Investigating Gaps in Higher Civil Engineering Education regarding Students' Level of Knowledge and Understanding of Basic Structural Concepts

by

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DECLARATION

I declare that the work undertaken for this MPhil Dissertation has been undertaken by myself and the final Dissertation produced by me. The work has not been submitted in part or in whole in regard to any other academic qualification.

Title of Dissertation:

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ABSTRACT

A key issue for young graduates of civil engineering is their ability to obtain the necessary knowledge and understanding of the basic concepts of civil engineering, which are necessary to work with success in real projects. The literature review indicates that there are some gaps between the understanding of civil engineering concepts provided to students studying at higher education institutes and the kind of understanding of these concepts that the workplace reality needs.

The research data is collected from students studying a civil engineering course in Greek and Scottish universities through a questionnaire that contains two different sections. The first section investigates students' knowledge level and the second section their understanding level of specific structural concepts.

Research data analysis is carried out based on the average percentage values but also on the highest and lowest percentage values in each of the following 4 categories in each of the universities tested; the categories on which data analysis is carried out are: 'Good Knowledge – Good Understanding,' 'No Knowledge – No Understanding,' 'Lack of Knowledge' and 'Lack of Understanding.' Moreover, a comparison between all universities tested in this research is presented by following the same procedure.

The outcome of the research indicates that the number of students in all universities tested that appear to have a problem in either knowledge or understanding or both of the structural concepts addressed in the questionnaire is quite high. On the other hand, the number of students that have a good level of knowledge and understanding of the structural concepts is low enough to allow further investigation in order to formulate new proposals for the improvement of civil engineering education.

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NOTATION

ABET	Accreditation Board for Engineering and Technology
BEng	Bachelor of Engineering
BSc	Bachelor of Science
CE	Civil Engineering
ICT	Information and Communications Technology
IStructE	Institution of Structural Engineers
MEng	Master of Engineering
MSc	Master of Science
NTUA	National Technical University of Athens
T.E.I.	Technological Educational Institute

MARKING NOTATION

GG	Good Knowledge – Good Understanding
PG	Poor Knowledge – Good Understanding
NG	No Knowledge – Good Understanding
GN	Good Knowledge – No Understanding
PN	Poor Knowledge – No Understanding
NN	No Knowledge – No Understanding

CHAPTER 1 INTRODUCTION AND OVERVIEW OF THE STUDY

1.1 Introduction

The aim of the present chapter is to provide an introduction and overview of the study. For this purpose, it starts with a background of engineering education which introduces the reader to the general subject of the study. Moreover, a personal and research statement are also presented in this chapter. Then the research aim and objectives are provided and the research questions are introduced. Finally, the significance of the study and the structure of the thesis are elaborated upon.

1.2 Personal Statement

A phenomenon that has been observed in the final stages of my study in BEng in Civil Engineering at T.E.I. of Serres, Greece in 2003 was the great difficulty that I and most of my fellow class-mates had in completing our studies and assignments. We all acknowledged that while we had passed our exams with a good grade and seemed to know the taught material, we could not apply our knowledge in order to complete our dissertation, and hence our studies, simply because we did not have a solid understanding of certain structural concepts. This was an observation which was initially made by our professors, and subsequently by us.

Thus during the course of my six-month internship, which was required as part of my BEng degree in Civil Engineering and where there were recent graduates from all civil engineering universities in the country in Greece, our employers came to the realization that it would be very difficult for us all to undergo training because even though we had the relevant background knowledge, we could not apply what we had learnt because we had not understood the concepts in great depth. Thus the employers were of the opinion that in order to rectify this situation, the graduates would first have to work hard and then subsequently after acquiring a lot of experience they would be able to come to terms with

an understanding and application of these structural concepts in the workplace, and thus become productive.

When I got a job as a civil engineer, I observed that all graduates who did not have experience on the job faced exactly the same problems. This observation or issue started to concern me on a more personal level and so I contacted the Human Resources department of the company where I was working and asked them what it was exactly that they were looking for when they hired new recruits or graduates without solid experience in the field. The answer I received was that what they were looking for was extremely hard to find; that is, graduates who were equipped with a good understanding of structural concepts, since that would help the company to train these newly recruited graduates as fast as possible, and thus increase the productivity and efficiency of the company at a much faster level.

One other of the main reasons that I have decided to do research on Enhancement of Higher Education in Civil Engineering (CE) is my personal experience as a student at Edinburgh Napier University, where I studied for my MSc in Advanced Structural Engineering in the academic year 2007-2008. During my MSc studies I was introduced to Structural Eurocodes and learned how to use them. As Eurocodes are soon going to be used by all civil engineers in the whole of Europe it has become mandatory for every civil engineering student to be familiar with them and to have a sound understanding of the design processes based on them. However, in order for a student to follow any of the design codes he or she should have first gained a sound understanding of all the fundamental structural mechanics and design concepts.

This was mainly caused due to knowledge gaps that all of us had after completing our graduate studies in CE. These knowledge gaps were a consequence of not having achieved a sound understanding of fundamental structural concepts during our Civil Engineering undergraduate studies.

1.3 Research Statement

The thesis research statement is the following:

'To investigate if the number of students in Greek and Scottish universities who face a problem in either knowledge or understanding or both in some basic structural concepts is considerably high'.

1.4 Background

At the end of the 20th century educational needs have changed dramatically as a function of the rapid development of productive activities, the globalization of the economy and the on-going dissemination of scientific information. The modernization of the economy, which coincides with the development of technology, productivity growth and competition, requires the constant development of individuals' education as a means of acquiring and developing the skills necessary for adapting to the modern era. Professional survival requires constant adjustment to new conditions, updated knowledge and continuing education and retraining. Getting a university degree is an important factor qualification necessary for entering and remaining in a highly competitive and uncertain market labour. The massive search access to higher education in recent decades of the 20th century in developed countries is directly related to the crucial role of scientific knowledge and the high demand for linguistic and other skills, which are more closely linked to a country's socio-economic development and in many cases with the formation of national consciousness. Meanwhile, the massification of university studies has led to a rapid increase in the operating costs of universities and often an unresponsiveness of traditional educational structures demand (Kawachi et al, 2008). Therefore, it is important to study the concept of education in civil engineering as it has been shaped during the past years so as to find the possible gaps that exist and to make suggestions on how to improve higher education in civil engineering.

The goal of undergraduate engineering instruction is to 'ensure that graduates of accredited engineering programs have the skills they need to become productive members of the profession' (Canadian Council of Professional Engineers, 2008). In striving to do so, engineering educators take an active role in developing the curriculum, instruction material, assessment methods, and delivery systems to help students become productive members of the profession, and of society in general. Students enrol and participate in a variety of courses during their tenure at Canadian universities, covering a broad range of subjects. Of these fields of study one of the most critical is engineering design. Tom Brzustowski, former President of the Natural Sciences and Engineering Research Council of Canada, defines design as the 'central creative process' of engineering (2004). As it is plainly apparent how important engineering design is to a student's development, improving upon design education can reap benefits for the student, the profession, and society. While design is one of, if not the most, important elements of engineering, it has not taken its rightful place within the curriculum. For over 40 years, engineering education has become more theoretical and analytically focused, losing some of the emphasis on the creative process, including design (May, 2006).

1.5 Research Aims and Objectives

The aim of the present study is to explore if there is a lack of understanding or knowledge or both among students in Greek and Scottish universities regarding certain principal concepts in civil engineering.

The objectives of the study are illustrated as follows.

- To organize and carry out interviews in Greece and Scotland with Civil Engineering professors / lecturers, the heads of human resource departments of construction companies and both undergraduate and postgraduate students.
- To investigate which structural concepts are considered, by professors/lectures and also by the industry, as the most commonly accepted and absolutely necessary

basic structural concepts that a civil engineering graduate should know and understand in depth.

- To construct a questionnaire in order to examine students' knowledge and understanding of the basic structural concepts as described in the first objective.
- To track the quickest, simplest and most effective and suitable way of testing students' knowledge and understanding of each of the basic structural concepts that the questionnaire would address.
- To use a pilot study to ensure that the respondents would answer each question of the questionnaire without being puzzled.
- To distribute the research questionnaire in as many Scottish and Greek Universities as possible in order to obtain research data from two different countries.
- To analyse the research data collected via the questionnaire, by conducting a statistical analysis in order to obtain descriptive statistics of the students' answers.
- To investigate the average percentage values of students studying in Greek and Scottish universities that have a good level of knowledge or understanding or both or, conversely, have a lack of knowledge or a lack of understanding or both of the basic structural concepts addressed in the questionnaire of this research project.
- To investigate the percentage value of students who have a below average level, an average level or a very good level of knowledge and understanding of the structural concepts tested in this research.
- To investigate in which university and in which of the ten questions of the questionnaire students appear to have the biggest problem in their knowledge and/or understanding.
- To examine which one of all universities in this research has the largest number of students who have both a good level of knowledge and understanding of the

structural concepts and at the same time which university has the lowest number of students who are facing either lack of knowledge or lack of understanding or both of the structural concepts addressed in the questionnaire of this research.

- To investigate which Greek or Scottish University tested in this research work, regarding a Master degree, appears to have the largest number of students who have both a good level of knowledge and understanding of the structural concepts addressed in the research questionnaire.

1.6 Research Questions

The research questions of the thesis are the following:

1. Do students in Greek and Scottish universities who pass our conventional examinations have an adequate level of knowledge and understanding of the concepts which these examinations should cover?
2. Is the number of students that appear to have a good or, conversely, a lack or poor level of knowledge and understanding in basic structural concepts in Greek and Scottish universities high?
3. Is there any difference between students' knowledge and understanding level of basic structural concepts in Masters as opposed to Bachelor's degrees in civil engineering in different universities?

1.7 Contribution of the Study

One of the main aims of this research is to investigate if there are discrepancies between students' answers and their real understanding of the structural concepts addressed in the questionnaire.

This is an important issue because the demands of the workplace require a solid understanding of such concepts and students may graduate without having an in-depth understanding of them. If such an issue is revealed throughout this research then it could lead to further research and eventually to the formulation of new proposals for the improvement of civil engineering education.

Moreover, this research work, along with its methodology, could be applied in the future by other research students in other engineering courses such as Timber, Mechanical, Electrical or Electronic engineering courses or in any Engineering science. This research work could thus contribute to improving the quality not only of Civil Engineering education but in general the quality of any kind of engineering education.

Finally, it is worth mentioning that this research uses a sample of foreign students at both Greek and Scottish universities. This suggests that further research could take place in the future, in different countries, to investigate if Civil Engineering graduates' lack of knowledge and/or understanding of basic concepts is a global phenomenon.

1.8 Structure of the Thesis

Chapter 1 serves as an introduction guiding the reader through the main purposes and objectives, as well as research questions, of the study.

Chapter 2 establishes the related literature. The aim is to identify the differences between having the knowledge and understanding of the basic principles of civil engineering. The literature review will also discuss whether the context of the modules taught in universities is related to the reality of the workplace.

Chapter 3 provides an overview of the research methodology which will be followed in the next chapter in order to examine the research hypotheses. It is divided into five subsections. In the first subsection research questions are formulated. Then, the research design is discussed and subsequently the sampling procedure is presented. Next, the

questionnaire is discussed and the questionnaire's validity is elaborated upon. After that, the statistical procedure is presented and ultimately the methodology chapter concludes.

Chapter 4 presents the results of the questionnaire used for each university tested in this research project. The average percentage value of student answers in four research data analysing categories along with the highest and lowest values in these four categories is provided. A discussion of the results for each university is also provided.

Chapter 5 presents a comparison of the research results between the universities tested. A comparison based on the average percentage value of student answers in four research data analysing categories is also presented in more detail. Moreover, a comparison based on the highest and lowest percentage value in each of these categories is provided. Additionally, a comparison based on the highest and lowest percentage value in each question of the questionnaire along with a comparison between BSc-BEng and MSc-MEng courses is presented. Finally, a discussion of the results is also provided.

Finally, the sixth chapter presents a summary of all the research results along with a discussion of the general findings. The chapter concludes by gesturing towards the need for future work and research in this area.

CHAPTER 2 LITERATURE REVIEW

2.1 Civil Engineering Education

At the end of the 20th century educational needs have changed dramatically as a function of the rapid development of productive activities, globalization of the economy and the on-going dissemination of scientific information. The modernization of the economy, which coincides with the development of technology, productivity growth and competition requires the constant development of individuals' education as a means of acquiring and developing the skills necessary for adapting to the modern era. Professional survival requires constant adjustment to new conditions, updated knowledge and continuing education and retraining. Getting a university degree is an important factor qualification necessary for entering and remaining in a highly competitive and uncertain market labour. The massive search access to higher education in recent decades of the 20th century in developed countries is directly related to the crucial role of scientific knowledge and the high demand for linguistic and other skills, which are more closely linked to a country's socio-economic development and in many cases with the formation of national consciousness. Meanwhile, the massification of university studies has led to a rapid increase in the operating costs of universities and often an unresponsiveness of traditional educational structures demand (Kawachi et al, 2008).

Therefore, it is important to study the concept of education in civil engineering as it has been shaped during the past few years so as to find the possible gaps that exist and to make suggestions on how to improve higher education for civil engineering students.

2.1.1 A brief introduction to the development of civil engineering education

Civil engineering is a not a new scientific principle. The story of civil engineering goes together with the development of building and constructions throughout the history of mankind. Civil engineering started from the early days of the first organized civilizations, which were developed in the Middle East, Egypt and later in Greece and South Europe as one of the most important scientific disciplines along with mathematics, medicine,

philosophy and literature. In many cases the states had to develop some massive projects, such as the pyramids or Athens' Acropolis which needed not only the finding of the right materials and builders but also the presence of civil engineers to monitor the whole process (Shroff and Dhananajay, 2003). The education of civil engineers took place with informal ways such as with mentoring where in most of the cases the apprentice was the son of the engineer and the mastery of civil engineering was considered as a secret which had to be kept within the limits of the family of the engineer or of the few civil engineers that could be found. However, as mankind started developing new structures and cities were in need of massive constructs such as roads and government buildings and housing projects, engineering started to have high demand which created the need to produce more engineers. The outcome was that from the 15th century many stonemasons and other artisans became master builders which was the equivalent of today's civil engineering. The next step was the development of private schools and later of university departments, firstly in Italy and Germany and then all over the world (Narayanan, 2003).

According to Atkan et al (2007), the teaching of civil engineering on higher education developed based on various principles and techniques throughout time. As the society and the techniques of engineering changed, the way of teaching civil engineering changed. For many years civil engineering was applied mostly for large building projects which required the presence of an engineer. However, after the second W.W. the presence of a civil engineer was necessary due to changes on the legal framework of this profession. The conditions and requirements for a new construct changed and became very strict, hence there was an increased need for engineers and this led to the creation of civil engineering departments in most of the higher education institutes in the USA and all over the world. Together with the development of those departments many new approaches and methodologies were developed. Atkan et al (2007) refer to the fact that the creation of so many departments created a large number of graduate engineers who had a solid academic background but lacked a 'field-centred' culture and the development of skills which would be needed in the labour market of civil engineering. Students were not equipped with the skills which were necessary to construct and manage a building. There was a need for a greater focus on the combination of field techniques

with pedagogical doctrines and diversity on the content of those programs. Furthermore, Atkan et al (2007) have remarked the lack of a global standardized system regarding what to include in a civil engineering course.

Anderson et al (2007) seem to agree with Atkan et al (2007) on the issue that there is a need to reconsider the curriculum of civil engineering in higher education institutes. Anderson et al (2007) have made a comparison between the changes that have occurred in the Department of Civil and Environmental Engineering at the University of Wisconsin – Platteville (UWP) from 1985 to 2005. The findings of the paper indicate that there have been several changes, including the introduction of ICT and of new construct methods while emphasis is given also on the sustainability of constructs. Of course there is a core of modules such as soil mechanics and many others which compromise the traditional civil engineering modules.

