaching hours are the demanded and should not be reduced".

Physician (T.E.I.): "The teaching scientific level is good enough and teaching hours are as many as demanded. Physics, as well as Mathematics are infrastructure subjects, whose teaching needs to be in depth and in high level. I believe that, our students are enough educated and they are ready for the work market. I also believe that we don't need many changes with regard the teaching material and teaching hours".

Wind and Steam Turbines (University): "Teaching hours are enough and a deep theoretical background should exist. Students participate by undertaking different projects and exercises, their mathematical background is in high level so they are productive concerning this specialized subject".

Wind and Steam Turbines (T.E.I.): "Teaching is in a good enough level and it covers the subject's aims in a big extent. The necessary theoretical and laboratory teaching hours are included. The attendance is satisfactory".

In total, the teachers of the Mechanical Engineering Department of the University, insisted on a single core of basic knowledge, so as the students be able to develop mathematical and particular geometric thought. This knowledge does not alter with time, while technology makes continuous

breakthroughs, so that the educational process, it is impossible to follow. The excessive specialization is not doing good, because the Greek reality requires the engineer to be generally aware of everything, because of the absence of a specialized industry in Greece.
The teachers of the Mechanical Engineering Department of TEI stressed that the new engineers should be more ready to take on tasks in companies and for this purpose must the courses equip students with modern and directly convertible into production knowledge and skills. They also said that we must give to the graduates a comprehensive background knowledge in a particular area and not to load them with general knowledge from various fields.
The teachers of the both two departments agreed that:
a) During the period of study must be given a basic knowledge on financial and on legal details related to vocational rehabilitation;
b) There needs to be a greater connection and contact within the study and production;
c) The curriculum must include courses, in the form of a seminar, on issues concerning the profession of engineer;
d) There is a need to organize and encourage the practice of students during the study;
e) An emphasis must close up be given to personal work within courses and on the dissertation as well, with which the student combines and composes his knowledge.

b. Interviewing students

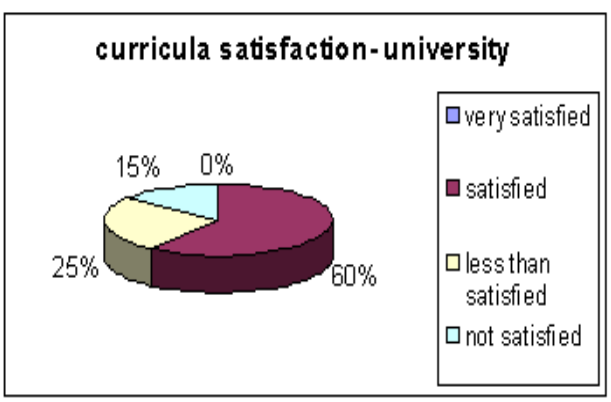
The sample of the investigation overall was 45 students, 20 from the Department of Mechanical Engineering of the University and 25 from TEI. The students were attending the final year of their studies.
This option was taken because the students in the final year of study would have a more comprehensive and clear view of the issues surveyed. It could be said that the interview with the students was a combination of interview and questionnaire. Initially, they answered a questionnaire investigating the satisfaction they enjoy in relation to matters concerning the following:
a) The curriculum;
b) The teaching material (notes, books);
c) The projects;
d) The teaching hours;
e) The communication with teachers.

Then an open-ended interview was followed (i.e. a form of debate), where students gave their opinions on the questions asked in the questionnaire. In addition, in some cases the discussion was extended to matters related to proposals for improving the functioning of the departments and to an important issue, as well as, which regards the existence of two kinds of engineers in Greece, and this issue ultimately emerged as a key research question.

It should be mentioned that some restrictions worked against the execution of the investigation. Although a number of one hundred questionnaires were shared to students, only 45 students returned it completed. Although they received the assurance that the anonymity and confidence of their answer is assured there was not a willingness by many students to answer the questionnaire and to give a little time for a short interview. The questionnaire was given with the researcher's own hand and completed immediately by the participating students. This possibly created a psychological pressure. Moreover, these appointments were made after the end of a course, and the students did not have more time that 5 to 10 minutes, thus there was a degree of time pressure.

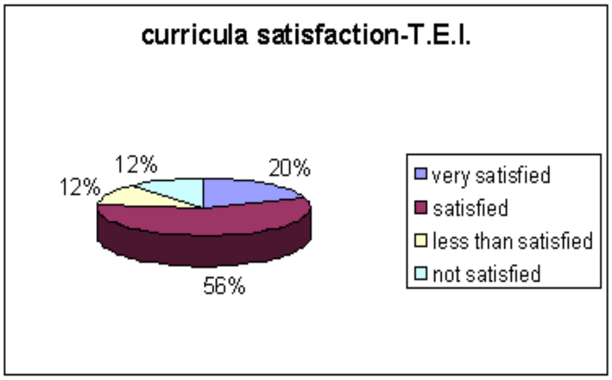
In Table 3.8 and Figure 3.9 are shown the student's satisfaction with the curriculum of the Department of Mechanical Engineering of the university while Table3.9 and Figure 3.10 shows the respective results from Mechanical Engineering of TEI. The question put to the students was whether the curriculum met their expectations and whether the knowledge gained is satisfactory for their entry to the labour market.

Figure 3.9: Curricula satisfaction-University



satisfactory factor	frequency	percentage %
very satisfied	0	0
satisfied	12	60
less than satisfied	5	25
not satisfied	3	15
total	20	

Table 3.8



satisfactory factor	frequency	percentage %
very satisfied	5	20
satisfied	14	56
less than satisfied	3	12
not satisfied	3	12
total	25	100

Table 3.9

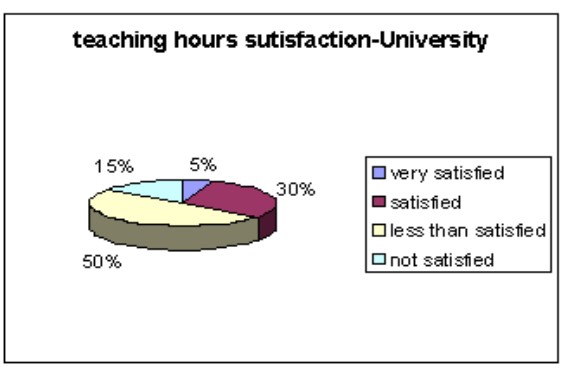
Figure 3.10: Curricula satisfaction-T.E.I

It can be observed that a large percentage of students (60% and 56%) respectively from the University and from the T.E.I indicate that they are satisfied with the curricula of their departments. As mentioned, the content of studies at the university is more theoretical than its counterpart in the TEI. The students from the university said that they thus acquire a solid scientific background, suited to face significant problems when they are going out into the marketplace of work. The students of the Mechanical Engineering of TEI are satisfied with the practical nature of the curriculum, because that brings them closer to the real world of work from the beginning of their study.

In Table 3.10 and Figure 3.11 can be observed the student's satisfaction with the teaching hours of the Department of Mechanical Engineering of the university, while Table 3.11 and Figure 3.12 show the respective results from the Mechanical Engineering of TEI.