Indeed, as society and its values change, civil engineering has to change also (Atkan et al, 2007). This can be seen from the work of Teixeira (2008) and Chau (2008), who have worked on the incorporation of the concept of sustainability on courses made for civil engineers. During the past years there has been a negative perception and stance of society towards the construction of building projects in terms of their effects on the environment and on the quality of life. Teixeira (2008) examines the case of civil engineering curricula in Portugal. The paper indicates that the Portuguese universities focus on the standard courses for site management and construction but they do not include modules regarding the construction's management. Issues such as waste management, the contamination of land and water, noise, etc., are out of the core modules. The survey which took place among six Portuguese universities shows that their syllabus lacks any reference to such matters. However, Teixeria (2008) writes that when the graduates will go to work they will not have a sound knowledge of those skills which are necessary based on EU and national legislation. Therefore, there is a gap between the work reality and the regulation that a civil engineer has to follow what is taught at the universities. Chau (2008) examines the case of a civil engineering curriculum in Hong Kong. His survey has identified a number of barriers on the integration of the content of the university's modules with workplace reality. Chan (2008) mentions the lack of

modules regarding sustainability but also the lack of developing problem solving skills. Indeed, during the construction of a project the engineer would have to face numerous problems and he would need to develop problem solving skills. Those skills need not only a strong knowledge but also decision making skills which are not developed at the university. The survey is very important since Chau (2008) used triangulation. His research included the views of students but also of supervisors on projects and employers. In this way he had the chance to cross-check the results as they derived from the survey. The outcome was that the civil engineering students are not aware of sustainability concepts and this was recognized by those who worked in the workplace.

We must mention that the lack of sustainability in the university's curriculum is just part of the problem. According to Russell and Stouffer (2005), the national curricula of the US for undergraduate degrees in civil engineering are problematic. They rely a lot on technical standards, accreditation and on exams but there is a lack of field research. Manokhoon and Najazi (2007) compare two undergraduate civil engineering programs and the methods used by two universities; one in Florida and another one in Thailand. At this point the interest of the paper veers towards teaching modes. We must mention that national culture has a great impact on the teaching methods and approaches for adult learning (Mantas et al, 2008). Manokhoon and Najazi (2007) claim that the teaching method used at the American university prioritizes students' interaction and participation while in the case of the university in Thailand there is an instructor-led approach with less emphasis on field research and the active involvement of the learner. Another issue was the use of ICT. The American university used the latest advanced technology while the university in Thailand did not rely so much on new technologies. Manokhoon and Najazi (2007) also noticed that in the case of the university in Thailand the knowledge gap of its academic stuff was filled by visiting lecturers from well-known institutions from abroad.

Pender et al (1999) have written about the changes in learning techniques used in the postgraduate courses in Civil Engineering at Glasgow University. The survey indicated the case study approach and project-learning methods as the ones used in the courses in order for the students to acquire the knowledge and skills necessary to meet the aims of

their course which have replaced the traditional learning methods where the lecturer provides a set of notes and exercise that the students would have to answer without giving attention to case studies and problem-solving projects.

On the previous paragraph the use of ICT was mentioned. Indeed, the work of Ebner and Walder (2007) refers to the changes that e-learning has brought about for civil engineering students. The research lasted for 6 years and it took place at the University of Graz in Austria. The project was called iVISiCE (interactive Visualizations in Civil Engineering) and it included a wide range of web page applications such as visualizations, interactive learning objects, wikis, podcasting etc. The paper indicates that those new approaches had a positive reception from students. E-learning is the latest trend in education. Ebner and Walder (2007) note that the key advantage of e-learning is the access to an unlimited source of knowledge and practices. However, there is also the negative aspect that the access to a huge flood of data and information may derail the student from the objective of the course or provide him with access to false information. Therefore, there is a need for guidance from the lecturer. Siqueiera et al (2003) have studied the case of the use of ICT in the University of Lisbon. Among the benefits we can note an increase in students' motivation, independence of education from time and place and collaborative learning where the student comes into contact with the experts or students from other universities.

To conclude at this stage, civil engineering started as a science which was taught from father to son and then to small groups of builders. However, as society and its perceptions on building have changed, so the way that civil engineering was taught from higher education institutes has changed as well. On the other hand, there are several issues which have arisen. For example, we have mentioned that from the development of ICT has emerged the issue of using ICT techniques such as e-learning but also new methods including case study and collaborative learning. However, the crucial issue, which is the gap between the knowledge gained in the classrooms and practical experience, still exists. Numerous cases have shown that the universities cannot provide the practical experience which is necessary for the introduction of the graduate student into the labour market.

2.1.2 Previous research on civil engineering education

We must admit that civil engineering education from an academic perspective is not a new topic. Brohn and Cowan (1977) have conducted a survey on modules related to structural engineering. Their survey indicated that students have not developed a sound understanding of structural behaviour. However, a comment made by Brohn and Cowan (1977) was that students had a very good theoretical background but they lacked a real understanding of the structural engineering concepts and how they could be applied. Cowan (1981) has remarked that a lot of research on the abilities and knowledge of civil engineering students relies on quantitative methods, while the content of the module focuses on exercises with mathematical methods but it does not focus on allowing the students to develop a critical approach and reflection of their study object. Addis (1986) has also mentioned that students of civil engineering courses focus on statistical and theoretical aspects of engineering but not on the reasons why a construct will develop an actual behaviour.

However, when the young engineer will decide to go to work after his graduation he must have the ability not only to determine the condition of a structure but also to develop the ability to understand why a construction is in that situation. Cowan (1981) has written that many graduates have developed unique quantitative competencies but they lack the ability to develop a qualitative understanding of the phenomena associated with civil engineering. Brohan and Cowan (1977) refer to the fact that most examinations on civil engineering rely on questions where the student will have to show his ability to make the appropriate calculations but still does not have the ability to manage the ‘unknown’ variables that may come up during the project. Thus he does not have the ability to cope with uncertainties that may come up during the process.

2.1.3 Problems and gaps in civil engineering education

The aim of this subchapter is to provide a glance into the gaps and the problems that exist in civil engineering education. Such a gap has been identified by Dunican (1983), who refers to the gap between practice and theory. As a matter of fact, the graduate would have to work in the field as a civil engineering professional. However, Dunican (1983) has identified that there is a gap between theory and practice. The divergence gap exists due to the fact that universities rely mostly on developing skills and knowledge related with the theoretical background of civil engineering and not so much on what the civil engineer needs to have in reality.

Addis (1988) has investigated this topic by referring to the reasons which cause this gap. According to his paper, there is a misunderstanding as to the aims of civil engineering. The academics are preoccupied with their academic research and their teaching tasks, which mean that their aim is not significant with the aim of a practitioner who focuses on developing skills which are necessary for his job. These skills do not relate only to his work but also to communication and leadership skills. During his work as a civil engineer the individual will have to face numerous challenges such as communicating with the stakeholders of the project and with his subordinates. Those skills are not taught in the classrooms but emphasis is given mostly on the theoretical background of students. The same argument has been expressed also by Harris et al (1983), who have conducted a survey among civil engineers. The conclusion was that the practitioners expressed their concerns about the outcome of the graduate degrees. Addis (1986) also remarks that education for civil engineers focuses on design and on the extended use of mathematics but not on the reality of the workplace. For this reason the degree courses must also include a variety of topics such as design and qualitative understanding of structural behaviour.

May and Johnson (2008) have remarked that many freshers join the courses with a sufficient lack of knowledge in mathematics and mechanics. According to their paper, there is a need to change the requirements for the entrance of students to civil engineering courses so as to welcome students who will have a very good knowledge in those two

disciplines. Otherwise there is the danger that there may be several setbacks during the courses since they will not understand some basic concepts and the lecturers would have to explain to them what is going on.

There have been many changes in education during the past years. One of the most important changes was the introduction of ICT. Arafeh (2004) writes that the use of ICT may have some advantages such as the use of graphics and visualization but it also fosters distance learning. This means that the student would not have to attend the courses, which is important if the student lives away from the campus or works, while the lecturer would be able to organise the material by using software such as Moodle. However, despite the fact that overall ICT has been welcomed as an approach that leverages the studies of civil engineering, there have been some criticisms over the use of ICT in the study of civil engineering.

According to Arup (1984), the use of computers has reduced the ability of students to understand some basic elements of civil engineering to a great extent. For example, he refers to the case of understanding how structure behaves when it is under loading actions. For Arup (1984) it is essential to allow the students to examine such issues with exercises written on the paper and not via the use of computers which will make all of the thoughts and calculations in an automatic way without leaving space for the student to develop his analytical skills.

However, we must mention that the criticism over the use of computers and other automatic calculations has been made from the very early years of computing. For example, Hilson et al (1970) and Billintgon (1980) have referred to the use of multitask calculators which reduce the ability of the student to develop a qualitative understanding of structural behaviour which is an essential part of civil engineering. Brohn (1984) has continued by claiming that if we think of the case that computers would replace most of the basic human made calculations, then the students will lack the ability to make calculations on structural design which is an essential part of their job. It is important for the students to have the experience of making the appropriate calculations and to understand why they have done them and to interpret the results of their actions. Postle

(1980) has written that a civil engineering student who is doing the calculation on his own will have several gains, such as developing analytical skills and being able to make a 'synthesis' of the findings that he made so as to use them in his field work. Postle (1980) has written that synthesis is even more important than analysis. The use of computers means that a lot of mathematical models related with structural engineering are making the student, who in the near future will be a professional, lose control of the operation of those models. He is not involved in the process of designing and understanding the models anymore or in making experiments so as to find which model fits best with his work. Postle (1980) claims that the automatisation of such procedures creates the so-called 'black box' of computation, which is the fact that the learner receives results without being able to make a qualitative control or judgment on how those results were produced.

Addis (1986) has claimed that using computers and calculators means that the student lacks the ability to understand and acquire knowledge related with the methods used to come to an end-result. Furthermore, the student shows 'faith' in those procedures which means that he is not able to verify whether there can be some kind of a failure or mistake. The outcome is that soon what the learner has acquired from the university lecture will be forgotten. This will have a negative impact when the newcomer will try to work in a real situation. We must not forget that when someone works as a civil engineer he will often have to take some immediate decisions upon the construction field. The engineer will not have the chance to make calculations on his computer nor to run structural models. He must have the ability to run the calculations in his mind without a second thought and of course to produce some results which will make sense and improve the structure of the construction. Hilson (1970), in the early days of the entrance of information technology in the civil engineering classrooms, had claimed that the use of computers would take away from the student the feeling of structural behaviour which was a necessity for understanding the design process.

However, despite the criticisms that some authors have made, computers today are becoming an important part of civil engineering studies. A student has at his disposal a large volume of computers which are able to make tremendous and very difficult

calculations, create and analyse models and find solutions to structural problems. The student is able to use the computers for issues regarding dynamics, non-linear materials, buckling etc. The issue for the student today is how detailed the analysis of the data should be. It is not a question of whether or not to use computers but rather a question of how much the student will use them. However, using computers does not mean that all of a student's worries have been solved. According to MacLeod (2006) a student using computers would have to face two key issues. The first one is to define which model is the most suitable and, secondly, to ensure that the software used does not have any errors and has been validated in terms of how it approaches results. Mann and May (2006) have expressed their deep concerns as to whether the software used by students, which is often downloaded from non-authorized distributors, is of good quality and whether it is frequently updated in order to ensure the quality of the models and the calculations obtained therefrom.

According to an article by IStructE (2002), a key aspect of modelling in civil engineering is the ability of the student to verify and validate the model that he is using along with the analysis methods. According to this report, there are concerns about some computer programs which are models of structural behaviour that have not been validated by experts and the appropriate authorities. The outcome is that no one can guarantee for the students the quality of the software that they are using. However, IStructE (2002) also remarks on the high cost of civil engineering programs. The outcome is that many students are forced to download them since the university does not provide them nor can they afford to purchase them.

An important aspect is the verification of computer results. Verification of computer results means that the user would have to make a number of equilibrium checks combined with hand calculations so as to ensure the validity of the results made by the computer system. According to MacLeod (2007), academia has the responsibility for helping the students to develop skills which will help them not only to run those computer-based models but mostly to be able to understand them and be able to verify the results made. Ji and Bell (2006) have mentioned that since hand calculations have been replaced by computer systems, academia must find new ways of helping the

students to understand the structural concepts of civil engineering. The over reliance of the student on computer systems means that the student is not able to understand complex structures such as bridges and big buildings which are necessary so as to help the student cope with the reality of the workplace. The reliance of students on computer results and processes means that they are unable to judge the reliability of the results but also to get familiar with structural concepts. This means that universities are producing students who can hardly understand some basic concepts of civil engineering. Surely such students will have problems when they go out into the marketplace.

2.2 Contemporary Issues for Education

2.2.1 Difference between 'Knowledge' and 'Understanding' regarding concepts in education

According to Bruner (1966), symbolic concepts help the student to define scientific knowledge and understand the concepts which lie behind every type of knowledge. Furthermore, Cowan (1983) argues that the use of concepts in order to develop knowledge needs to be developed within a certain educational framework. The student needs to understand the subject and sense the concepts which constitute the knowledge. Cowan's (1983) work is important for current research since he has studied how students in universities pass their examinations but at the same time lack a solid understanding of the structural concepts that the university curriculum is supposed to cover. In a similar research, Cowan and Brohn (1977) have found that students do not have a good knowledge of structural behaviour. Despite the fact that they have managed to pass their exams, in some cases with merit, they cannot fully understand some basic concepts. Additionally, Cowan (1980) has not only provided us with the differences between the qualitative and quantitative descriptions when we refer to engineering knowledge but also to how qualitative and quantitative understanding can fit together.

The surveys conducted by Brohn (1982;1983) are also significant. Brohn has written about the effectiveness of visual markers in order to understand the qualitative aspects of civil engineering. He wrote in 1983 that qualitative understanding is much better when it occurs with a picture or a graph which will indicate the examined concept. Brohn (1982) has also mentioned that despite the fact that the visual understanding of the most important concepts is well-accepted by the academic community, universities have still not developed formal methods for indicating to lecturers and tutors how to use visual representations.

Similarly, Postle (1980) has argued that in order to have a deeper understanding of a concept the students should be able to make a synthesis, which means to 'see' the concept and then to combine it with what they have learnt from the related theories taught during the course in order to create a 'synthesis' which will combine elements learnt from the courses and from the examples given in graphical representation. This 'synthesis' is very important since it helps the student to understand the nature of the course.

It is important to mention that understanding and synthesis have become quite important with the wider use of ITC in regards to the learning process for civil engineering students. MacLeod (2007) has referred to the fact that computers can more easily facilitate the models used to understand the concepts of engineering. Of course there has been some criticism regarding the use of computers from authors such as Hilson (1970), who mentions that the use of computers may hinder students' ability to understand some basic structural concepts, while Arup (1984) argues that computers have reduced the ability of the student to understand some basic concepts and make the appropriate calculations since many procedures, including basic calculations, have been computerized with the limited participation of the student. From a critical point of view, this has become more obvious than ever during the last few years since the introduction of ICT into civil engineering courses, which means that many functions which needed mathematical calculations or design by hand are made automatically by computer systems. This, according to Arup (1984), reduces the abilities of the students but also their understanding of how a calculation was produced.

According to Marton et al (1984), effective learning can be reached by two approaches; the deep approach (which is understanding) and the so-called surface approach (which is rote learning). They have claimed that a student would have to choose between these two approaches.

More analytically, the surface approach is the learning process which involves rote memorizing based on a material used without the learner having to understand the basic concepts or even how those concepts are related to the course's aims. In this case the learner does not aim to have a full understanding of the examined concept but is focused on achieving and acquiring high marks. Marton et al (1984) have mentioned that achieving a high mark is often more important than acquiring the knowledge and the skills needed to become a successful engineer. On the other hand, when we refer to a deep approach we have to deal with a learning process in which the learner seeks to obtain a deep understanding of the knowledge found behind the examined courses and topics. The student will not seek to achieve a high grade but to optimize the knowledge given by the university. This means that the student will come into a dialogue with the material used in the course while at the same time developing a critical approach regarding the nature and the content of the course. Therefore, the student will have a deep understanding of the examined theories and approaches. Compared to the surface approach, the student feels lees anxious or threatened.

Based on the analysis given in the above mentioned paragraph, the deep approach of learning includes elements such as a focus on the learning material in order to understand the overall meaning of the course. The factors affecting the deep approach are considered the high intrinsic motivation of the student, the experience that the student may have in the course, low levels of anxiety, and an active attitude during the learning process (Marton et al, 1984). At this point Cowan (1986) adds that in the deep approach the learner achieves more than just a simple understanding of the concept; the learner develops a critical approach on the examined subject. Bruner (1966) has also mentioned that during a deep approach the learner will prioritize the development of physical, visual and linguistic skills in order to understand the subject of the course but also to acquire meta-learning process skills.

On the other hand, the surface approach is an atomistic view of learning. It is characterized by things such as rote memorizing where the learner memorizes parts of the learning material but not the whole meaning of the course. On many occasions the learner will select only the material which is convenient for him and not the material which has a significant importance for the course (Marton et al, 1984). The factors which influence this process include extrinsic motivation such as the hidden curriculum and the anxiety that the student feels. Also on many occasions anxiety may reduce the active and reflective behaviour of the student towards the course material. Another influencing factor is the overload curricula (Marton et al, 1984).

From the points above we have mentioned that there are two key approaches which can help us to understand how students can reach understanding and knowledge. With the deeper approach the student is closer to understanding. He or she has developed a critical stance towards the subject of study and cares for developing his or her skills and knowledge. The surface approach is about focusing on achieving a high grade but without much interest in the content. At this level the student has a sound knowledge, but has still left the understanding behind. The student is pretty anxious about the grade that they will receive and not about the knowledge/skills obtained during the course.

2.2.2 The role of emotions in higher education

The learning process is often influenced by the emotional state of the student. According to Ramsden (1984) the student's emotions will affect the course of the learning process. An example is given by Ramsden (1984), who refers to the case of students who are overloaded with coursework. On many graduate courses the lecturers have produced a very demanding set of courses which include assignments and examinations along with lab tests. This mode of intensive learning creates anxiety for the student and the outcome is that he or she adopts a rote memorization process which leads to surface learning. From a critical point of view this is not the ideal type of learning since the student tries to cope with the over-demanding schedule rather than on acquiring the knowledge.

Ditcher (2001) has pointed out that students feel anxiety when they are in large classrooms and the delivery of the knowledge is lecture-based in large amphitheatres. This does not allow an open dialogue between students and the lecturers. Within the 45 minutes of the lecture the professor would have to deliver the weekly load of material without allowing the students to have an active role. Even in the case where a lecturer would allow the students to make questions and provoke an open dialogue, there are so many restraints – such as the large number of students and the time limits – and this often leads to a dialogue between the lecturer and only a few selective students (Laurillard, 1993). Another issue is that the students dislike being educated in large lecture rooms, which leads them to create a negative stance which prohibits them from having an active role in the learning process. This lack of interaction and dissatisfaction among students means that they can acquire some knowledge but that they are still far away from achieving a critical understanding of the content of the course, and it is still a far away claim that they have acquired the necessary knowledge and understanding needed to become a professional engineer.

Ditcher (2001) has also referred to overload of content on the course which is an obstacle to learning and understanding the principles of civil engineering. The content of the course include a huge variety of secondary activities including contact hours, tutorials and seminars. In many cases students have a limited time due to their professional, family and social obligations. Those activities are disrupting them from focusing on the real essence of their studies, which is to study the course material and do their homework. Given the overload of information they receive in the degree, especially in the senior years, the students would prefer to have a surface approach to their studying.

According to Saljo (1984), the surface approach has been used by students because of the needs of modern higher education institutes to ‘do business’ rather than focus on the core of their operations which is to offer studies. Furthermore, Borhn (1977) has pointed out the same, which is that the current methods used to teach engineering promote the surface approach, which has devastating results for the students’ transition to the labour market. On the other hand, Cowan (1986) claims that universities need to focus on the deep approach since it will allow the students to have a qualitative understanding; they will not

focus only on how an engineering phenomenon occurs but also why and what processes have occurred in order to end up with this phenomenon. For this reason, Cowan (1986) refers to the adult education theories, such as the one made by Rogers, which claims that the adult student must be responsible for his own learning.

At this point we must highlight the use of the means of learning. What we mean here is that during a course the educator may have to use a variety of means to transfer his knowledge to his students and help them to understand the principles of the course. Rose (1985) at this point has focused on the use of visual means, like charts, the use of auditory means, the way that the lecturer talks to his students and the kinaesthetic that the lecturer uses, including his movements within the classroom and his body language. Rose (1985) writes that all of these approaches must be used. Rose (1985) believes that a lecturer must use all of the kinds of means available to him so as to provide a holistic approach to his lecture and to give motives to the young learners to become more active and have a deep approach to learning. Another factor, as mentioned by Bruner (1977), is the mastery of the degree from the side of the lecturer. This refers to issues such as his familiarity with the material used in the course and the motives given to the students so that they can have a more active role in the classroom.

Another factor that we examine is the use of mental models. Skemp (1979) writes that students can learn through a single scheme (mental model) or they can understand a topic from more than one schema, where students understand the meaning of the course through multiple sources of information and knowledge but also from different learning materials which allow them to retain more knowledge in their minds than the isolated rote-memorized learning materials used by single mental models. For Skemp (1979) an effective teaching style in a higher education institute means that the lecturer is able to use the appropriate mix of teaching materials so as to maximize the sources from where the learner will receive his knowledge. This means that the effective lecturer is the one who will be able to maximize the use of as many sources of knowledge as possible. Furthermore, the lecturer would have to strengthen his presence in the classroom with supportive actions such as to consult his students, provide useful material, pay attention to what the learners have to say and adjust the learning material on the experiences and

the existing knowledge of the learners (Cowan, 1980). The above mental methods, which focus on those who combine different means of learning, will optimize the levels of understanding.

In the paragraph above, but also in previous parts of this thesis, we have mentioned that the majority of higher education programmes are teacher-centred. This means that they follow a 'hands off' culture where the lecturer is the epicentre of the learning process and uses materials such as lecture notes and diagrams. Mills (2003) writes at this point that the traditional way of teaching reduces the ability of the students to re-think or develop critical skills upon the examined topic. This decreases the chance of understanding the course and acquiring skills which will be necessary for the transition to the labour market. Mills (2003) also adds that since the 1950s nothing has changed in the way that civil engineering is being taught in universities. The practices are similar and they include large classes and a lecture-based delivery type which is the norm. This comes despite the fact that there are numerous new methods such as tutorials in groups with less than 5 students and blended learning.

As has been discussed above, the use of visual means can have a critical role to play in civil engineering courses. It has been the epicentre of much discussion. For example, Skemp (1979) has noted that the use of visual aids can increase the awareness of the student about the course and motivate him to have a more active role in the whole process. Visual aids facilitate creative thinking and concept formation that lead to a better understanding of the terms. Ornstein (1979) claims that the use of visual aids like pictures or graphs invokes the intuitive mode of thinking for graduate students.

2.2.3 Engineering design and understanding

Engineering design is related to the ability to devise a system so as to meet some of the desired needs and targets set. This means that the person who is involved with this must be able to understand some of the characteristics and the rules that govern issues related

to engineering design. Furthermore, engineering design involves a high stake of creativity and knowledge. According to ABET (1994), engineering design constitutes a large part of civil engineering in universities. The ABET report claims that engineering modules taught in universities must include not only technical issues but should also focus on allowing students to develop their creativity and design. According to Kartam (1998), engineering design is mostly taught during the last years of the civil engineering modules at universities. However, design is not just a simple procedure as some lecturers think and at the same time it involves a great deal of work. For this reason it is essential for it to be taught from the very early stages of the learning procedure since it involves many techniques and needs great effort and practice on the side of the learner, which means it cannot take place in just a few months.

Addis (1986) has linked design with the knowledge that a civil engineer needs in order to accomplish his mission and provide some quality work. This means as long as the student will acquire and develop new knowledge and understanding of civil engineering, then he will have to develop his design skills at the same time. Harris (1980) has mentioned that engineering design is a component of the professional engineer so the universities must help their graduates to acquire all of the necessary skills related with design. Harris (1980) has also written that most of the successful structural engineers are also good in engineer design; they have developed the unique ability to turn their ideas into a design which is a very complicated procedure. Morgan (1971) writes that engineer design is not just making diagrams and drawing plans; it is actually an artistic process where the developer must have plenty of skills, creativity, a very good understanding of the basic engineering principles and their practical application. Therefore, design shall be taught from the very early stages of the learning process till the end of this process (Cowan, 1981).

Indeed, as Williamson and Hudspeth (1982) have claimed, there is a need to have the design at the heart of civil engineer studies and not to consider it as something secondary compared with other modules. Cowan (1981) has claimed that overall design is the final

product of civil engineering studies; it is where the student will show his understanding of the knowledge that he has acquired.

2.2.4 Basic civil engineering /structural concepts

When we talk about structural concepts of engineering, we refer to some basic concepts which the engineer needs to have. These are concepts such as the centroid, the shear centre, the major or minor axis and the deform line of a beam. These concepts are also examined in the questionnaire. There are several terms and concepts that a civil engineer would have to know by heart in order to perform the duties that he has been assigned.

This issue is very important in countries like Greece where the buildings have to face several challenges such as earthquakes, which affect the structural behaviour of buildings in Greece. Therefore, a civil engineer must be familiar with terms such as centroid, minor axis-major axis, and structural behaviour, which are the key structural concepts needed to work properly. As happens in every science, in civil engineering the students must be familiar with these terms in order to become professionals. According to Mills and Treagust (2003) the structural concepts are defined as the terms which compromise the fundamental concepts of civil engineering. Without those terms, it is not easy for anyone not just to graduate but even to work. May and Johnson (2008) have argued that the lack of a sound knowledge of structural concepts creates a problem in the transition from the university to the workplace. In many cases new engineers drop out of work as soon as their employers find out that their newcomers do not have a sufficient understanding of these new terms and are, therefore, not fit for the job.

2.3 Methods of Conducting Surveys

One of the important tasks that a researcher has to accomplish is to read up on the existing literature in order to know what other people have done in the field of research regarding Education in Civil Engineering, and what methods other researchers have used. Then the researcher has to identify the methods that he can use and to pick the most appropriate. According to Bryman (2004) many academic researchers have been criticised or even rejected not for their quality of data but for using the wrong path towards acquiring the necessary knowledge so as to produce the conclusions of the thesis. This means that it is essential for a researcher to state why and how he has used the selected methods.

Before we move on with the justification of the methods used, the author would like to go ahead with the presentation of the research approaches. There are two key philosophies or research approaches; there is the quantitative (positivist) approach and there is the qualitative (phenomenology/interpretive) approach.

According to Collis and Hussey (2009) positivism is a "paradigm that originated in the natural sciences. It rests on the assumption that social reality is singular and objective, and is not affected by the act of its investigation. The research involves a deductive process with a view to providing explanatory theories to understand social phenomena". It relies on the assumption that reality is independent from us and knowledge is produced from scientific verified methods, such as the statistics which derive from statistics, hence from quantitative research. The key limitations of this approach is that it not easy to separate the subject of research from the social context in which they exist. Furthermore, analysing complex phenomena only with a single measure, such as only with statistics, is often misleading (Bryman, 2004; Collis and Hussey, 2009).

On the other hand, there is the interpretivism which is defined as "a paradigm that emerged in response to criticisms of positivism. It rests on the assumption that social reality is in our minds and is subjective and multiple. Therefore, social reality is affected by the act of investigating it. The research involves an inductive process with a view to

providing interpretive understanding of social phenomena within a particular context" (Collis and Hussey, 2009). Interpretivism relies on the assumption that social reality is not objective but highly subjective and hence there is a need for an in-depth look at what causes the social phenomena. It is strongly associated with qualitative research. Its limitations is that it cannot bring results with high reliability while often it relies on the perceptions that the researcher has about reality (Bryman, 2004)

Quantitative research relies on the use of statistical calculations and compares the effects that one variable has on some others it looks at causal. A key advantage of this method is that the researcher can reach a large audience and can draw some solid evidence based on the outcome of the statistics. However, there are some limitations. A key limitation is that it can help us to understand a situation but it cannot help us to go deep in to the examined problem and to find out what has caused this situation (Seale, 1999). In this case we have the qualitative research which comes to fill in this gap by conducting research which aims to interpret the behaviour of the participants. In this case, we have research which uses methods such as the case study analysis, participant observation, in-depth interviews and focus groups in order to generate data which will be interpreted and analysed by the researcher. A key limitation of this method is that there is a high level of bias towards its results and it can generate results which will be based on how the researcher had perceive the examined object (Denzin and Lincoln, 2000).

In an effort to conduct reliable and objective research, quantitative research methods were employed along with some elements of qualitative research. Dörnyei (2007) provides us with an illustrative definition of quantitative research methods:

Quantitative research involves data collection procedures that result primarily in numerical data which is then analysed primarily by statistical methods. Typical example: survey research using a questionnaire, analysed by statistical software such as SPSS or Excel which was used in this research.

The reasons why these methods were opted vary. First of all, quantitative research is based on numbers; numbers are powerful. Still, numbers need contextual support in order not to be faceless. In other words, accurate definitions of the content and the boundaries

of the variables used are essential so that the data analysis can yield acceptable results in the field of social sciences as they do in natural sciences.

However, often the numbers are not enough. There is always a need to have the support of a method which will indicate what lies behind a result and on this field there is the need to have qualitative research.

Next, a priori categorization and the choice of specific variables entails easy processing of the data collected; the variables in turn, lend themselves to assign values to categorical data not to mention that the relationships between variables can be identified and manipulated. Dörnyei (2007) contends that the specification of the relationships among variables consists of the quintessence of the social research.

Furthermore, the quantitative research methods entail statistical analysis which in turn helps to create systematic, reliable, accurate results which are applicable to other contexts. All these elements favour the use of the quantitative research methods. Their downside is that they do not allow the researcher to figure out the reasons underlying the participants' choices. In addition, they offer generalized results without acknowledging the individual entity. Nevertheless, these drawbacks do not seem to be enough to counterbalance the use of the quantitative methods. This is why a questionnaire was employed for this study along with elements of qualitative research. Nevertheless, these drawbacks do not seem enough to counterbalance the use of the quantitative methods - namely, a questionnaire employed for this study along with elements of qualitative research which were provided through in-depth interviews.

Regarding the elements of the qualitative research, the researcher has used a number of questions which relied on tests done to judge the quality of the knowledge and understanding that the students had for the use of the civil engineering method and how it could be used in their future career, which was open to interpretation. Actually, it is not easy to judge who has a good understanding and who does not. Hence, the method included a qualitative approach but there was also an element of qualitative input. Furthermore, the researcher has made a number of in-depth interviews in order to support her research.

Regarding the instruments of collecting data via qualitative research, the key methods are (Bryman, 2004):

- Case study is about going into an organisation analysis where the researcher combines information taken from within the organisation along with her own sources of information, such as observation so to have a full view of his case. In this case the author examines a number of universities and it would be difficult to receive information regarding so many universities.

- The focus group concerns the creation of homogenous groups made up of 6-8 persons who are discussing a variety of issues. The key advantage is that through the discussion the researcher has the ability to listen to a number of arguments in order to determine which arguments are to be favoured. However, there is also the disadvantage that a researcher would have to look carefully so as to create the ideal synthesis of the group. There is also the issue that some persons would not like to expose their views in public for various reasons.

- Participant observation is about taking an active part in the examined processes; i.e. the researcher follows a class of civil engineering and remarks on the progress of the students. However, there are several obstacles, for example, the researcher would have to be granted the authority of observation and she must also find the appropriate funds so as to follow courses in various universities for long periods of time. Hence, it would be very difficult to adopt such an approach.