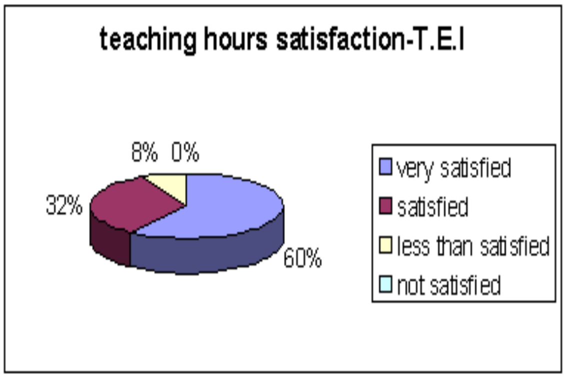
Figure 3.11: Teaching hours satisfaction-University

Table 3.10



satisfactory factor	frequency	percentage %
very satisfied	1	5
satisfied	6	30
less than satisfied	10	50
not satisfied	3	15
total	20	100

Figure 3.12: Teaching hours satisfaction-T.E.I



satisfactory factor	frequency	percentage %
very satisfied	15	60
satisfied	8	32
less than satisfied	2	8
not satisfied	0	0
total	25	100

Table 3.11

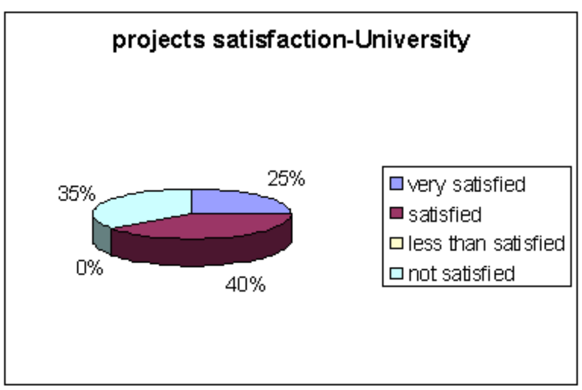
50% of the university students state that they are less than satisfied. 65% overall of students believe that teaching hours are too many, while the remaining percentage considers it necessary to cover the program of courses. About the 60% of students of TEI state that they are very satisfied with the number of teaching hours and 32% are satisfied. Generally, the students of TEI believe that the teaching hours are as needed.

Tables 3.12 and 3.13 and Figures 3.13 and 3.14 show the student's satisfaction concerning the taking and development of work and projects.

Table 3.12

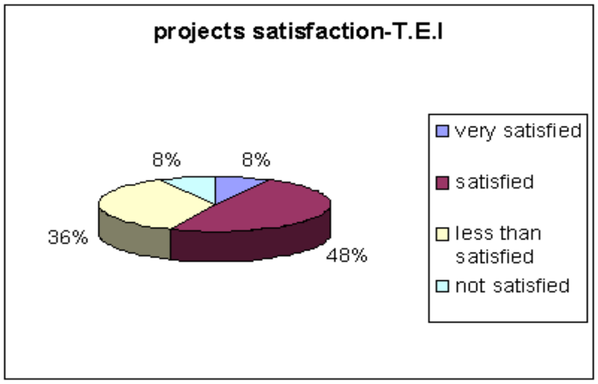
satisfactory factor	frequency	percentage %
very satisfied	5	25
satisfied	8	40
less than satisfied	0	0
not satisfied	7	35
total	20	100

Figure3.13: Projects satisfaction-University.



Only 35% of the students of the University say that they are satisfied with the number of projects carried out during their studies. They would want more work, especially with more practical content.

Figure 3.14: projects satisfaction-T.E.I.



satisfactory factor	frequency	percentage %
very satisfied	2	8
satisfied	12	48
less than satisfied	9	36
not satisfied	2	8
total	25	100

Table 3.13

The majority of the students of TEI are satisfied with their participation in projects. They consider to be very important the practical work for one semester, during the final year of their studies.

Tables 3.14 and 3.15 and Figures 3.15 and 3.16 show the student's satisfaction with the provision of teaching equipment.

Figure 3.15: Teaching equipment satisfaction-University

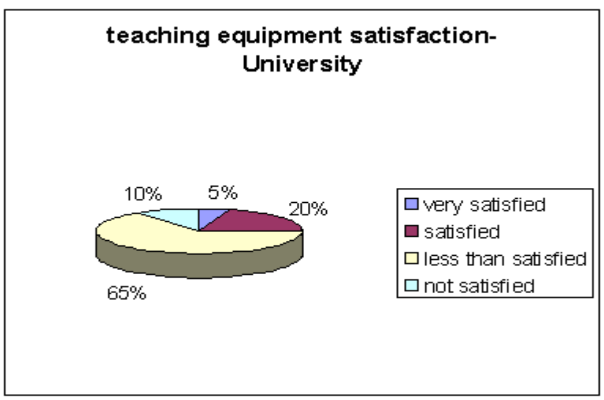
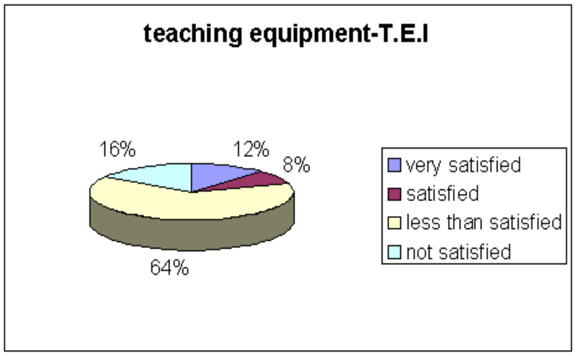


Table 3.14

satisfactory factor	frequency	percentage %
very satisfied	1	5
satisfied	4	20
less than satisfied	13	65
not satisfied	2	10
total	20	100

In the question that has to do with teaching material, most University students said that they are not sufficiently satisfied (65%) and not at all satisfied (10%). This has to do with the fact that books, notes from teachers and generally the teaching materials do not meet the student's expectations. It is noteworthy, that during the interview/ discussion it was mentioned by many students that the first thing that they would change, if they had the opportunity, would be the badly- written notes.

Figure 3.16: Teaching equipment satisfaction-T.E.I



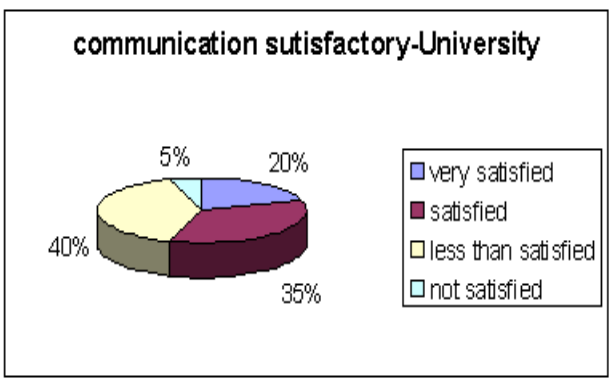
satisfactory factor	frequency	percentage %
very satisfied	3	12
satisfied	2	8
less than satisfied	16	64
not satisfied	4	16
total	25	100

Table 3.15

The same occurs in the responses of students of TEI.and these students are barely satisfied with the benefits of their department regarding the teaching material.

Tables 3.16 and 3.17 Figures 3.17 and 3.18 show the students' satisfaction in relation to their communication with teaching staff.

Figure 3.17: Communication satisfactory-University.