- In-depth interviews. This is an approach where the researcher has the chance to set up a number of questions but also to discuss these in person with the participant. Actually this is the chosen method. It allows the researcher to go deeply into the examined problem while the participant feels comfortable enough to speak freely. The author has guaranteed the anonymity of the respondents and hence this motivates the participant to express his views without bias.

At this point, it is important to mention that this is an MPhil thesis and this means that the researcher not only examined the existing theory but also produced a genuine outcome

(Bryman, 2004). Therefore, the qualitative input given by the research allowed the researcher to have the necessary autonomy and space so as to produce a genuine theory and define what the level of understanding is of civil engineering methods based on personal observation and interpretation of the data (Shank, 2002).

In this case it is important to mention that there are various data collection methods.

In the case of the questionnaire there are three methods. These are:

- **The phone-based method**. This is a method of collecting survey information by using the telephone. There have been some software products which allow the researcher to produce some automatic procedures so as to speed up the process. The phone-based method has the advantage that it can help the researcher to reach a wide audience but it has the disadvantage that it cannot be used for complex research (Bryman, 2004). For example, in our case the questionnaire included many drawings that the subject of the research would have to examine in order to provide their answer. Hence a phone-based method could not be used in this survey. Furthermore, such a survey is too costly.

- **The web- based questionnaires**. During the past years there have been many surveys which have taken place through the Internet. There have been many web sites and applications which can promote such activities such as Google Docs, Survey monkey and other web sites. The key advantage is that the author can construct the questionnaire within a few minutes and share it with friends using social media. It is also very easy for the participant to fill in the answers of the questionnaire. In addition to this, most of the web-based questionnaires generate the answers along with graphs so they speed up the process of the analysis (Collis and Hussey, 2009). However, in our case a web-based questionnaire would not have an input for adding images and drawings which was necessary for our research. Furthermore, the sample was quite restricted, hence a web-based questionnaire, despite its advantages, could not produce a questionnaire which would meet the needs of this research.

- **Paper-pencil questionnaire**. This is the traditional method. It is the most common method and despite the development of new methods, it has managed to gain the trust of respondents. Actually, the respondent feels very safe and more relaxed with this kind of research. His trace cannot be identified, unlike the previous methods, where the respondent would not feel comfortable in giving out his phone number, email or postal address. Furthermore, this kind of questionnaire allows the researcher to use drawings, which is very important for this research (Bryman, 2004). The researcher can deliver the questionnaire to the respondents directly and they can immediately answer all of the inquires that the respondent may have. For this reason the paper-pencil questionnaire was chosen.

Similarly with the questionnaires there are also various data collection approaches for in-depth interviews. The telephone interviews can save the researcher a lot of time but they are based on the access and availability of the respondent. In addition to this, the lack of physical presence will not help the researcher to gain the trust of the respondent and hence his answers may not reveal the truth or be as in-depth as the respondent would like (Bryman, 2004). The same rule applies for Computer Assisted Personal Interviewing (CAPI), which reduces the ability of the researcher to go deeply into the examined issues and to discuss some of the answers. The respondent will feel isolated and will not give the necessary answers. On the other hand, the researcher has relied on face-to-face interviews. There are many advantages such as that the respondent will trust the researcher but will also have the ability to discuss the contents of the answers (Dörnyei, 2007). For this reason the author has chosen to commit to a face-to-face interview.

CHAPTER 3 METHODOLOGY

3.1 Introduction

The purpose of the present chapter is to provide an overview of the research methodology which will be followed in the next chapter to test the research hypotheses. The research hypothesis of this project is that students who are studying civil engineering in Greek and Scottish universities have a lack of knowledge or understanding or both of the basic structural concepts addressed in the research questionnaire. Hence, this chapter is divided into five subsections. In the first subsection research questions are formulated. Then, the research design is discussed and subsequently the sampling procedure is presented. Next, the questionnaire is examined and its validity is elaborated upon. Subsequently, the statistical procedure is presented.

3.2 Research Design

3.2.1 Research approach

Research design represents the blueprint for the collection, measurement, and analysis of data (Blumberg et al, 2005). For this reason, it is important for unique research objectives and problems to be identified and included in every approach to research. Hence, an appropriate research design can be used as a plan for solving the research problem. Consistent with Burns and Bush (1998), there are three types of research design exploratory research, descriptive research and causal research. In view of the fact that the objective of the present research project is to investigate the quality of civil engineering education in terms of knowledge and understanding of structural concepts in Greece and Scotland, a descriptive research was chosen as the research method. Keeping in line with Burns and Bush (1998), the descriptive research provides answers to questions such as who, what, where, when, and how. Hence, in combination with qualitative and

quantitative research methods, a better understanding of the reasons behind the consumer decision making process can be obtained**.**

However, given certain constraints – word and time limits – the questionnaire survey will be the main method used, along with the statistical analysis which will be used as the basis for an analysis of the findings. Furthermore, the research questions are the hypotheses put forward, and the data collected from the questionnaire will be gathered on an MS Excel spread sheet in order to answer the research hypotheses of the research project.

3.2.2 Data sources

The collection of data can be classified into two categories: primary and secondary. Consistent with Malhotra and Birks (2005), 'primary data are originated by a researcher for the specific purpose of addressing the problem at hand. Secondary data is data that has already been collected for some purpose other than the problem at hand.'

For the purposes of the present project, secondary data such as periodicals, reference books and market data on the Internet were collected in order to obtain the comprehensive background information on the topic of civil engineers' education. In accordance with Malhotra and Birks (2005) secondary data provides a starting point for research and makes the study a more in-depth process.

In contrast, primary data is used specifically since it assists the researcher to answer the research questions and test the research hypotheses of the study, which have been formulated to address specific objectives (Webb, 1999).

Consequently, in order to test the hypotheses of the present research, the questionnaire survey has been preferred as the primary data collection method. In the next paragraph the advantages of primary data collection are discussed.

First of all, it is an effective tool to get opinions, attitudes and descriptions as well as for getting cause-and-effect relationships (Ghauri and Gronhaug, 2002). Furthermore, the questionnaire method can focus completely on the researchers' objectives through the formulation of pertinent questions; the responses are totally relevant to the topic, as area the respondents' answers to the questions. Moreover, the questionnaire can eliminate bias because of the highly personalized responses of the participants, as they relate to each participant's own individual situation. Thus one participant's response is not influenced by that of other respondents (Langford and McDonagh, 2003). In addition to this, with the use of the questionnaire survey all the completed responses can be collected within a short period of time. Consequently, the researcher has decided to use the questionnaire method for collecting primary data based on the above reasons.

3.3 Sampling

3.3.1 Population and sample frame

According to Malhotra and Birks (2005), 'a population is the aggregate of all the elements that share some common set of characteristics and that comprise the universe for the purpose of the marketing research problem.' In this project, the population is defined as all those people who are being trained and educated in order to become civil engineers.

Nevertheless, it is impossible to conduct a survey of the whole population. As a consequence, determining a sampling frame is perceived both as necessary and important, since the representative elements of the target population can be targeted (Malhotra and Birks, 2005).

Consequently, the students in civil engineering departments in Scotland and Greece who are studying in their final year for either a Bachelor or a Master course have been selected as the sampling frame.

3.3.2 Selecting sampling method

As regards sampling techniques, these can be generally categorized into non-probability and probability sampling. Consistent with theory, non-probability sampling relies on the personal judgement of the researcher rather than on the chance to select sample elements (Malhotra and Birks, 2005). Moreover, in non-probability sampling, the chance of selection of a particular population is not known and, as a consequence, the results may not be subject to the entire population (Proctor, 2003). In addition to all the above, non-probability sampling may be useful in order to gain insight into a phenomenon encountered in qualitative research (Ghauri and Gronhaug, 2002). Subsequently, the writer of this project has decided to use simple random sampling (which is a probability sampling) as this study's sampling method, in which each element in the population has a known and equal probability of being selected (Malhotra and Birks, 2005). The advantage of using probability sampling is that with random sampling the element of bias is removed. This is a good method to use in smaller populations. Although it does not eliminate bias completely, it is a faster way of obtaining information. A lot of time and patience is needed if the sample is a large segment of the population, and there is no guarantee that the respondents' answers will reflect what the entire population believes. However, since the researcher had a smaller sample, probability sampling was thought to be the best and most unbiased method at hand for obtaining the required information. Although non-probability sampling is more accurate because you are targeting a specific group, there is likely to be more bias because the sampling is not random.

3.3.3 Sample size

'Sampling techniques provide a range of methods that enable researchers to reduce the amount of data they need to be collected by considering only data from a subgroup rather than all possible cases or elements (McDaniel and Gates, 1998**).**

Keeping in line with Malhotra and Briks (2005), the larger the sample size the lower the likely error of generalising about the population. For this reason, the researcher has decided to set a quote of 63 and 40 questionnaires for the Scottish universities of Edinburgh Napier and Herriot-Watt, respectively, and 234 for the Greek universities.

The research data has been obtained through a questionnaire that was distributed to students studying for a Civil Engineering course in both Greek and Scottish Universities. In Scotland the researcher collected the research results from Edinburgh Napier University and Heriot-Watt University. In Greece the author collected the research results from The Aristotle University of Thessaloniki, The National Technical University of Athens (NTUA), The Technological Educational Institute (T.E.I.) of Pireaus and The Technological Educational Institute (T.E.I.) of Serres.

a) Scottish universities

In total, 103 students studying in Scottish universities have answered the research questionnaire.

Edinburgh Napier University

In Edinburgh Napier University, research results have been obtained from four different courses, an MSc in Advanced Structural Engineering, an MEng in Civil Engineering, a BSc in Civil Engineering and a BEng in Civil Engineering. Sixty three students answered the research questionnaire. Out of the 63 students who answered the questionnaire, 24 were doing an MSc course, 8 students were doing an MEng course, and 25 were doing a BSc course while 6 students were studying for a BEng.

Herriot-Watt University

At Herriot-Watt University, research results were obtained from people in two different courses; an MSc in Structural and Foundation Engineering and MSc in Civil Engineering

and Construction Management, and an MEng in Structural Engineering and in Structural Engineering with Architectural Design. Forty students in total answered the research questionnaire. Out of the 40 students who answered the questionnaire, 21 were studying for the MSc course and 19 students were studying for the MEng course.

b) Greek universities

In total, 234 students studying in Greek universities have answered the research questionnaire. 151 students were doing a BEng in Civil Engineering at a Technological Educational Institute (T.E.I.) while 73 students were doing an MEng in Civil Engineering at the Aristotle University of Thessaloniki and National Technological University of Athens. Note that the research questionnaire was translated into Greek as this was a requirement by the Greek universities in order for the research to be conducted.

Technological Educational Institutes of Piraeus and Serres

At the T.E.I. of Piraeus, research results have been obtained from 87 students who were doing a BEng in Civil Engineering, while at the T.E.I. of Serres, research results have been obtained from 64 students who were doing a BEng in Civil Engineering.

National Technological University of Athens

At NTUA, research results have been obtained from 38 students who were doing an MEng in Civil Engineering.

Aristotle University of Thessaloniki

At The Aristotle University of Thessaloniki, research results have been obtained from 35 students who were studying for an MEng course in Civil Engineering.

3.4 Questionnaire Design

The questionnaire translates the research objectives into specific questions, and answers to these questions provide the data for testing the hypotheses of the study (Nachmias, 1992). In other words, a questionnaire is a formalized set of questions for obtaining information from the chosen respondents. In questionnaire construction, the following guidelines (Hussey, 1997) were followed:

- Questions must be intelligible and unambiguous
- The questionnaire must be clearly laid out, and easy to complete
- The questionnaire must not be longer than is absolutely necessary so that it will not affect response rates and the quality of data
- The respondent should not feel threatened by the experience.

3.4.1 Construction of the research questionnaire

The Appendix A illustrates the questionnaire that was used in this research for data collection. This questionnaire was constructed after completing a series of personal interviews with professors, lecturers and students in each of the universities in which this research was conducted. Moreover, personal interviews were carried out with the heads of human resource departments of construction companies mainly in Greece.

Regarding interviews that were carried out with professors/lecturers in each university in which the research survey was conducted, it was decided that the most suitable people to be asked for advice and feedback from where the people teaching Structural design modules.

Regarding interviews with students studying in each of these universities it was decided that the most suitable students to ask advice and feedback from would be students in the last year of their studies in BEng or BSc courses and also students studying for an MSc or

MEng degree. This was based on the fact that these students would have already been taught these concepts, and all of them would have had a better academic background in the basic structural concepts that the questionnaire addresses.

Regarding interviews with the head of human resource departments of construction companies, it was decided that the best companies to get advice from would be either big construction or fairly small family-based companies looking to mainly recruit graduates. This was based on the fact that in both cases a solid academic background and very good knowledge and understanding of basic structural concepts were necessary.

There were two main aims of the personal interviews. The first was to narrow down the number (to a dozen or less) of the basic structural concepts that would be considered in the industry as absolutely necessary for a civil engineering graduate to know and understand in depth. The second was to track and follow the easiest, quickest, simplest and most suitable way of testing students' knowledge and understanding of each of these basic structural concepts that the questionnaire would address.

The personal interviews with professors, lecturers and the head of human resource departments of construction companies were mainly aimed at revealing and tracking down ten of the most widely accepted (that is, viewed by most people in both the industry and academic arena as being the most significant concepts) basic structural concepts to be addressed in the questionnaire. The same aim applies also to the personal interviews carried out with students studying at each of these universities. These interviews allowed us to track down those structural concepts that students were facing problems with and had trouble understanding.

3.4.2 Interviews with the head of human resource departments of construction companies

One of the main reasons for interviewing six people that were working as heads of human resource departments in construction companies was to track and narrow down the basic

structural concepts that would be considered, by the industry, as absolutely necessary for a civil engineering graduate to know and understand in depth. Another main reason was to get advice and suggestions from the industry, in order to find and follow the quickest, simplest and most suitable and/or effective way of testing students' knowledge and understanding of each of the basic structural concepts that the research questionnaire would address.

Completing the interviews with four people that were working as a head of human resource departments in construction companies allowed the researcher to obtain first-hand knowledge of the structural concepts that the industry considers as absolutely necessary for a graduate civil engineer to know and understand in depth. Some of the concepts they all suggested are the following: the tension; compression; torsion; bending; principal axes; centroid; the geometrical properties of materials; how various structures act under different loading conditions; support conditions; the placement of the main tension reinforcement of a structural element.

It also provided the researcher with a lot of suggestions regarding the simplest, most suitable and/or effective way of testing students' knowledge and understanding for almost all the above mentioned structural concepts. As an example, regarding the tension and compression concepts, their suggestions were focused on using a cantilever beam with a vertical distributed load q applied on it in order to test students' knowledge and understanding of the correct placement of the main tension reinforcement at that cantilever beam.

Moreover, regarding the concept of torsion their suggestions were focused on testing students' knowledge and understanding of the shear - centre of a cross section.

Regarding the concept of bending they suggested that the best way of testing students would be by placing a cross section vertical relative to the ground the first time and parallel to the ground the second time. Students would be asked to find which one of the two cases has the maximum bending resistance.

Furthermore, regarding the concept of the principal axes their suggestion was to use two different symmetrical cross-sections and in each case test students regarding the major axis and the minor axis respectively.

Regarding the geometrical properties of materials their recommendations were about the axis with the maximum and the minimum second moment of area on an equal-angle section. According to their suggestions one of the best procedures in order to test if students know and understand in depth how various structures act under different loading conditions would be to investigate their understanding of the deformed line of a beam.

Finally, regarding support conditions in structures they recommended investigating their reasoning behind choosing which part of a frame can be constructed first, without the existence of any of the other present.

Choosing the most accepted structural concepts as the absolutely necessary basic structural concepts that a graduate civil engineer should know and understand in depth was the first step required by the industry. However, the interviews with people working in the industry also directed the researcher to track, choose and follow the quickest, simplest and the most suitable and effective way of testing students' knowledge and understanding of each of these basic structural concepts.