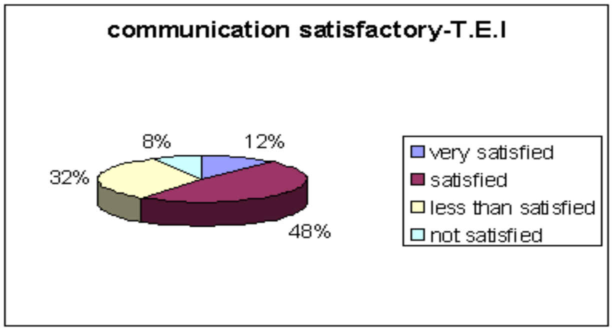


satisfactory factor	frequency	percentage %
very satisfied	4	20
satisfied	7	35
less than satisfied	8	40
not satisfied	1	5
total	20	100

Table 3.16

The question given is: "Teachers were available when you attempted to contact them? (personally phone, e-mail)". Approximately 20% of students at the University claimed to be very satisfied and 35% satisfied, while 12% of students at TEI is very satisfied and 48% satisfied. This shows that in the both two departments there is a good communication between teachers and students.

Figure 3.18: Communication satisfactory-T.E.I.



satisfactory factor	frequency	percentage %
very satisfied	3	12
satisfied	12	48
less than satisfied	8	32
not satisfied	2	8
total	25	100

Table 3.17

3.2.3. Conclusions

This section presents the results of the research resulting from the previous analysis. The investigation following processing of data as well as the answers given by teachers and students of both departments, reached the conclusions which are summarized as follows:

1. The first and main difference between the two departments has to do with the purposes for which they were created. The purpose of each Educational Department is different as the Greek Legislation fixes.

The TEI is oriented to applied research and technology while universities are primarily oriented to theoretical and basic research. The Department of Mechanical Engineering of the University trains scientists engineers, emphasizing the acquisition of deep theoretical infrastructure. This is illustrated by the fact that 48% of Courses are purely theoretical, unlike the corresponding proportion of the TEI which is just 22.5%.

2. The number of obligatory courses for the degree and the teaching hours in the section of the University is much more than those in T.E.I. The students (at 65%) consider that the teaching hours are too many and a great time is spent on the monitoring of courses.

3. The level of teaching material is quite different between the two departments. In the University, the subjects are taught in all their extent and in a high scientific level. On the contrary in the T.E.I the subject matter is considerably shorter and without much time to elaborate on the subject.

4. In the section of the University a great emphasis is given to the teaching of basic infrastructure courses, which are taught during the first years of study. Mathematics, physics, chemistry are subjects taught in high level and in depth, which is not so in the department of the TEI. The specialized courses and the laboratory courses are the same in terms of numbers.

5. The curriculum of both departments provides students with a very small number of courses concerning the development of personality and the role of engineering in society (ethics, humanities).
6. The students of both departments do not prepare a sufficient number of projects relating to real world problems. The exception is the prepared project within the last year of studies. Nevertheless, the students said that they were satisfied with the number of work projects drawn up during their studies.
7. There is no immediate relationship, during the study, with industry and in general with the future work space. Only the students of the TEI are obliged to undertake practical work in production during their studies.
8. The teachers from the both departments consider that the knowledge offered to their students is as required. The professors from the University believe that students should acquire such knowledge to be able to exercise mathematic and scientific thinking, a fact which should not be changed. The teachers from the TEI believe that the new engineers should not be loaded with general knowledge but should acquire those skills that are necessary for the immediate solution of real world problems. At this point, it seems that the persistence in the status quo and the reaction of teaching staff to a possible change and improve solutions of existing problems.
9. Students generally declare that are satisfied (60% at university and 75% in the TEI) from their curricula and provided knowledge and skills.

3.2.4 Summary

This chapter has outlined my use of a constructivist epistemological approach using quantitative and qualitative methods to collect data for the two selected engineering departments that were selected for comparison (i.e. the Mechanical Engineering Department of the University of Patras and the Mechanical Engineering Department of the T.E.I).

Noting the above conclusions, it is easy to understand the existing problem of engineering in Greek universities. The two schools educate two different types of engineers, with significant differences in the scientific background and claiming the same area in the professional arena. On one hand the differences have to do with the purposes for which the two schools were created as Greek Legislation fixes and on the other hand although the status of TEI was transformed to University status, there is not the appropriate improvement in the quality of studies.

The results suggest that both types of engineering are necessary, as their roles are different. One of them **produces** knowledge and technology and the other **applies** technology. The different roles must be accepted by all those involved in the educational process, so that the Greek universities and TEI have been subject to competition imposed by the rapid changes occurring in the political, economic and social global environment. In the next chapter a model curriculum is proposed, which could be adopted by the two engineering departments, fitted to their standards and based on the conclusions to the research described here.

Chapter 4: The proposed curricula model

4.1 Introduction

As is reported in the second chapter, Engineering education, more than many other discipline, has a permanent need to respond to a variety of sometimes fast-changing demands and to continuously develop its programs and improve its curricula and teaching/ learning arrangements. So, schools are faced with the need to establish a system for continuously updating their curricula.

It was shown in Chapter 2 that increased knowledge, new technologies, and expanding regulatory standards (all that constitute the 'modern society') affirm the need to significantly restructure the engineering curriculum. However, for practical reasons it is simply impossible to "add" new courses and to meet such requirements with the advent of each new development. Schools are faced with the need to establish a system for continuously updating the curriculum, re-assessing the 'basics' versus the 'specialty', updating applications and case studies, updating their own technologies, and ensuring opportunities for the professoriate to maintain currency in their expertise.

Globalization brings a whole new set of variables. Engineering students will enter an employment world which is characterized by multi-national standards and applications as well as increasing numbers of international regulatory requirements. Whether included directly in the curriculum or in the development of and in accessing new reference systems, engineering schools must ensure currency in the world of engineering applications.

The literature review and the primary analysis indicate that like other professions, engineers now find themselves having to apply their trade in a multifaceted environment with increased responsibilities. There is growing pressure from employers to improve students interpersonal and communication skills, increase their knowledge of related fields and integrated applications, and to significantly increase their 'creative' and entrepreneurial abilities. Normally, these would all require additional courses and time spent on tasks, but now schools are faced with 'integrating' these new requirements into a traditional curriculum. In addition, employers are also expecting, universities to prepare engineers for a world of life-long learning.

In spite of continued efforts that have been made to reform the tertiary educational system in Greece, it was suggested in Chapters 2 and 3 that gaps between the graduate profiles and the societal requirements are becoming larger. When designing the improvement or the change of one curriculum the first thing that must be considered is the current situation in order to highlight the problems that exist within it. An important conclusion from the analysis made in the previous chapter, is the significance of the number of the specialized courses taught to students in Greek engineering departments. This relates to the qualification of the staff who teach the curriculum. We could say that the majority of courses are selected based on the basis of the knowledge and skills of the available teachers and not on the basis of the necessary knowledge, that the engineering graduate must have. So, regarding the courses of specialization, the curriculum is more teacher-centred than student-centred. At this point it seems from the research that any new proposal for change and reform of the curriculum is confronted with the old *status quo* and refusing to accept a change of culture. Researchers who have studied cultural change suggest that the challenges are much more extensive than is usually recognized. Seel (2000) suggests that cultural change in engineering education will be achieved only when the nature of the conversation about engineering education has changed. Eckel and Kezar (2003) suggest that transforming engineering education will require that the majority of engineering faculty members change the way they think about engineering education. So, the first thing that must be taken into consideration is the role that the engineer has to play in society and that ultimately must determine the profile of the engineer. Generally, higher education can be seen as a public good in the sense that society as a whole benefits culturally, economically and socially from maintaining high-quality higher education.

4.2 Developing a model curricula

4.2.1 Curricular philosophy

As we try to predict the future of the engineering profession and therefore engineering education, we must take into account some important factors. First, history has shown that changes in the engineering profession follow changes in cultural, social, and political environments. Evidence shows that these changes in the profession have led to technology breakthroughs that helped or harmed social progress, depending on the political environment surrounding them. Second, as we think about the engineering profession of the future and education to prepare the engineer of 2020 and beyond, we should keep in mind statistical projections relevant to anticipated social and economic changes: (Educating the Engineer of 2020: Adapting Engineering Education to the New Century).

• By 2050, 8 billion of the 9 billion people on Earth will live in developing countries, and economic growth in these countries will be only 2 percent below the expected economic growth in the developed world;

• By 2050, the biggest social problem occupying the world will be poverty, and its primary impact will be on the female population;

• In 20 to 30 years, the primary economic growth in nations around the world will depend on females working in all professions, from farming to high-tech industry.

Engineering education prepares students to affect the world of tomorrow, thus engineering education researchers must explore what the engineer of tomorrow will need to know. Students and employers alike expect a high degree of synergy between what is learned in classroom and what is needed in the field for successful practice. Describing and defining the nature of engineering work as a professional enterprise and articulating the roles of engineers in that work are critical components of creating this synergy. Although there is an implicit understanding of the essence of engineering thinking and knowing, as evidenced both in our current educational system and in reports seeking to facilitate improvements in engineering education, the profession needs research that will help characterize the nature of engineering knowledge (i.e., its technical, social, and ethical aspects) and ways of engineering thinking that are essential for identifying and solving technical problems within dynamic and multidisciplinary environments.

(Educating the Engineer of 2020: Adapting Engineering Education to the New Century. http://www.nap.edu/catalog/11338.html)

With these factors in mind, it is very easy to conclude that Greek engineers will in the future face totally different problems from the ones that they face today. In future Greek engineers will have to address and help solve a variety of problems. In effect, Greek engineers must become global engineers and they will therefore have to be aware of socioeconomic changes and appreciate the impact of these changes on the social and economic landscape in Greece as elsewhere.

According Davis, Beyerlein, and Davis (*Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition Copyright ©2005, American Society for Engineering Education)*, the profile of an engineer is a valuable tool for addressing a variety of curricular issues. It provides a basis for establishing educational program outcomes that reflect both the faculty (i.e teaching staff) and employer aspirations. The follow Table 4.1 (*Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition Copyright ©2005, American Society for Engineering*

Education), provides an expanded definition of the profile of an engineer. Associated with each role is a set of actions that give evidence of the engineer's knowledge, skills, and attitudes used in that role – thereby communicating understandable attributes of an engineer who performs effectively.

Table 4.1: Roles and Holistic Behaviors of an Engineer

Technical Roles	Holistic Technical Behaviors
Analyst	When conducting engineering analysis, the engineer adeptly applies principles and tools of mathematics and science to develop understanding, explore possibilities and produce credible conclusions.
Problem Solver	When facing an engineering problem, the engineer produces solutions that properly address critical issues and assumptions and that are conceptually and contextually valid.
Designer	When facing an engineering design challenge, the engineer develops designs that satisfy stakeholder needs while complying with important implementation, societal, and other constraints.
Researcher	When conducting applied research, the engineer designs and conducts studies that yield defensible results and answer important applicable research questions.
Interpersonal Roles	**Holistic Interpersonal Behaviors**
Communicator	When exchanging information with others, the engineer prepares, delivers, and receives messages that achieve desired outcomes.
Collaborator	When working with others in joint efforts, the engineer supports a diverse, capable team and contributes toward achievement of its collective and individual goals.
Leader	When providing needed leadership, the engineer promotes shared vision

to individuals, teams, and organizations and empowers them to achieve their
individual and collective goals.

Professional Roles	Holistic Professional Behaviors
Self-Grower	Motivated for lifelong success, the engineer plans, self-assesses, and achieves necessary personal growth in knowledge, skills, and attitudes.
Achiever	When given an assignment, the engineer demonstrates initiative, focus, and flexibility to deliver quality results in a timely manner.
Practitioner	Driven by personal and professional values, the engineer demonstrates integrity and responsibility in engineering practice and contributes engineering perspectives in addressing societal issues.

In this table it can be seen that the roles of an engineer and the needed skills can be grouped into three broad domains: the technical, the personal and the business domains.

So, the literature suggests that the knowledge and skills required in engineering, and in engineering education, must come from all of the sciences, and from the world of professional practice. This suggests that faculty in a school of engineering need to keep abreast of progress in the relevant sciences, that is the natural sciences and the economic and social sciences, and the mathematical and engineering sciences. Taking into account the above the engineering programs must demonstrate that their graduates have:

(a) An ability to apply knowledge of mathematics, science, and engineering;
(b) An ability to design and conduct experiments, as well as to analyze and interpret data;
(c) An ability to design a system, component, or process to meet desired needs;
(d) An ability to function on multi-disciplinary teams;
(e) An ability to identify, formulate, and solve engineering problems;
(f) An understanding of professional and ethical responsibility;
(g) An ability to communicate effectively;

(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context;

(i) A recognition of the need for, and an ability to engage in life-long learning;

(j) A knowledge of contemporary issues;

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. Engineering criteria 2000,. ABET, Dec. 1997).

The curriculum must be designed to give students all of these capabilities. Rigorous technical courses and hands-on projects throughout the curriculum require that students apply engineering concepts to real problems. Interdisciplinary courses and projects make explicit connections in the technical world and also between the engineering discipline and society. The literature suggests that extensive design experiences, significant work in the arts and humanities, and an emphasis on original expression encourage students to develop and apply their creativity. This in turn suggests that the continuous use of teamwork, communication skills, and entrepreneurial thinking in the engineering curriculum give students the tools they need to take their solutions from the research laboratory to the world at large.

4.2.2 Structure of proposed curricula for Greek Engineering Departments

The academic community in Greece as well as almost all the Greek society is opposed to the reduction of study time into three years because it considered that it is accompanied by reducing the basic theoretical underpinnings of graduates and ultimately the obsolescence of engineering degrees. On the other hand, however, five years of study are too many, taking into consideration that the majority of students who complete their studies averaged about 7 years. (Document of Greek Technical Chamber). This fact of course has many causes such as non-mandatory surveillance of theoretical courses and the need of some students to work. This extension of the study has the effect of increasing the cost of training both for universities and for the Greek families.

As mentioned before, the resistance to change is great. The entrenched perception of the professorial staff over the years, the opposition of the Technical Chamber of Greece and probably some political interests are a number of factors that prevent the acceptance of radical change. The National Technical University, which is the largest and oldest university in Greek Engineering has implemented the mandatory five years study for obtaining a master degree in order to align more with the idea of change. Accordingly the other universities are expected to follow this idea. This would satisfy the future engineers whose preference is in favor of the status quo.

Actually this work is very difficult to be binding on a deep-rooted status quo and propose changes. So the work merely proposes a model of program for TEI.