Their recommendations were based on their own method of testing the applicant's knowledge and understanding when they were recruiting. All of them mentioned that usually applicants are asked to answer questions that do not require any calculations. Moreover, they pointed out that usually most of their applicants for graduate positions complain that they are not familiar with their questions and that the questions in university exams are very different. As an example people applying for graduate positions can do complicated calculations in order to find the centroid of a cross-section that has a complicated shape but a very low percentage of them can find the centroid of a very simple shape of a cross section without using any mathematical equation. Furthermore, they suggested that the best way of testing someone's understanding of any topic is to simply ask for its definition and try to reason what that means in a practical

example by using figures, structural elements and cross-sections that most people are familiar with.

3.4.3 Reasoning behind the choice of the specific structural concepts used and the design of the questionnaire

After completion of the personal interviews a first draft of a list with basic structural concepts was created. This list had actually more than 15 concepts but it was decided that the list had to be reduced to only 10 concepts to reduce the time needed to answer the test in 50 minutes. The ten basic structural concepts that were used in the questionnaire were in fact the ones that both professors/lecturers and the heads of human resource departments of construction companies had suggested, and they were mainly concepts from structural mechanics and structural analysis modules.

May and Johnson (2008) conducted a survey which notes that many civil engineering students come to their courses with a limited understanding of mechanics. Brown (1990) has also confirmed this fact. He emphasizes in his book Understanding Structural Analysis that for the understanding of the Structural Analysis module it is required that there be a conceptual understanding of the Mechanics module. The author has noticed that many students have gaps in comprehending this module. Furthermore, Brown and Cowan (1977) tested graduates and came to the conclusion that they do not have a sound understanding of structural analysis. Thus, it was decided that the questionnaire should include many structural concepts that are taught in Mechanics and Structural Analysis modules.

Finally, for simplicity and time-consuming reasons it was decided that the questionnaire would be constructed in such a way that no math or any calculations would be required in order to complete the questionnaire. This is also the case in the research which was carried out by Brown and Cowan (1977).

Following this research it was decided to investigate separately if students have a good knowledge but also a sound understanding of structural concepts and structural behaviour. Professor Cowan provided valuable feedback on many different aspects relating to this work and, following his advice, it was decided that each question would be divided into two different sections. The first section would investigate students' knowledge while the second one would examine students' understanding of the structural concepts present in the questionnaire. Students' understanding is actually tested in the second section of the questionnaire, where students are asked to provide their reasoning behind their answers to the first section (knowledge) or their definitions of relevant concepts.

As can be seen in the appendix, it was decided that the structural elements used in each section of the questionnaire should be simple**,** and that the figures should be familiar to the students and also widely used in the industry or construction sites, typical examples being cross-section poles and determinate and indeterminate beams.

3.4.4 Description of the Research Questionnaire

The questionnaire used in this study was composed of two sections. In the first section demographic information about the respondents was gathered, while in the second section information regarding the main topic which answers the research questions of the study was collected.

Thus, the demographic section of the questionnaire is used to collect information about the respondent's gender, nationality, their programme of study (BSc, BEng, MEng, MSc), as well as if they are working or not. All the demographic questions are categorical/nominal.

The second section of the questionnaire is used to collect information on the main study and is comprised of ten questions. Each of the 10 questions is composed of two sections. All questions in the questionnaire are divided into 2 sections. The first section examines

the student's knowledge of the concept (if the student knows the answer by selecting one of the available multiple choice answers), while the second section assesses and evaluates the student's understanding (if the student can explain their mode of reasoning in section 1 or provide the definition of a concept). The questionnaire has been constructed in this way since understanding in general is confirmed when people can explain certain concepts or ideas. Thus, there is merit in devising the test questions in such a manner so that the graduates not only provide an answer but also explain their line of thinking. Once the results have actually been obtained, discrepancies will be noted between students' answers in the 'Knowledge' and 'Understanding' sections.

The first question collects information on the centroid and consists of two sub- questions. In the first sub-question, six pictures are shown and the respondents have to choose which one depicts the correct position of the centroid in each picture. In the second sub-question students are asked to define the centroid briefly. The purpose of the first question is to conclude if, first of all, the respondents understand the meaning of the centroid; then, to examine if the respondents are able to determine the focus of a cross before they calculate the position by doing arithmetic calculations.

The second question of the instrument assesses if the respondents can understand and appreciate the shear centre of a cross-section. Furthermore, it investigates if respondents are able to determine where the shear centre of a cross-section is before they need to calculate the position by applying mathematical calculations. Moreover, the question tests if the respondents know the theory of a shear flow generated in an intersection when on a cross-section a shear load is applied. Hence, in the first sub- question respondents have to choose the correct position of the shear centre of the cross-sections in each of the three pictures presented to them and thus choose the correct answer. The second sub-question asks respondents to briefly define shear centre.

The third question of the instrument concentrates on the major axis. Thus, it investigates if the respondents know that the major axis is the axis which has the maximum value of the second moment of area on any cross-section. Furthermore, it assesses if the respondents are able to identify which is the major axis of a cross- section without doing

numerical calculations. Accordingly, a figure of a rectangular section is provided with four (4) different axes marked on it. The respondents are asked to identify which of the four axes is the major axis of the section by choosing the correct answer from a choice of four. The second sub-question asks respondents to provide a brief definition of the major axis.

In opposition to this, the fourth question of the instrument concentrates on the minor axis. The aim of this question is to examine if the respondents know that the minor axis is the axis that has the minimum value of the second moment of area on any cross- section. Additionally, it assesses if the respondents are able to recognize which is the minor axis of a cross-section without having any numerical information. In view of this, a figure with an I-section is provided with four (4) different axes marked on it. The respondents are asked to identify which one is the minor axis of the I-section by selecting the correct answer. The second part of the fourth question asks the respondents to briefly define the minor axis.

The fifth question of the instrument focuses on both the maximum and minimum second moment of area. First of all, the purpose of this question is to evaluate if the respondents can identify which axis has the maximum second moment of area, I_{max}, and which axis has the minimum second moment of area, I_{min} , in a given cross- section without the provision of any arithmetic (math) information. Additionally, it examines if the students know how the axes of symmetry are related to the principal axes. Besides, the purpose of this question is to investigate if the respondents can identify from which of the two principal axes the majority of the cross-section's material abstains, and also near to which of the two principal axes the majority of the cross-section material is located without being provided with any numerical information. For this reason, a figure is provided with an equal-angle section and four different axes marked on it. The respondents are asked to identify which of the axes has the maximum second moment of area - I_{max} - and which axis has the minimum second moment of area - I_{min}. The respondents are asked to select the correct answer separately for each second moment area - I_{max} and I_{min}. The second subsection asks the respondents to provide a brief justification of their answers separately for each second moment area.

The sixth question aims to investigate if the respondents recognize that the stiffness of a beam is proportional to the second moment of area of the cross-section of the element. Furthermore, this question aims to clarify if the respondents appreciate that the bigger the second moment of area about an axis the more difficult it is for a section to bend around this axis. Finally, the question investigates if they can answer correctly without the provision of numerical information. Accordingly, in the first sub-question two figures are provided, namely a and b, with two different placements of exactly the same rectangular plate in space, which is supported on two masonry walls. In Figure (a) the plate is illustrated horizontally placed in space relative to the ground while in Figure (b) exactly the same plate is illustrated placed vertically in space relative to the ground. The respondents are asked to choose the correct answer on the assumption that for both cases exactly the same vertical force F is applied and at exactly the same point on the plate. The second sub-question asks the respondents to choose at least one correct answer from a list of five in order to scientifically explain their answer.

The seventh question aims to assess if the respondents can choose the correct shape of the deformed line (shape) of a beam. Moreover, it aims to evaluate if the respondents can correctly identify how the beam is directed at the points of support by applying a load in clockwise or anticlockwise rotation at the end of the beam. Besides, the purpose of this question is to examine if the respondents can give correct answers when there are different ways of supporting the same beam using the same charge. Accordingly, the question presents the respondents with three different cases and each case is illustrated with four different shapes of the deformed line of a beam. In the first case the illustrated beam is named as Beam (i), in the second figure the illustrated beam as Beam (ii), and in the third figure the illustrated beam as Beam (iii). Respondents have to answer which one of the cases (a), (b), (c) and (d) is the correct shape of the deformed line of the Beam (i), Beam (ii) and Beam (iii). In the second sub-question respondents are asked to briefly justify their answer for Beam (i) only.

The eighth question aims to assess if the respondents can determine how to deform the beam due to a temperature increase at the exact point shown in the figure. Moreover, the question examines if the respondents can select the right shape of the deformed line of

the beam, as well as if they can correctly appreciate the clockwise or anticlockwise rotation. Finally, this question aims to identify if they can give correct answers when there are different ways of supporting the same beam by applying the same charge.

The ninth question aims to examine if the respondents can distinguish which of the three provided parts of the frame can be built on the ground. Furthermore, it examines if the students can give the correct answer without doing any mathematical calculations. The second sub-question asks the respondents to scientifically explain their answer.

The tenth question examines if students can distinguish in which part of the cantilever beam, when a vertical load q is applied to it, the tensile stresses and compressive stresses appear. Furthermore, it investigates if students know that the main tension reinforcement of a section should be placed at the part on the section where tensile stresses are present. The second sub-question asks the respondents to choose at least one correct answer from a list of four in order to scientifically explain their answer.

3.4.5 Rating students' answers

As described in the previous section, the questionnaire used in this research for data collection was constructed in order to investigate both students' knowledge and understanding of each of the ten basic structural concepts addressed in it. Each question in the questionnaire consists of two parts. The first one investigates knowledge and the second part addresses understanding. A score for knowledge and for understanding was used to distinguish if a student presents with a score of 'good,' 'poor' or 'none.' However, it was decided that understanding could not be considered as being 'poor' since you either have an in-depth understanding of something or you do not. Thus, knowledge was given a rating of either 'good,' 'poor' or 'none' while understanding was considered as being either 'good' or 'none.' Having this rating in mind, student answers were classified into six categories as shown below:

1. Good Knowledge – Good Understanding
2. Poor Knowledge – Good Understanding
3. No Knowledge – Good Understanding
4. Good Knowledge – No Understanding
5. Poor Knowledge – No Understanding
6. No Knowledge – No Understanding

Note that in Questions 3 and 4, it is assumed that a student has poor knowledge when s/he has answered axis d-d which is the symmetrical axis of the cross-section in the first section and the same time s/he gives a right answer in the second section. On the other hand, if students have answered axis d-d in the first section and give a wrong answer in the second section this means that they have no knowledge. Moreover, if students give as an answer the axes a-a or c-c then they have no knowledge without taking into consideration the second section of the question because these axes are not the symmetrical axes of the cross-section.

In the next chapters and mainly in the appendices of this research, symbols are used for each of the above categories in order to draw tables and reduce the use of text.

Table 3.1 below shows the six categories of students' answers along with their symbols as they are used in this research.

Table 3.1 – Symbolism and title of the six categories of students' answers

Symbols	Student answers
GG	Good Knowledge – Good Understanding
PG	Poor Knowledge – Good Understanding
NG	No Knowledge – Good Understanding
GN	Good Knowledge – No Understanding
PN	Poor Knowledge – No Understanding
NN	No Knowledge – No Understanding

3.4.6 A quick explanation of each student answer category

An explanation of each student answer category is provided below.

1. ‘Good Knowledge – Good Understanding.’ Symbol “GG” is used to classify a student answer in this category. A student answer rated as ‘Good Knowledge – Good Understanding’ means that the student has provided correct answers to both the first and second sections (Knowledge and Understanding) of a question in the questionnaire.

2. ‘Poor Knowledge – Good Understanding’. Symbol “PG” is used to classify a student answer in this category. A student answer rated as ‘Poor Knowledge – Good Understanding’ means that the student has provided correct answers to all but one of the multiple choices in the first section (Knowledge) and a correct answer in the second section (Understanding) of a question in the questionnaire.

3. ‘No Knowledge – Good Understanding.’ Symbol “NG” is used to classify a student answer in this category. A student answer rated as ‘No Knowledge – Good Understanding’ means that the student has provided two or more wrong answers to the multiple choices in the first section (Knowledge) and a correct answer in the second section (Understanding) of a question in the questionnaire.

4. ‘Good Knowledge – No Understanding.’ Symbol “GN” is used to classify a student answer in this category. A student answer rated as ‘Good Knowledge – No Understanding’ means that the student has provided correct answers to all of the multiple choices in the first section (Knowledge) and a wrong answer in the second section (Understanding) of a question in the questionnaire.

5. ‘Poor Knowledge – No Understanding.’ Symbol “PN” is used to classify a student answer in this category. A student answer rated as ‘Poor Knowledge – No Understanding’ means that the student has provided correct answers to all but one of

the multiple choices in the first section (Knowledge) and a wrong answer in the second section (Understanding) of a question in the questionnaire.

6. 'No Knowledge – No Understanding.' Symbol "NN" is used to classify a student answer in this category. A student answer rated as 'No Knowledge – No Understanding' means that the student has provided two or more wrong answers to the multiple choices in the first section (Knowledge) and a wrong answer in the second section (Understanding) of a question in the questionnaire.

3.4.7 Research data analysis categories

By analysing and combining some of the six student answer categories as described in previous section, research data is analysed in the next chapters, for each university, according to the four following categories:

1. Good Knowledge – Good Understanding
2. No Knowledge – No Understanding
3. Lack of Knowledge
4. Lack of Understanding

A list of each research data analysis category and a quick explanation of them is provided below.

1. 'Good Knowledge – Good Understanding.' A student answer rated as 'Good Knowledge – Good Understanding' means that the student has provided correct answers to both the first and second sections (Knowledge and Understanding) of a question in the questionnaire.

2. 'No Knowledge - No Understanding.' A student answer rated as 'No Knowledge – No Understanding' means that the student has provided two or more wrong answers to the multiple choice questions in the first section (Knowledge) and a wrong answer in the second section (Understanding) of a question in the questionnaire.

3. ‘Lack of Knowledge.’ A student answer rated as ‘Lack of Knowledge’ means that the student has provided two or more wrong answers to the multiple choice questions in the first section (Knowledge) of a question in the questionnaire. Note that in this case we do not take into consideration the second section of any question in the questionnaire as we are interested in investigating if a student has a lack of knowledge of the structural concepts tested. The category ‘Lack of Knowledge’ is in fact the sum of the two student answer categories ‘No Knowledge – Good Understanding’ and ‘No Knowledge – No Understanding’ as described in previous section.

4. ‘Lack of Understanding.’ A student answer rated as ‘Lack of Understanding’ means that the student has provided a wrong answer in the second section (Understanding) of a question in the questionnaire. Note that in this case we do not take into consideration the first section of any question in the questionnaire as we are interested in evaluating if the student has a lack of understanding of the structural concepts tested. The category ‘Lack of Understanding’ is in fact the sum of the three student answer categories ‘Good Knowledge – No Understanding,’ ‘Poor Knowledge – No Understanding’ and ‘No Knowledge – No Understanding’ as described in previous section.

3.5 Pilot Testing and Validity

Pilot testing refers to testing the questionnaire on a small sample of respondents to identify and eliminate potential problems’ (Malhotra et al, 2003).

Riley (2000) has argued that the rationale for carrying out pilot testing is in order to observe whether the methods selected meet the research objective. In other words, pilot testing intends to refine the questionnaire so that the respondents will answer the questions of the instrument without obstacles.

Saunders and Thornhill (2003) note that the pilot test enables the researcher to assess the question's validity and relevance, as well as the likely reliability of the data which will be collected. Therefore, a small sample size of 15 respondents in this project completed the pilot test. The pilot study was conducted carefully and in several stages:

1. Piloting of test items with two colleagues, taking recorded protocols of their thoughts as they worked their way through the items – without conversing with the researcher until afterwards.
2. Modification of items accordingly.
3. The repetition of item 1 with two graduate students who recently completed their degree.
4. Repetition of stage 2.
5. In all of these, a noting of how long the subjects took to cope with the items. Modification and subdivision of the instrument(s) accordingly.
6. Trial of sub-sections of the test on small groups of undergraduates.
7. In all of this, apart from the refining of items, a concentration of attention to the differences between the tick box answers and the reasoning, looking for possible discrepancies.