As already mentioned in Chapter 2 in June 2001 the Law 2916 was passed in application, according to which the status of the T.E.I. was transformed to University status. This includes the expansion of study-years to 4, without a respective improvement whatsoever in the quality of studies as demonstrated by the results in Chapter 3. The introduction of an improved curriculum will allow students of TEI to improve and ultimately raise the level of their training and their knowledge so as to be equivalent towards the graduates of the universities and to pursue the same professional rights.

Taking into consideration this fact as well as the curriculum models that successfully implement some universities in the international arena, this work propose the following model curricula for the Greek Technological Engineering Departments believing that it could be a proposal for the solution.

The proposed curricula consists of two phases: a. **foundation**, b. **orientation** (**specialization and realization).**

The basic structure and requirements of the curricular "foundation," encompasses approximately the first two years of a student's education. This first phase of the program is applied to all engineering departments regardless of the direction. Mechanical engineers as well as electrical and civil engineers follow the same program.

A central block of the foundation is the courses on the basic mathematical, scientific and engineering fundamental knowledge needed by engineering graduates.

Figure 4.1 Illustration of the concept of the two first years study.

- Physical and Mathematical foundation (calculus, differential equations, linear Algebra, Probability and Statistics);
- Chemistry- Biology- projects;
- design project;
- Arts, Humanities and Social Sciences;
- Projects;
- Laboratory;
- Industrial placement

Another prominent feature of the curriculum is the **design project** in the first year. The design project offers a significant opportunity for students to develop their own ideas, develop project implementation plans, and manage the process of bringing projects to fruition. To provide a broader context for their engineering studies, students will also take courses in the **arts, humanities, and social sciences.** In addition, in each semester of the foundation, students will participate in projects, that allow them to apply what they were learning in individual courses to interdisciplinary problems. For example, a project about the groundwater allows students to explore connections among geology, mathematics, chemistry, economics, humanities, and social sciences by studying the process and wider implications of groundwater flow.

After two years of basic education for all students, the phase of the orientation is followed. In this phase each student has to choose what kind of engineer would be done.

From a common list of subjects, students choose a number of courses which will give them the opportunity to become mechanical, civil, or electrical engineers.

The general concept for the third and fourth years of the curriculum is adopted the **specialization**, in which students develop and apply in-depth knowledge in their chosen fields; and the **realization**, in which students bring what they have learned to bear on problems approaching professional practice. The Specialization lessons might revolve around different application areas of interest. Each course will be linked with a project. In the final year the students will be focused on an ambitious **project** that occupies at least half of the student's time for the year. In this project, students combine knowledge from different subjects. The final result should be a design or a construction process, which gives the students more confidence before their graduation.

The **practical** training of future engineers is also, a very important event. The students should come into contact with the real world and the real problems of their future profession before they graduate. The first two years will be the ideal time for **corporate experience.** For three or four weeks of the first and second year, students can be trained in the production processes of a private or public enterprise.

- Specialized lessons
- Required technical content- projects;
- Free elective or independent interdisciplinary study;
- Arts, Humanities and social sciences, business and communication;
- Laboratory;
- Project- dissertation.

Figure 4.2 Illustration of the concept of specialization and realization.

The student's progress in both theory and practice is evaluated at the end of each year during an assessment period that includes written examinations, oral examinations, team exercises, and other forms of authentic assessment.

The above proposed model is based on Olin's College (Massachusetts-USA) implemented curricula in the fall of 2002.

In the next figure 4.3 is presented a proposed model of curricula that could be implemented in the Technological Institute, giving the probably chosen subjects and teaching hours.

Figure 4.3 Proposed curricula for the two first year study

First Year

First Semester

Calculus and Analytical Geometry I (5 h.)

General Physics I (3 h.)

General Chemistry (3 h.)

General Chemistry Laboratory (2 h.)

Engineering lecture (2 h.)

Elective in Social Sciences or Humanities (2 h.)

Second Semester

Calculus and Analytical Geometry II (5 h.)

General Physics II (4 h.)

Biology (3h.)

General Chemistry (organic) (3 h.)

Elective in Social Sciences or Humanities (2 h.)

The entering student's first year is spent mastering the basics of science: math, chemistry, and physics. Building on this base, in the second year students begin to take fundamental courses such as statics, dynamics, basic circuits and electronics, thermodynamics, and strength of materials.The first two years provide a general grounding in fundamentals across the engineering spectrum.

As shown above, the students of all engineering departments attend common courses that are required to obtain an appropriate scientific background in relation to engineering. This knowledge will give them the ability to correctly select the next phase that is the orientation of their study.

Second year

First Semester

Introduction to Computing with Application to Engineering and Physical Sciences (3 h.)

Calculus of several variables (3 h.)

General physics III (4 h.)

Statics (2 h.)

Introduction to engineering Design (3 h.)

Second Semester

Differential Equations (3 h.)

Introduction to science of Materials (3 h.)

General Physics IV (2 h.)

Thermodynamics (3 h.)

Introduction to Electric and Electronic Circuits (2 h.)

Introduction to Electric and Electronic Circuits-Laboratory (2 h.)

The following is the model for the next two years of study, using as example a program suitable for mechanical engineers. The programs for the other engineers will be similar by checking the appropriate specialization subjects.

Third Year

First Semester

Introductory Gas Dynamics (4 h.)

Engineering Materials (4 h.)

Modeling and Analysis of Dynamic System (3 h.)

General Physics V (2 h.)

Linear Transformations and Matrices (3 h.)

Second Semester

Heat Transfer (4 h.)

Fundamentals of Signal Processing, Instrumentation and Control (3 h.)

Mechanical Design II (3 h.)

Design for Manufacturability (3 h.)

Elective in Social Sciences or Humanities (3 h.)

Fourth Year

First Semester

Mechanical Design III (3 h.)

Heat Transfer- Laboratory (2 h.)

Elective in Social Sciences or Humanities (3 h.)

Elective specialized course 1 (3 h.)*

Elective specialized course 2 (3 h.)*

Second Semester

Mechanical Engineering Design Project (3 h.)

Elective in Social Sciences or Humanities (3 h.)

Elective specialized course 1 (3 h.)*

Elective specialized course 2 (3 h.)*

Elective in Social Sciences or Humanities (3 h.)

* Choose from a departmentally approved list.

By the third year, students are taking specialized courses in the subfields of engineering (Mechanical, Civil, Electrical). Finally, during the fourth year, students have the opportunity to both broaden and deepen their knowledge of their field through technical elective courses. The final year will also be focused on an ambitious **project** that it will certainly look quite a bit like professional practice.

Engineering design, communication, teamwork, and laboratory experiences are integrated throughout the curriculum from the first year to the last year.

The designed curriculum puts the students in a design environment where they learn engineering science and technology and when they need to use them. In addition, they are required to work as team, exercise their communication, project management, leadership and other skills. Specifications for life cycle engineering requirements and environmental considerations give students the opportunity to relate their design activities and decisions to social and professional responsibilities. This approach is a major improvement from the traditional one, which provides the students with all the engineering science and technology materials but where most students have little or no ‘engineering appreciation’.
As result of all above the design of proposed curricula is presented in the next figure.

Figure 4.4 Design Curricula Framework

Challenges

- Globalization of all kinds of professional activities requires as never before that engineers must be able to adopt quickly as never before to working within cultures new to them.
- Globalization, new technologies, new forms of work, new financial and social environment are some of the new challenges to which companies and organizations are called to respond with inter-complementary approaches giving emphasis to customers needs, to competitive pressures to learning and to the creation of flexible infrastructures.
- Technically-oriented higher education is increasingly seen as playing a key roll in the economic well-being of society.
- The political changes and the opening of international markets has placed educational institutions in a new and challenging situation.

↓

Moral and social responsibilities

Engineering and society are inter-related-each one shapes the other. It is imperative to understand the influences of diverse human talents on society in order to encourage innovation, creativity, and global understanding to achieve a more equitable, inclusive, and prosperous world community.

↓

Philosophy

Students should be equipped with the solid foundation in mathematics and natural sciences (including life science); with strong foundation and training in engineering principles and engineering practice; with very new specialized knowledge; with the ability to recognize and define problems, to apply relevant engineering principles and experimental methods, design calculation methods to solve problems; with historical and social perspectives towards the role of technology; and with the broad vision of interdisciplinary approach.

↓

Structure

Foundation: courses on the basic mathematical, scientific and engineering fundamental knowledge needed by engineering graduates. **Specialization:** students develop and apply in-depth knowledge in their chosen fields.

4.3. Conclusions

The main challenge to modern global reality is the general understanding of the philosophy and the objectives of undergraduate studies. Today, the main task for each program is not to fix rigidly the titles and content of subjects taught, but to identify the knowledge that must be accumulated, the abilities that must be gained, the skills that must be learned and in general the qualifications that must be acquired by students during their studies. It may be said that the last decades, globally, were marked by rapid growth of technology without an equivalent progress in the basic knowledge of engineering graduates. This has led to an orientation of the technology studies to some specifications that are often accompanied by a deterioration of the solid base of fundamental knowledge of engineering. So, a great risk exists for Universities; as the tendency may be for present engineering curricula to produce ‘perishable’ engineers, whose expertise will be made obsolete by the obsolescency of the technology in which they trained.

The engineers of the 21st century are thus expected not only to be technical experts but also to integrate science and technology into society as a whole. The idea of a broad education is, however, not new. It is worth noting that, as early as 1893, William Burr, a professor of civil engineering at Columbia College, School of Mines, described the 'ideal engineering education' as having two characteristics: First, a broad, liberal education that would allow engineers to interact well with people generally; secondly, a thorough training which includes the body of mathematical and scientific knowledge constituting the theory of engineering. (Parrish 1996).

In 1925, the founders of Technion, the Israel Institute of Technology, set their goals in engineering education with the statement that: 'The subject matters taught should lead to broad education rather than narrow specialization'. (Tadmor et al 2001). The author believes that this idea is timely as ever. The engineer is not the person who knows only to work on a component or to install the component at a construction. The requirements of the time (globalization, mobility, change agency…) set the requirement for engineers to have a broad education based on a balance of fundamental theoretical and practical knowledge. The engineer must be an integrated personality who is going to have the ability to ‘foresee the future’ and have the innovation skills to lead people into new areas. The engineering curriculum must ensure complete scientific and professional competence to produce and modulate cultured scientists who are able to think scientifically at all levels and not only in their subject.

So the proposed model of curricula is designed to satisfy the above requirements, so that our graduates should be able to:

- Apply sound design methodology in multidisciplinary fields of engineering.
- Competently use mathematical methods, engineering analysis, and measurement and instrumentation techniques.
- Practice effective oral and written communication skills.
- Understand the environmental, ethical, diversity, cultural, and contemporary aspects of their work.
- Work collaboratively and effectively in engineering and manufacturing industries.

4.4 The proposal's assessment by the Curricula Committee of the Mechanical Engineering Department of TEI.

The above suggested curriculum was submitted for evaluation to the Curricula Committee of the Mechanical Engineering Department of TEI. This committee consists of three members; the dean of the Mechanical Engineering Department and two members of the teaching staff. At the current period the Committee is occupied with the creation of a new curricula which should be ready to be submitted to the Ministry of Education by the end of March. Therefore, there was a prompt reply to our proposal.

A copy of the fourthy chapter of this essay was handed to each member of the Committee, so that the hereby proposed alternative Curricula would be considered and evaluated by them. Additionally, a personal meeting of the author with the members of the Committee took place so that further clarifications could be made.

The Committee's opinion concerning the proposal of this study was unanimous and was stated as follows:

"We generally consider that the suggested Curriculum is a very good idea. The study proposes separating the four years of study into two years of training for all students concerning issues of basic general science and engineering so that they can choose a certain specialization in the next two years. We believe that this type of Curriculum would result in a better education and more correct preparation of future engineers. Actually, each student could follow the professional direction that really suits him. This proposal, however, requires a radical change in the structure and operation of Greek universities, which is a political issue and it is up to the government to take such an initiative. However, it could be possible for some elements of the proposed program to be adapted to the existing situation. For example, the introduction of courses and assignments which require teamwork, especially in the first and second year of studies, would be appealing and attract the students' interest. Therefore, one could say that such a change would consist a great improvement in the existing problem of the small number of students attending the courses. The level of the taught courses is another issue addressed in the proposed program. At this point there may be another intervention in the existing situation. So, in general, apart from the first point mentioned, we believe that your proposal is interesting and could help in our efforts to improve the curriculum of the Mechanical Engineering Department of TEI. Your presence and the statement of your point of view will help in this direction".

My audience has been very surprised about the proposed curriculum for Mechanical engineering department. My approach was based on the cooperation between the departments of the engineering school. They couldn't imagine that it was for the benefit of their students to follow the cooperation instead the department lonely path. Even though the departments of the Higher education have the freedom to form their own curriculum the tutors claim that such approach must be approved by the ministry of education.

My conclusion is that my colleagues couldn't follow the philosophy of the proposed curricula. They were trying to understand what kind of training material and workload was demanded by each title of subjects and how it would affect their personal professional life in the department.

The head of the department expressed his opinion about the changes that our curriculum proposed. He was sure that if the department decided to approve the new approach many of the educational staff would be in the difficult position to change for good the context of the lessons that they teach. He expressed his doubts if it could be achieved.

Above comments agree with Seel's suggestion that the cultural change in engineering education will be achieved only when the nature of the conversation about engineering education would be changed.

4.5 **Summary**

This chapter describes a model curriculum for the Mechanical Engineering Department of TEI. The reasons for this choice are: a. the status of TEI was transformed to University status without the respective improvement in the quality of studies. b. the academic community in Greece is opposed to the changes according to the Bologna Declaration, because is considered that conducts to the obsolescence of engineering degrees.

The main concept of the proposed curricula is the implementation of two phases of study.

a. foundation: the program of this phase is applied to all engineering departments regardless of the direction. So, the students will have a broad understanding of Engineering and scientific principles and they will also have the ability to apply mathematics, science and engineering solving real complex problems in multy-disciplinary domains.
b. Orientation: in this phase the students have to choose what type of engineering want to follow.

   This concept give them the opportunity to create and control the development of their learning as it is based on a student-centred approach.

The proposed model of curricula is designed so as our graduates should be able to: Apply design methodology in multidisciplinary fields of engineering, to use mathematical methods, engineering analysis, and measurement techniques, to practice effective oral and written communication skills and understand the environmental, ethical, diversity, cultural, and contemporary aspects of their work. All these above is the answer to the current requirements of the time (globalization, mobility, change agency, new forms of work…) that set the need as the engineering curriculum must ensure complete scientific and professional competence to produce and modulate cultured scientists who are able to think scientifically at all levels and not only in their subject.