As regards validity, Saunders and Thornhill (2003) associate it to the representativeness and suitability of the questions and to the overall structure of the questionnaire. In other words, validity is concerned with the question of whether or not each item has been designed to measure a certain particular issue objectively and purposely. Tests of validity are usually highly stressed when conducting actual surveys. However, concurrent validity is difficult to establish due to the lack of equivalent measuring instruments. More importantly, there remains the issue of how to test for it and how to deal with inconsistencies. For these reasons all such tests can remain inaccurate and imprecise (Saunders and Thornhill, 2003).

Overall, this chapter demonstrates the methodological considerations of this study, considerations such as the research approach, the questionnaire design, the formulation of a pilot study, as well as the sampling method and its reliability and validity. Overall, the

chapter not only elaborates upon the methodology used but also on how and why a certain methodology was chosen – that is, either because of its suitability for the purpose or its relevance for the task at hand. In the next chapter I will go on to discuss certain concepts which the questionnaire broaches, and generally discuss the questionnaire in more detail (see ‘Appendix A’ section for a questionnaire sample).

CHAPTER 4 RESULTS OF THE RESEARCH

4.1 Research Data Analysis for Each University

First, the results of the survey will be analysed separately for each university in this chapter and then a comparison of all the universities will follow in chapter 5. The analysis is presented in each case in both numerical and percentage data.

Research data analysis for each university based on:

1. The average (in terms of the 10 questions of the questionnaire) percentage value of students' answers in each of the four Research Data Analysis Categories.

The objective of this analysis is to investigate the average percentage value of students in each university that have a good level of knowledge and understanding, and also to examine the average percentage value of students' answers in each university tested that appear to have either Lack of Knowledge or Lack of Understanding or both.

2. The percentage value of students' answers in each of the four research data analysis categories in each university.

The category 'Good Knowledge – Good Understanding' is analysed, in three categories: the percentage of students who answered correctly between 0 and up to 4 out of 10 questions, 5 out of 10 questions and 6 or more out of 10 questions, in order to investigate the percentage value of students that appear to have a below average level, an average level and a very good level of knowledge and understanding of the structural concepts tested in this research.

Moreover, the categories "No Knowledge – No Understanding'", "Lack of Knowledge" and "Lack of Understanding'" are further analysed in the percentage of students who answered at least 3 and up to 10 out of the 10 questions of the questionnaire.

3. The highest and lowest percentage value of students' answers in each of the four research results analysis categories in all universities tested.

The aim of this analysis is to investigate in which university and in which of the ten questions of the questionnaire students appear to have the biggest problem in their knowledge and/or understanding in each university tested.

Due to the fact that each university analysis includes the same procedure and the results of each university lead to the same outcomes, an analytic analysis is provided for only one university, the Aristotle University of Thessaloniki, and then the results of all other universities tested in this research follow without text details. Finally, in this chapter a summary of all the universities' results is provided.

4.2 Analysis per University - Greek Universities

4.2.1 MEng at Aristotle University of Thessaloniki, Thessaloniki, Greece

At Aristotle University of Thessaloniki the questionnaire was distributed to 35 students of diverse nationality who were studying for a MEng degree course in Civil Engineering.

In the Appendix B there are nine tables and one figure with all research data for this university. Each table shows either numerical or percentage data. A list of all the Tables and Figure in the Appendix B along with a description for each of them is provided below.

Table B.1 shows each student's answer for each question of the questionnaire along with its demographic data. It also illustrates each student's average success percentage (for all 10 questions) in all the students' answer categories used in this research. Note that the symbols in Table B.1 ("GG", "PG", "GK", "PN", "NG" and "NN") correspond to the six students' answer categories as described in Chapter 3.

Table B.2 shows the university's demographic data in numerical format while Table B.3 shows the university's demographic data in percentage format. From Table B.3 one can see that 77,14% of the students who participated in the survey are male and 22,86% are

female. 80% of students are Greeks while 20% are Foreigners. Of the students only 22,86% are working whilst studying while 77,14% of them do not work while studying.

Table B.4 presents the number of students that answered in each of the six student answer categories (as described in Chapter 3) for each of the 10 questions of the questionnaire.

Table B.5 presents the data of Table B.4 in percentage format.

Table B.6 presents the average value (for all 10 questions) in percentage format for each of the six student answer categories (as described in Chapter 3) and Figure B.1 illustrates the data from Table B.6.

Table B.7 presents the average percentage value of student's answers in each of the four research data analysis categories.

Table B.8 presents the number of students that answered in each of the four research data analysis category for each question of the questionnaire.

Table B.9 presents the percentage of students that answered in each of the four research data analysis category for each question of the questionnaire.

4.2.1.1 Research results analysis based on the average percentages of students' answers

In the Appendix B, Table B.4 shows the average values (for all 10 questions), in percentage format, for each of the six students' answer categories. As described in Chapter 3 by combining some of these six categories the research data will be analysed for each university in the next subchapters according to four categories. The four categories are the following: 'Good Knowledge – Good Understanding,' 'No Knowledge – No Understanding,' 'Lack of Knowledge' and 'Lack of Understanding.'

Figure 4.1 below presents the average value (for all 10 questions) in percentage format for each of the four above-mentioned categories.

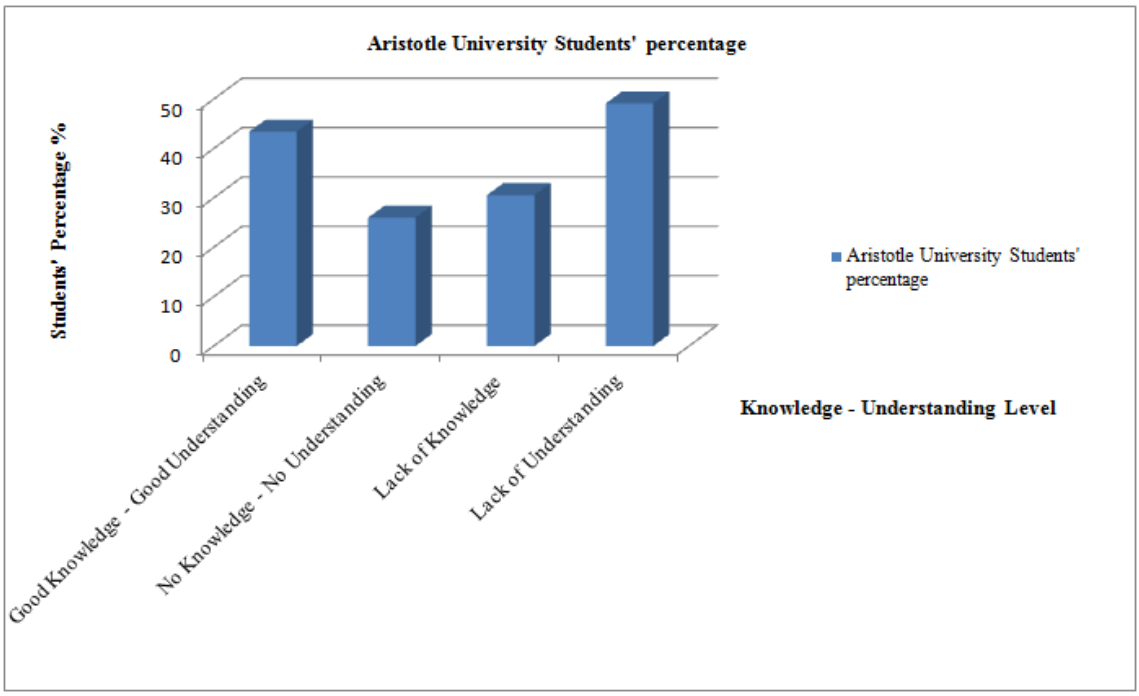

Figure 4.1 - Average percentage value of students' answers in each of the four research data analysis categories at Aristotle University of Thessaloniki

4.2.1.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Table 4.1 presents the number and the percentage value of students that scored 'Good Knowledge - Good Understanding' between 0 and up to 10 out of 10 questions of the questionnaire. For example, in column five of Table 4.1 we can see that 7 of the 35 students, or 20% of students, answered 'Good Knowledge - Good Understanding' in 4 out of the 10 questions of the questionnaire. Note that Table 4.1 is a quick summary of Table B.1 in Appendix B regarding the student answer category 'Good Knowledge – Good Understanding.'

Table 4.1 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Aristotle University of Thessaloniki

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	6	5	7	9	5	2	1	0	0
Percentage of students	0	0	17,14	14,28	20	25,71	14,28	5,71	2,87	0	0

In Figure 4.1 one can see that the average value (for all 10 questions) of students whose answers were rated as 'Good Knowledge - Good Understanding' is 43,43%. This figure indicates that the students who know and understand the basic structural concepts of this university in depth are less than half the students tested in the survey. This result is worrying as it shows that a large percentage of students (56,57%) show gaps regarding their knowledge and/or understanding of the basic structural concepts tested in this research.

From Table 4.1 we can observe that the highest percentage value of students is 25,71% and these are the students that answered 'Good Knowledge – Good Understanding' in 5 out of the 10 questions of the questionnaire. All other percentage values are considerably lower. In this research these students are considered to have a mediocre level of knowledge and understanding as they answered half of the questions correctly.

By summing the percentage values of students who scored 'Good Knowledge – Good Understanding' to 0 and up to 4 out of 10 questions (five first columns of the Table) in Table 4.1 (0% + 0% + 17,14% + 14,28% + 20%), it appears that a high percentage of students in this university (51,42%) are well aware of and understand in depth either 2, 3 or 4 of the 10 basic structural concepts addressed in the survey. This figure is a quite alarming figure revealing a serious gap in civil engineering education regarding these specific basic structural concepts. These students in this research are considered to have a

low level of knowledge and understanding as they answered less than half of the questions correctly.

In the same manner, by summing in Table 4.1 the percentage values of students who scored 'Good Knowledge – Good Understanding' in at least 6 out of the 10 questions of the questionnaire (7^{th} to 11^{th} columns of the Table), it appears that a very low percentage of students in this university (22,85%.) are well aware of and understand in depth either 6, 7, 8, 9 or 10 of the 10 basic structural concepts addressed in the survey. We can also notice that only 1 student scored 'Good Knowledge – Good Understanding' in 8 out of the 10 questions, whereas none of the students scored 'Good Knowledge – Good Understanding' for 9 or 10 of the 10 questions of the questionnaire. This reveals that the students who are well aware of and understand the basic structural concepts in depth are not many. These students in this research are considered to have a high level of knowledge and understanding as they answered more than half of the 10 questions of the questionnaire correctly.

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.2 presents the number and the percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of the 10 questions of the questionnaire. For example, in column five of Table 4.2 we can see that 8 of the 35 students, or 22,86% of students, scored 'No Knowledge – No Understanding' in 4 out of the 10 questions of the questionnaire. Note that Table 4.2 is a quick summary of Table B.1 in Appendix B regarding the student answer category 'No Knowledge – No Understanding.'

Table 4.2 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Aristotle University of Thessaloniki

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	2	5	12	6	8	0	2	0	0	0	0
Percentage of students	5,71	14,26	34,28	17,14	22,86	0	5,71	0	0	0	0

In Figure 4.1 one can see that the average value (for all 10 questions) of students whose answers were rated as 'No Knowledge – No Understanding' is 26%. This figure indicates that the students who do not know the basic structural concepts tested in this survey at all, or have not understood them in depth, are quite many.

From Table 4.2 we can observe that the highest percentage value of students is 34,28% and these are the students that answered 'No Knowledge – No Understanding' in 2 out of the 10 questions of the questionnaire. This figure indicates that there is a considerable number of students in this university that do not know and do not understand 2 out of the 10 basic structural concepts addressed in the questionnaire.

Summing in Table 4.2 the percentage values of students who scored 'No Knowledge – No Understanding' in at least 3 out of the 10 questions of the questionnaire (4^{th} to 11^{th} columns of the Table) it appears that a high percentage of students in this university (45,71%) do not know and do not understand 3 or more of the 10 basic structural concepts addressed in the questionnaire. This figure is a quite alarming figure, revealing a serious gap in civil engineering education.

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.3 presents the number and the percentage value of students that scored 'Lack of Knowledge' for 0 and up to 10 out of the 10 questions of the questionnaire. For example, in column five of Table 4.3 we can see that 12 of the 35 students, or 34,29% of students, answered 'Lack of Knowledge' in 4 out of the 10 questions of the questionnaire. Note that Table 4.3 is a quick summary of Table B.1 in Appendix B regarding the student answer category 'Lack of Knowledge.'

Table 4.3 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at Aristotle University of Thessaloniki

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	1	2	12	5	12	1	1	1	0	0	0
Percentage of students	2,86	5,71	34,29	14,28	34,29	2,86	2,86	2,86	0	0	0

In Figure 4.1 one can see that the average value (for all 10 questions) of students whose answers were rated as 'Lack of Knowledge' is 30,57%. This figure indicates that there are many students showing a serious weakness regarding their knowledge of the basic structural concepts tested in this survey.

From Table 4.3 we can observe that the highest percentage value of students is 34,29% and these are the students that answered 'Lack of Knowledge' in 2 out of 10 but also in 4 out of the 10 questions of the questionnaire. This figure indicates that there are a considerable number of students in this university who show a serious gap in their Knowledge of 2 to 4 questions of the questionnaire.

Summing in Table 4.3 the percentage values of students who scored 'Lack of Knowledge' in at least 3 out of the 10 questions of the questionnaire (4^{th} to 11^{th} columns of the Table) it appears that a very high percentage of students in this university (57,15%) have a serious gap regarding their knowledge of three or more of the 10 basic structural concepts addressed in the questionnaire. This figure is a quite alarming figure revealing a serious gap in civil engineering education.

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.4 presents the number and the percentage value of students who scored 'Lack of Understanding' for between 0 and up to 10 out of the 10 questions of the questionnaire. For example, in column five of Table 4.4 we can see that 7 of the 35 students, or 20% of students, answered 'Lack of Understanding' in 4 out of 10 questions of the questionnaire. Note that Table 4.4 is a quick summary of Table B.1 in Appendix B regarding the student answer category 'Lack of Understanding.'

Table 4.4 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Aristotle University of Thessaloniki

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	2	7	7	7	3	6	3	0	0
Percentage of students	0	0	5,72	20	20	20	8,57	17,14	8,57	0	0

In Figure 4.1 one can see that the average value (for all 10 questions) of students whose answers were rated as 'Lack of Understanding' is 49,14%. This large figure is quite

alarming and indicates that too many students have not understood the basic structural concepts tested in this survey in depth.

From Table 4.4 we can also observe that the highest percentage value of students is 20% and these are the students that answered 'Lack of Understanding' in 3, 4 and 5 out of the 10 questions of the questionnaire. This figure indicates that there is a considerable percentage of students (60%) in this university that do not understand 3, 4 or 5 out of the 10 basic structural concepts addressed in the questionnaire.

Summing in Table 4.4 the percentage values of students who scored 'Lack of Understanding' in at least 3 out of 10 questions of the questionnaire (4^{th} to 11^{th} columns of the Table) it appears that a huge percentage of students in this university (94,28%) do not understand 3 or more out of the 10 basic structural concepts addressed in the questionnaire. This figure is a quite alarming figure revealing a serious gap in civil engineering education.

4.2.1.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.2 below presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire.

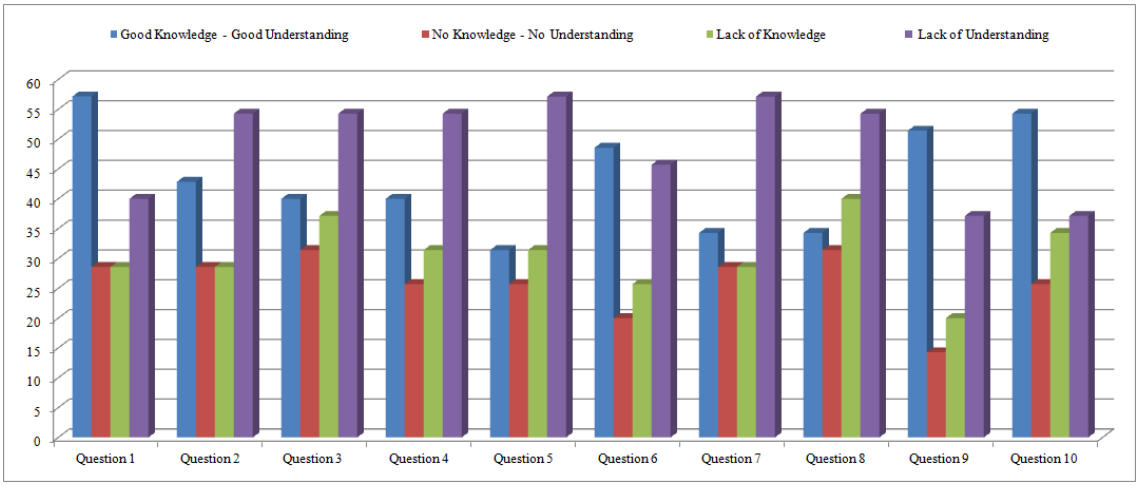

Figure 4.2 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Aristotle University of Thessaloniki

a) Research results analysis based on the highest and lowest percentages for the category 'Good Knowledge – Good Understanding'

From Figure 4.2, and by comparing the percentage values of the category 'Good Knowledge – Good Understanding', we can track the highest and lowest values of this category for each question of the questionnaire.

The highest rates occurred in Question 1 (57,13%), Question 9 (51,42%) and Question 10 (54,28%). Thus, most students of this university are well aware of and show a good understanding of the relevant structural concepts in these questions. Question 1 examines if the students can identify the right position of the centroid of a cross-section along with the definition of the centroid. Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present. Question 10 examines if the students can identify the correct placement of the main tension reinforcement on a cantilever beam when a vertical distributed load q is applied on it.

The lowest rates occurred in Question 5 (31,42%), Question 7 (34,28%) and Question 8 (34,28%). This means that there are not a lot of students that show a good understanding of the structural concepts in these questions. Question 5 examines if the students can identify the axis with the maximum and the minimum second moment of area on an equal-angle section. Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it. Question 8 examines if the students can identify the correct deformed line of a beam which is heated at a certain point.

From Figure 4.2 one can see that in Question 1 the highest percentage rate (57,13%) was in the category 'Good Knowledge - Good Understanding.' Note that this is the highest percentage score for this university in all questions of the questionnaire. Analysing, from a different point of view, the highest percentage rate of the category 'Good Knowledge – Good Understanding' (57,13%) one can see that an equally large percentage of students (43,87%) is experiencing problems in either Knowledge or Understanding or both.

b) Research results analysis based on the highest and lowest percentages for the category 'No Knowledge - No Understanding'

From Figure 4.2, and by comparing the percentage values of the category 'No Knowledge – No Understanding' we can track the highest and lowest values of this category for each question of the questionnaire.

The highest rates occurred in Question 3 (31,42%) and Question 8 (31,42%). Thus, there is a considerable percentage of students in this university that have no knowledge and no understanding of the relevant structural concepts in these questions. Question 3 examines if the students can identify the major axis of a cross section along with the definition of the major axis. Question 8 examines if the students can identify the correct deformed line of a beam which is heated at a certain point.

The lowest rates occurred in Question 6 (20%) and Question 9 (14.28%). This means that the percentage of students in this university that have no knowledge and no understanding of the relevant structural concepts in these questions is not very high. However, these figures are not very small and they reveal a gap in civil engineering education regarding both knowledge and understanding of the relevant concepts tested. Question 6 examines if the students can identify the largest value of the bending resistance on a rectangular plate, when a vertical force *F* is applied at a certain point on the plate, according to its location in space. Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present.

c) Research results analysis based on the highest and lowest percentages for the category 'Lack of Knowledge'

From Figure 4.2, and by comparing the percentage values of the category 'Lack of Knowledge' we can track the highest and lowest values of this category for each question of the questionnaire.

The highest rates occurred in Question 3 (37,13%), Question 8 (40%) and Question 10 (34,28%). Thus, there is a considerable percentage of students in this university that have no knowledge of the relevant structural concepts in these questions. Question 3 examines if the students can identify the major axis of a cross section along with the definition of the major axis. Question 8 examines if the students can identify the correct deformed line of a beam which is heated at a certain point. Question 10 examines if the students can identify the correct placement of the main tension reinforcement on a cantilever beam when a vertical distributed load q is applied on it.

The lowest rates occurred for Question 6 (25,71%) and Question 9 (20%). This means that the percentage of students in this university that have no Knowledge of the relevant structural concepts in these questions is not very high. However, these figures are not

very small and they reveal a gap in civil engineering education regarding knowledge of the relevant concepts tested. Question 6 examines if the students can identify the largest value of the bending resistance on a rectangular plate, when a vertical force *F* is applied at a certain point on the plate, according to its location in space. Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present.

d) Research results analysis based on the highest and lowest percentages for the category 'Lack of Understanding'

From Figure 4.2, and by comparing the percentage values of the category 'Lack of Understanding' we can track the highest and lowest values of this category for each question of the questionnaire.

The highest rates occurred in Question 5 (57,13%) and Question 7 (57,13%). Thus, there is a quite high percentage of students in this university who have no understanding of the relevant structural concepts in these questions. Question 5 examines if the students can identify the axis with the maximum and the minimum second moment of area on an equal-angle section. Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it.

The lowest rates occurred for Question 9 (37,13%) and Question 10 (37,13%). This means that the percentage of students in this university that have no understanding of the relevant structural concepts in these questions is also high. Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present. Question 10 examines if the students can identify the correct placement of the main tension reinforcement on a cantilever beam when a vertical distributed load q is applied on it.

4.2.2 MEng at National Technical University of Athens (NTUA), Athens, Greece

4.2.2.1 Research results analysis based on the average percentages of students' answers

Figure 4.3 presents the average value (for all 10 questions) in percentage format for each of the four research data analysis categories.

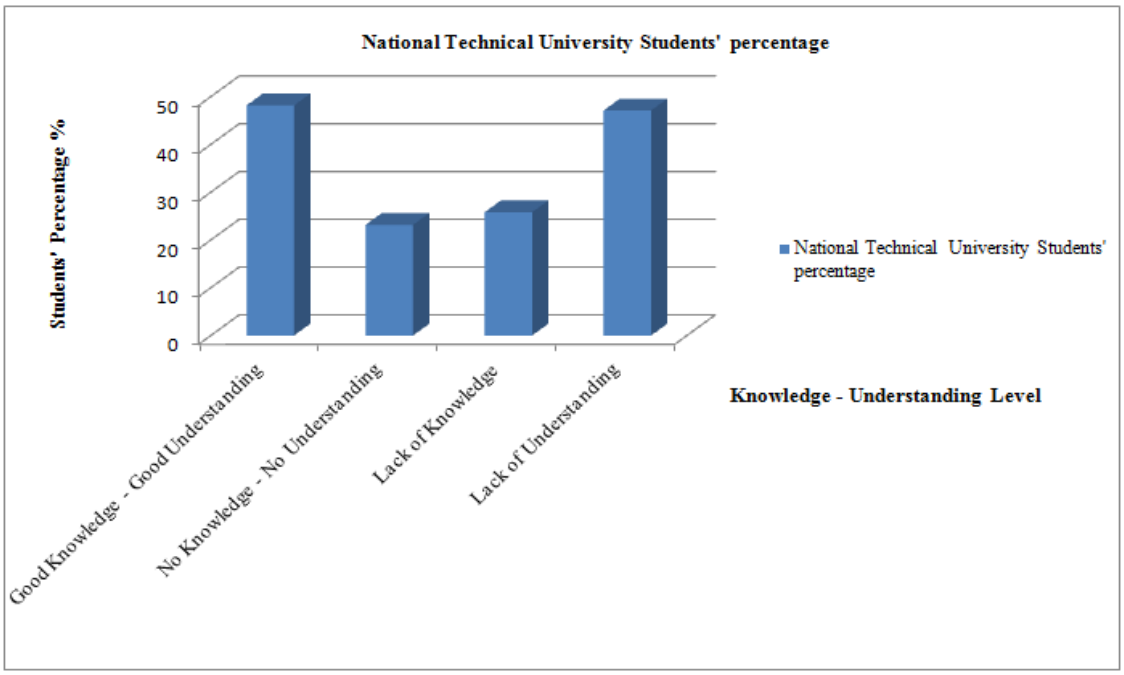

Figure 4.3 - Average percentage value of students' answers in each of the four research data analysis categories at (NTUA)

4.2.2.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Tables 4.5 to 4.8 present the number and the percentage value of students that scored in each of the four research data analysis categories for 0 and up to 10 out of the 10 questions of the questionnaire at NTUA.

Table 4.5 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at NTUA

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	2	5	11	7	8	3	2	0	0
Percentage of students	0	0	5,26	13,16	28,95	18,42	21,05	7,89	5,26	0	0

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.6 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at NTUA

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	5	7	12	6	4	1	3	0	0	0	0
Percentage of students	13,16	18,42	31,58	15,79	10,53	2,63	7,89	0	0	0	0

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.7 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at NTUA

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	2	10	7	9	7	0	3	0	0	0	0
Percentage of students	5,26	26,31	18,42	23,68	18,43	0	7,89	0	0	0	0

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.8 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at NTUA

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	2	8	7	9	8	2	2	0	0
Percentage of students	0	0	5,28	21,05	18,42	23,68	21,05	5,28	5,28	0	0

4.2.2.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.4 presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire at NTUA.

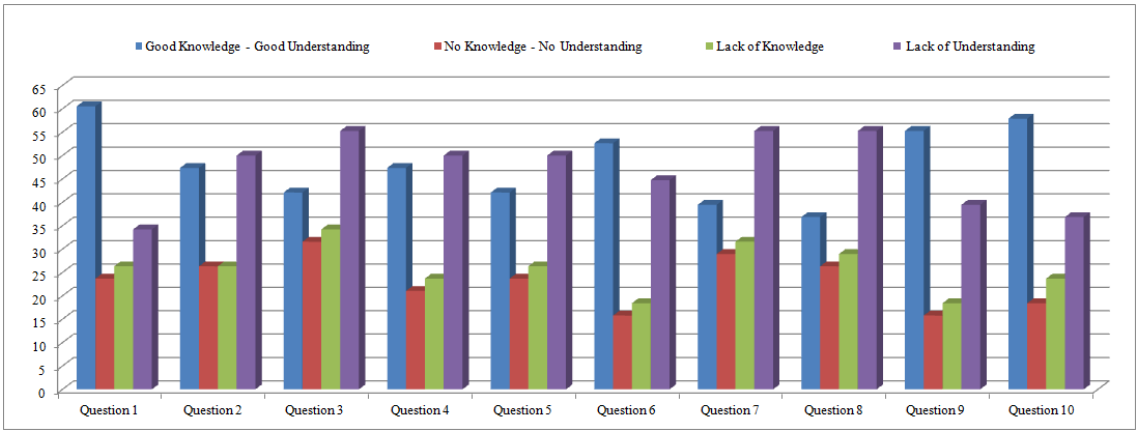

Figure 4.4 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at (NTUA)

4.2.3 MEng at T.E.I. of Piraeus University, Athens, Greece

4.2.3.1 Research results analysis based on the average percentages of students' answers

Figure 4.5 presents the average value (for all 10 questions) in percentage format for each of the four research data analysis categories at T.E.I. of Piraeus.

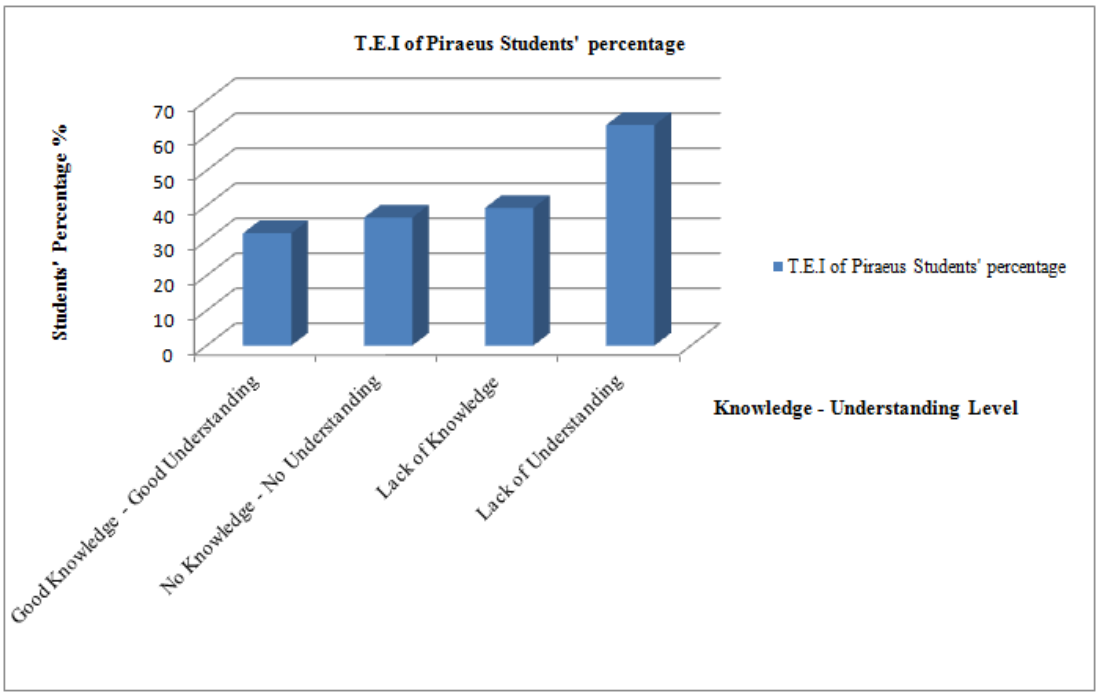

Figure 4.5 - Average percentage value of students' answers in each of the four research data analysis categories at T.E.I. of Piraeus.

4.2.3.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Tables 4.9 to 4.12 present the number and the percentage value of students that scored in each of the four research data analysis categories for 0 and up to 10 out of the 10 questions of the questionnaire at T.E.I. of Piraeus.

Table 4.9 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Piraeus

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	2	22	31	22	8	2	0	0	0	0
Percentage of students	0	2,30	25,29	35,63	25,29	9,20	2,30	0	0	0	0

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.10 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Piraeus

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	2	5	8	22	26	17	7	0	0	0	0
Percentage of students	2,30	5,75	9,20	25,29	29,89	19,54	8,05	0	0	0	0

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.11 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Piraeus

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	1	5	7	13	32	18	11	0	0	0	0
Percentage of students	1,15	5,75	8,05	14,94	36,78	20,69	12,64	0	0	0	0

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.12 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Piraeus

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	0	1	2	19	28	22	15	0	0
Percentage of students	0	0	0	1,15	2,30	21,84	32,18	25,29	17,24	0	0

4.2.3.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.6 presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire at T.E.I. of Piraeus.