This proposal could be generalized and the proposed curricula could be adopted by all Greek Engineering departments, adapting it to their own requirements. This is possible because the work proposes a model in which is given a big importance to the philosophy that must have the structure of the curricula as the acquired knowledge to be based on a sustainable scientific background. So, all engineers must be educated in this direction regardless of the location of the University where they study.

Chapter 5: Critical Review of the study- Future work

The purpose of this final chapter is to present a summary of the whole study. It begins with a brief overview of the study and concludes with some recommendations for future work.

5.1 **Overview of the study**

The aim of this work was to investigate the existing problem in Greek state relating to Engineering Education in Universities. In the first and second chapter of the work a detailed presentation of the Greek educational system for higher education is shown, where the Universities together with the Greek Technological Institutions (T.E.I) constitute the Tertiary Sector of Education similar to British situation between Universities and polytechnics before 1992. Sixteen year later we are facing the same problem without any realistic approach to be solved. The existence of two different types of engineers was identified (who claim the same professional rights in the labour market), highlights the great problems of education in both engineering and the Greek society as well. My country has signed the Bolognia agreement and up to now we have not done any step towards the changes of our education problem. Tertiary education must be the place where all the major revolutionary ideas to be materialised. It seems that it is not the case in Greece. I have concluded that we are a very conservatory society which is not ready to move forward to major changes that are much needed in the new era.

In Chapter two a substantial body of literature research over engineering education is referenced, such as quality in Higher Education, engineering culture, engineering curricula and globalization of engineering education. The in-depth study and analysis of this literature research led to a confirmation of the research questions of this work, which have to do with the existing engineering problems have been formulated as follows:

- Does the Greek market need both practical and theoretical graduate engineers?

- What is the most appropriate duration an engineering studies curriculum- 4 or 5 years?

- What are the suitable curricula for Greek engineering departments so that the students can successfully participate in engineering activities upon graduation taking into account the social demands and needs?

After formulating the research questions, an interpretive research approach was investigated and selected to address these research questions using qualitative and quantitative research tools.

Chapter three presents in detail the data collected for the two selected engineering departments that were selected for comparison (i.e. the Mechanical Engineering Department of the University of Patras and the Mechanical Engineering Department of the T.E.I). By quantitative and qualitative analysis of data the main problems were identified again. The differences arising from the analysis of data on the different way in which the two engineering types are educated, the critical analysis of international literature and the social experience of the author have enabled this work to answer the questions of research and propose a model curriculum which could be adopted by the two engineering departments, fitted to their standards. This model of a revised engineering curricula is described and explained in Chapter Four.

Actually the survey methodology as well as the research tools used was responded very well to highlight the current situation in the research field of this mphil project. The choice of a combination of methods allowed a more comprehensive description of the phenomenon under investigation. For instance, the interviews with teaching staff and students enabled the author to identify the variables that quantitative measures cannot describe and to gain more in-depth information about existing situation.

5.2 Self-evaluation and Critical evaluation of the methodology

Reaching the end of the MPhil adventure I feel very similar to Odysseus when he reached to Ithaki. The result of my research project is only 100 pages document that it is addressed to the Greek higher education community. Homer presents the disappointment feelings of Odysseus when he finally sees his motherland.

….για δαύτο και του σφάνταζαν αλλιώτικα όλα γύρω,
Τα μονοπάτια τα μακριά, τα ολόκλειστα λιμάνια,
Τα δέντρα τα ολοφούντωτα, κι οι βραχουριές παντούθε.

Πετιέται πάνω, στέκεται, κοιτάζει την πατρίδα,
Και τότε θλιβερά βογγάει ,και λέει μοιρολογώντας:
¨Αλλοίς μου, και σε τι λογής ήρθα χώρα;
Να' ναι άραγες ασύστατοι κι αδικοπράχτες κι άγριοι, ή να'χουνε φιλοξενιά και θεοφοβιά στο νού τους;.....¨
……………………………………
And appeared to him all otherwise,
The paths, the harbours, the trees the rocks,
he is raising above, he is standing and looking at the homeland.
And then drearily says,
Alas! in which type of country I came? i wonder, are they wild or hospitable with the fear of god in the brain?
………………………………………

Spending hundreds of hours studying the relative literature, papers and presenting the findings of my research in international conferences I realize the truth of another Greek poet Kavafis :

Η Ιθάκη σ' έδωσε τ' ωραίο ταξείδι.

Χωρίς αυτήν δεν θάβγαινες στον δρόμο.

……………………………………….

Ithaki has given you the beautiful voyage.

Without her would have never set out on the road.

………………………………………………

The Mphil was the cause to start the beautiful journey of discovering new knowledge that professors in Greek higher education had not involved in, hoping that my this contribution will put a 'small stone' in what everyone involved in education is obliged to do, that is a better future for our children. And the future will be better for them if we take care for their qualitative education.

As mentioned the issue of this research was approached with a theoretical framework within an interpretive constructivist epistemological belief system. Constructivism proposes new definitions for knowledge and truth that forms a new paradigm, based on inter-subjectivity instead of the classical objectivity and viability instead of truth. So, the author as a supporter of this philosophical approach was unable to get rid of subjective factors, which obviously influenced the investigation.

Based on my personal study experience as chemical engineer I strongly believed that two years of theoretical subjects (physics, mathematics, chemistry etc) are undisputable subjects that must be contained in the curriculum of an engineer. It took me many hours of self evaluation to see the things in a different way. I was not in position to see futures colleagues in the field of engineering with less than five years studies.

Another drawback into my research was the fact that I have deep knowledge of the background of the students in Greek Universities as I am preparing students for the Pan Hellenic exams for their entrance to the Universities.

My research of the existing bibliography helped me to see the engineering education differently. I realised that there is no one truth for a problem which has many societal influences.

The methodology that I followed during my research path was very suitable for the purposes of the study. The open questions that I have asked for getting the answers was appropriate because they gave the opportunity to discover the real attitude towards the development of engineering curriculum.

Literature searching, as a methodological technique, was useful to me to identify all those items which deal specifically with my topic. This may seem theoretically perfectly obvious and simple to apply, but in practice, it is very easy to become sidetracked and waste a lot of time following up items of marginal interest. It was helpful to break my topic down into its different sections, and to search easier through issues of books, journal titles, journal articles and other sources relevant on my research topic.

The study of literature was an excellent source of knowledge on scientific approaches, strategies and methods that a researcher can follow and implement in a particular field of research.

The basic beliefs of an interpretivist constructivist research paradigm is that the world is socially constructed and subjective, the observer is part of what is observed and science is driven by human interest. In other words knowledge is not independent from the knower but is structured through the process of the learning, that means the knowledge is a personal and social trial as to have an order or a structure what we understand with our sensations or without them. Taking into account these criteria, I tried to trace the problem which was under investigation, I focused on meanings and concepts that are involved in the investigation process and I tried to develop ideas through induction from data. As my research was a survey, I fixed the exact purpose of my study from the beginning.

One of the tools for data collection was interviews. Looking into literature I gathered information on what exactly is an interview, how it is organized, which are the different interview types and which are the advantages and disadvantages of interview as a research tool. The interviewed groups were University Professors and students as was easy to me to be in contact with them. There were some considerations for both the categories of interviewed individuals. The first concern was about the response the call for interviews. In the end there was not a problem as the response percentage was very high for both interviewed groups. The second and more important concern had to do with the reliability and the validity of the interview. I felt very happy during the interviews procedure when I realized that the majority of the professors were surprised to answer very "uncommon" questions. Another research tool was questionnaire. Although it is a tool that requires many time to be structured it was a cheap tool for me in time and money, because the sample was no so large and I also gave the questionnaires by hand. Through this experience I came also to the following conclusion: in an interpersonal meeting, people are likely to reveal sides of themselves, their thoughts, their emotions and values, when this meeting is realised under "human conditions". It is essential that the interviewee feels comfortable. In other words, the unique human element of the interview is necessary for its validity. The more rationalist and distanced the interviewer is the less likely it is that the interview process is considered a friendly transaction. It is more likely that the answers will be more measured and therefore less reliable. Having acquired such knowledge from the interviewing process, I am sure that I will meet with greater success in a similar future challenge, avoiding mistakes which were certainly made especially during the first interviews.

The more important ascertainment in the duration of my research was the refusal for changes in the education area. From one side the opinion that the engineer needs 5 years of study ,that are deep rooted in the conscience of the academic community, and from the other side the off-hand confrontation of problem in T.E.I, the result of my research in the frames of her application likes with small Ithaki. Probably does not become never reality as it is not capable to change the culture of many years.

Finally, is meaningful to demonstrate how this MPhil adventure begun.

After my basic studies in Engineering Chemistry, I did not have the opportunity to continue my studies to the postgraduate level. As the time passed, my desire to expand my knowledge was growing continuously. These thoughts were crucial for a definite decision to be made and my research project to get started. My local supervisor's Dr. Kabouridis contribution to the choice of my investigation's subject was decisive. After a long discussion and exchange of ideas and opinions we came to the conclusion that a combination of "education" -which is the focus of my work for many years- and “engineering” –which is my basic studies’ domain- would be an interesting approach. “Engineering Education: comparison of the curricula of two Greek Engineering Departments” is the exact title of my research project.

Being a teacher as a profession, which means teaching students of 16 to 18 years old for over twenty five years, I considered that it would be for their benefit to introduce them to a new field different from what they were used to hear from me. I discussed with them the fact that I’m also a student, that I study and learn new things just like they do. Their interest on what exactly is that I do made me think that perhaps my effort to expand my knowledge could be for some of these children a good example leading them to their own improvement and progress. This is the bigger benefit from all this adventure, this is my small Ithaki…..

5.3 Risk and benefits of the proposal

At this point is important to demonstrate the limits and risk that maybe have the proposed curricula and its benefits as well. There is a possibility, a large number of students to express the desire to follow the same field in the second phase of program. So they will have problems with their training because of the lack of required infrastructure on equipment, teaching material, teaching staff etc. So, a system of student’s selection sould be created which probably will have problems with its reliability and validity.

As the proposed curricula requires a solid foundation on the basic sciences and Engineering principles and practice the students will have the appropriate education as to meet the current social and global challenges.

The adoption of the two phases of study gives to the students the opportunity to control their learning according to their personalities and capabilities. So the students of T.E.I will improve and raise the level of their knowledge and training as to be equivalent towards the graduates of the Universities and have the same professional reasons with them.

And finally if the Universities will adopt this proposal, their graduates will benefit following a curricula based on four years study as this proposal does not reduce the quality of their study but only the time.

5.4 Results of the Research

Finally, the most important results of this research are as follows:

1. Proposed model of engineering curricula:

a) The curriculum of engineering in Greece needs to have a single core of basic knowledge, as students develop mathematical and scientific thought in particular. The knowledge in basic sciences is not altered with time, while technology makes continuous breakthroughs, which the educational process apparently finds to be impossible to follow. This excessive specialization does not do good. Greek society requires an engineer who has a generalized education due to the absence of a specialized industry in Greece. In addition the changes in world landscape impose the Greek engineers to think and act like ‘citizens of the world’.

b) The duration of study that can meet the above requirements, it is proposed to be four years (Anglosaxon model) as analyzed in the fourth chapter.

2. The proposed curriculum for the Mechanical engineering department presented to the head of Mechanical Engineering department of T.E.I and their comments are the following:

a. They see the proposed curriculum as a very revolutionary idea which needs political approval. It seems that they have not realized that tertiary education must be independent and must try to implement new ideas and persuade the politicians to approve them based on the results that have been achieved.

b. They didn’t see the opportunities of the proposed curricula to give relative freedom to the students to choose the subject that suits better to their interests and talents.

3. The initial results of this research were presented in the 2nd Balkan Conference for Engineering Education, that took place in Romania in September of 2003. The work was awarded as the best presentation of the Conference.

5.5 Future work

Two areas of further research emerged from the findings of this work as to be productive for future work. The first was the Industry-University collaboration. The industrial companies have been actively influencing the transformation of engineering education in Greece. So, Industry-University collaboration seems to be actively increasing in the engineering education development in several areas. In the future both research and education will be multidisciplinary requiring knowledge from a broad range of fields. Probably the most important challenge of the whole university system is to get science and technology to serve better the needs of society (Boulding 1998, Rhodes 2004). In Greece there is a little contact between the requirements of production and the provision on education. Efforts have been made by both sides, but there is some hesitation, which is an issue that could be studied more.

The second area was about teaching and learning practices in engineering education in Greece. Changes in educational process are not simply a matter of adopting a new curriculum. Each classroom is an arena in which the culture of learners and the culture of teachers must negotiate their beliefs, values, and behaviours.

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APPENDIX A

The questionnaire answered by the students had the following form:

The aim of this research is to investigate the student's satisfaction in relation to matters concerning the following: a) The curriculum b) The teaching material (notes, books) c) The projects d) The teaching hours e) The communication with teachers.

Please answer as honestly and completely you can.

The anonymity and confidence of your answer is assured.

A. **General information**

1. Educational Unit: University ☐ T.E.I ☐

2. Department …..

3. Year of study ………………………………………………

B. Please demonstrate your satisfaction on the follow:

1. How satisfied you are with the curricula offered from your department?

Very satisfied	satisfied	Less than satisfied	Not satisfied

2. Are you satisfied with the number of teaching hours offered from your department?

Very satisfied	satisfied	Less than satisfied	Not satisfied

3. Are you satisfied with the development of work and projects?

Very satisfied	satisfied	Less than satisfied	Not satisfied

4. How satisfied you are with the teaching equipment?

Very satisfied	satisfied	Less than satisfied	Not satisfied

5. Are you satisfied with the communication with your teachers? (Teachers were available when you attempted to contact them?).

Very satisfied	satisfied	Less than satisfied	Not satisfied

Thank you for your time.

APPENDIX B

A. Interviewing teaching staff

The questions answered by teachers during the interview were structured as follows:

1. What is your opinion on the curricula in engineering?

2. Do you believe that the time of study must be 5 or 4 years?

3. Do you believe that the subjects are taught with a high scientific level as students receive the necessary training?

4. Do you believe that the teaching hours are the needed?

5. Do you believe that the students should have more practical experience before their graduation?

6. Is the way of teaching attractive to students?

7. What do you think that should be changed in Greek Universities?

8. What is your position on Bologna Declaration?

B. Interviewing students

After completing the questionnaire the students gave answers to the following questions:

1. Does the curriculum meet your expectations and interests?

2. What you like most in your department's program?

3. If you have the opportunity what you change?

4. What is your opinion about the existence of two types of engineer in Greece?