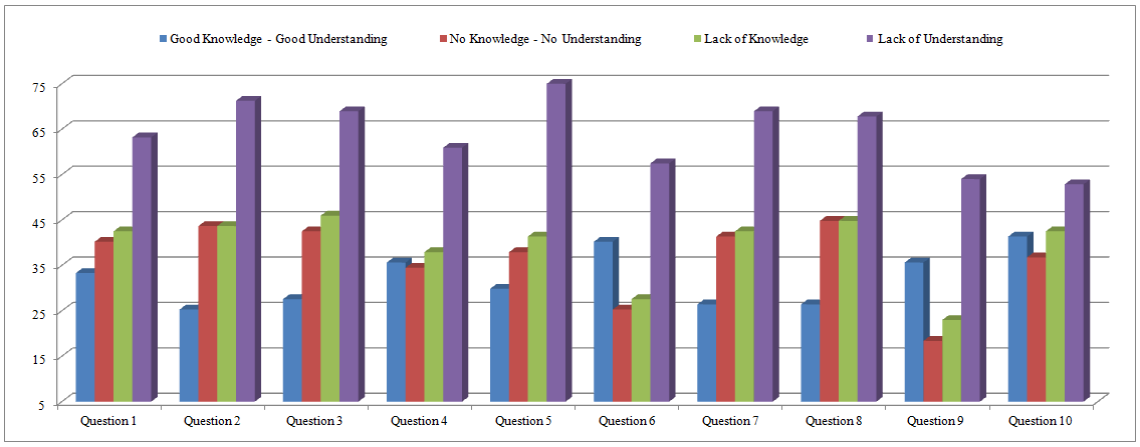

Figure 4.6 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at T.E.I. of Piraeus

4.2.4 BEng at T.E.I. of Serres, Serres, Greece

4.2.4.1 Research results analysis based on the average percentages of students' answers

Figure 4.7 presents the average value (for all 10 questions) in percentage format for each of the four research data analysis categories at T.E.I. of Serres.

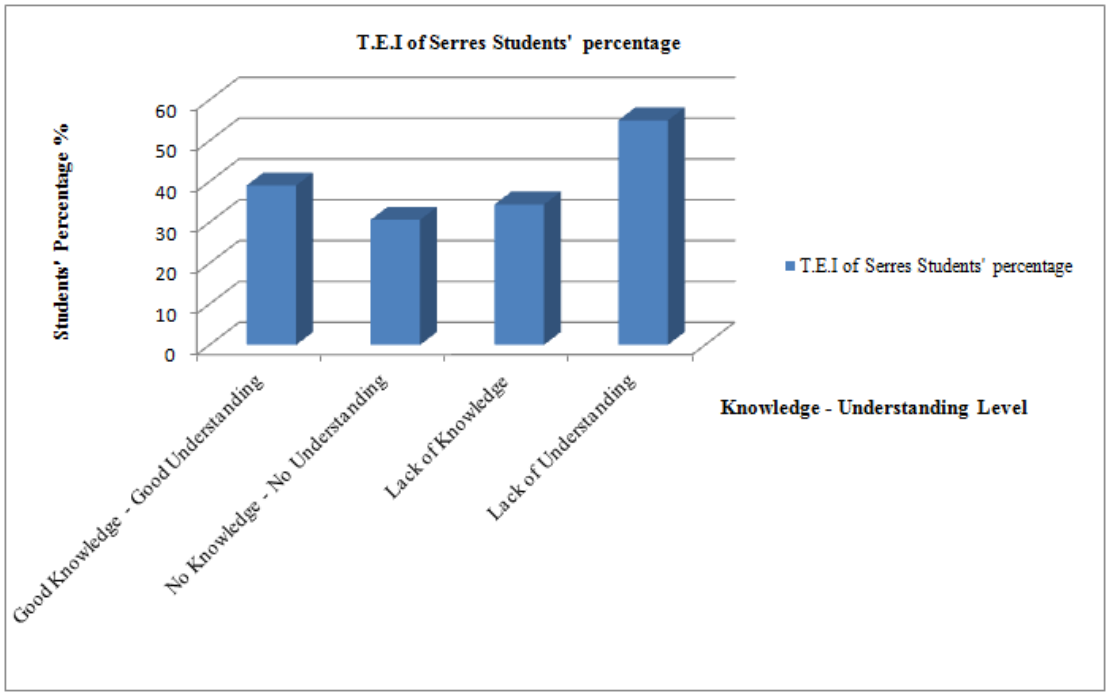

Figure 4.7 - Average percentage value of students' answers in each of the four research data analysis categories at T.E.I. of Serres

4.2.4.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Tables 4.13 to 4.16 present the number and the percentage value of students that scored in each of the four research data analysis categories for 0 and up to 10 out of the 10 questions of the questionnaire at T.E.I. of Serres.

Table 4.13 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Serres

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	1	9	13	22	13	3	3	0	0	0
Percentage of students	0	1,56	14,06	20,31	34,38	20,31	4,69	4,69	0	0	0

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.14 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Serres

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	8	18	14	15	5	3	1	0	0	0
Percentage of students	0	12,5	28,13	21,86	23,44	7,81	4,69	1,56	0	0	0

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.15 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Serres.

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	4	10	21	18	6	4	1	0	0	0
Percentage of students	0	6,25	15,62	32,81	28,12	9,38	6,25	1,56	0	0	0

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.16 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at T.E.I. of Serres

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	3	1	9	21	14	10	6	0	0
Percentage of students	0	0	4,69	1,56	14,06	32,81	21,86	15,62	9,38	0	0

4.2.4.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.8 presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire at T.E.I. of Serres.

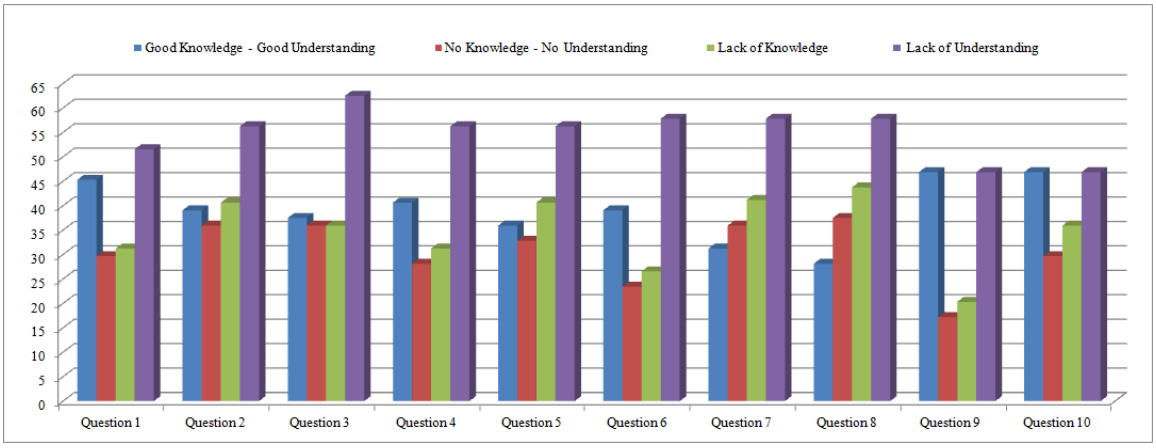

Figure 4.8 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at T.E.I. of Serres

4.3 Analysis per University - Scottish Universities

4.3.1 MEng - MSc at Heriot-Watt University, Edinburgh, Scotland

4.3.1.1 Research results analysis based on the average percentages of students' answers

Figure 4.9 presents the average value (for all 10 questions) in percentage format for each of the four research data analysis categories at Heriot-Watt University.

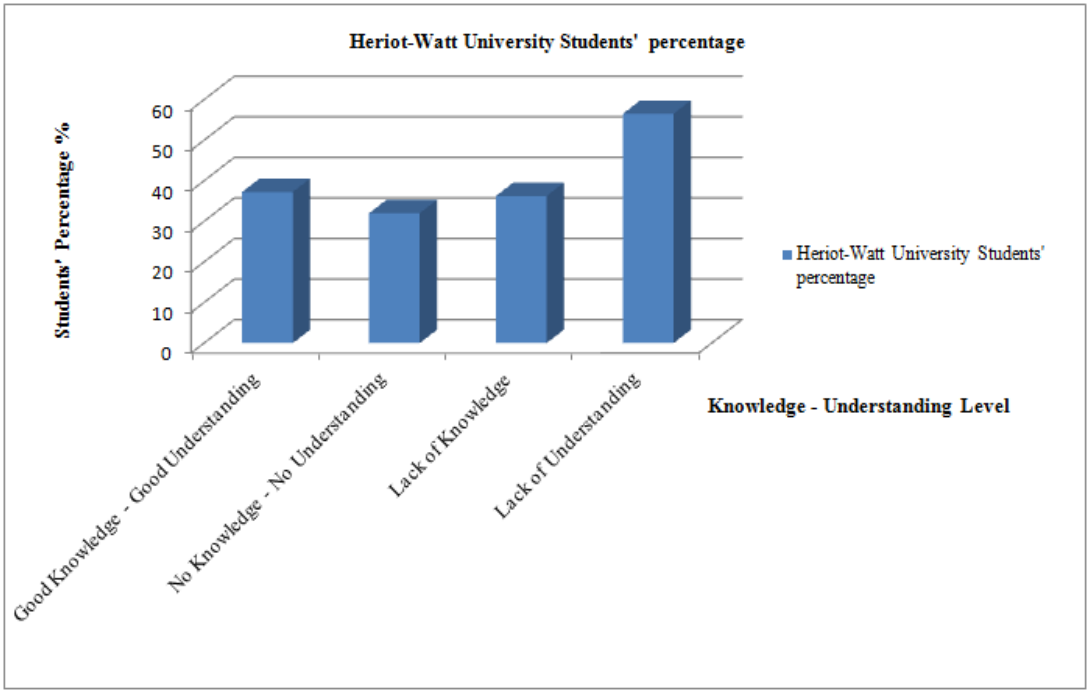

Figure 4.9 - Average percentage value of students' answers in each of the four research data analysis categories at Heriot-Watt University

4.3.1.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Tables 4.17 to 4.20 present the number and the percentage value of students that scored in each of the four research data analysis categories for 0 and up to 10 out of the 10 questions of the questionnaire at Heriot-Watt University

Table 4.17 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Heriot-Watt University

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	2	1	5	8	12	7	4	1	0	0	0
Percentage of students	5	2,5	12,5	20	30	17,5	10	2,5	0	0	0

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.18 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Heriot-Watt University

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	1	3	8	11	12	2	3	0	0	0	0
Percentage of students	2,5	7,5	20	27,5	30	5	7,5	0	0	0	0

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.19 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at Heriot-Watt University

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	4	6	9	11	5	2	3	0	0	0
Percentage of students	0	10	15	22,5	27,5	12,5	5	7,5	0	0	0

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.20 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Heriot-Watt University

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	1	1	5	13	10	7	1	1	1
Percentage of students	0	0	2,5	2,5	12,5	32,5	25	17,5	2,5	2,5	2,5

4.3.1.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.10 presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire at Heriot-Watt University.

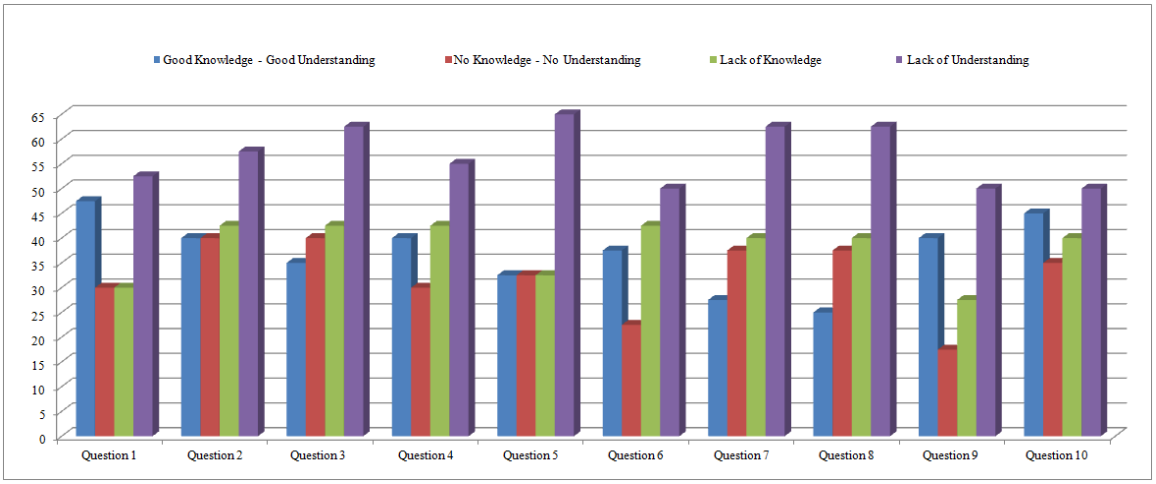

Figure 4.10 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Heriot-Watt University

4.3.2 MSc-MEng at Edinburgh Napier University, Edinburgh, Scotland

4.3.2.1 Research results analysis based on the average percentages of students' answers

Figure 4.11 presents the average value (for all 10 questions) in percentage format for each of the four research data analysis categories at Edinburgh Napier University.

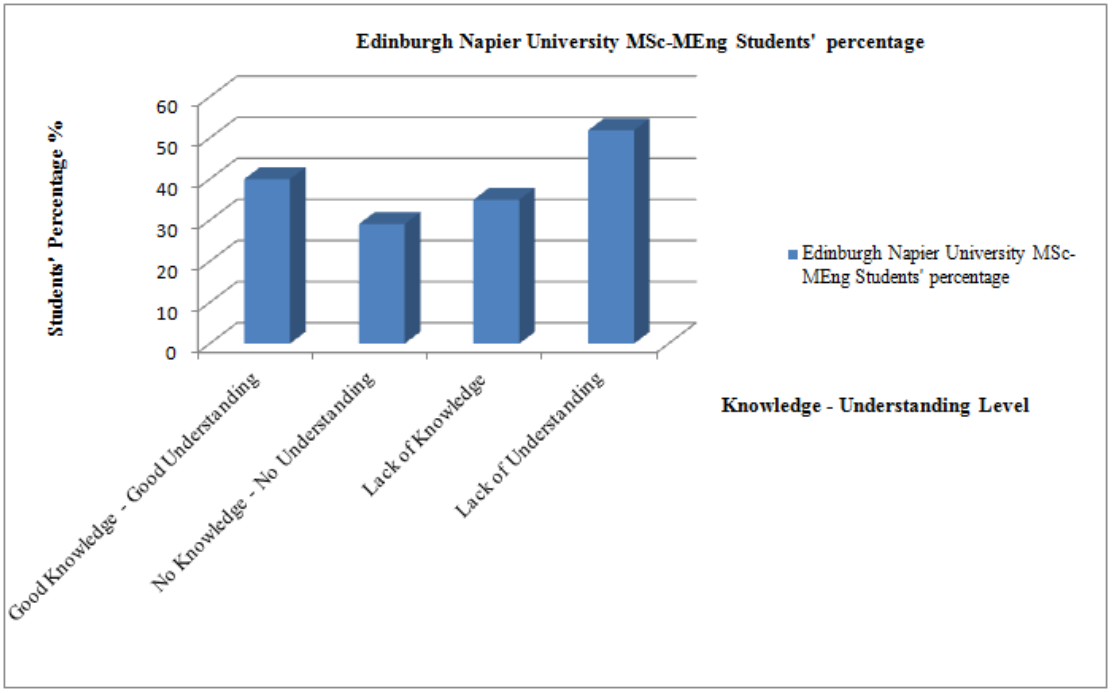

Figure 4.11 - Average percentage value of students' answers in each of the four research data analysis categories at Edinburgh Napier University (MSc-MEng)

4.3.2.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Tables 4.21 to 4.24 present the number and the percentage value of students that scored in each of the four research data analysis categories for 0 and up to 10 out of the 10 questions of the questionnaire at Edinburgh Napier University.

Table 4.21 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (MSc-MEng)

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	1	5	3	13	6	2	2	0	0	0
Percentage of students	0	3,13	15,63	9,38	40,63	18,75	6,25	6,25	0	0	0

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.22 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (MSc-MEng)

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	1	5	9	8	1	6	2	0	0	0	0
Percentage of students	3,13	15,63	28,13	25	3,13	18,75	6,25	0	0	0	0

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.23 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (MSc-MEng)

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	1	2	4	8	9	6	2	0	0	0	0
Percentage of students	3,13	6,25	12,5	25	28,13	18,75	6,25	0	0	0	0

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.24 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (MSc-MEng)

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	1	6	6	5	6	4	3	1	0
Percentage of students	0	0	3,13	18,75	18,75	15,63	18,75	12,5	9,38	3,13	0

4.3.2.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.12 presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire at Edinburgh Napier University.

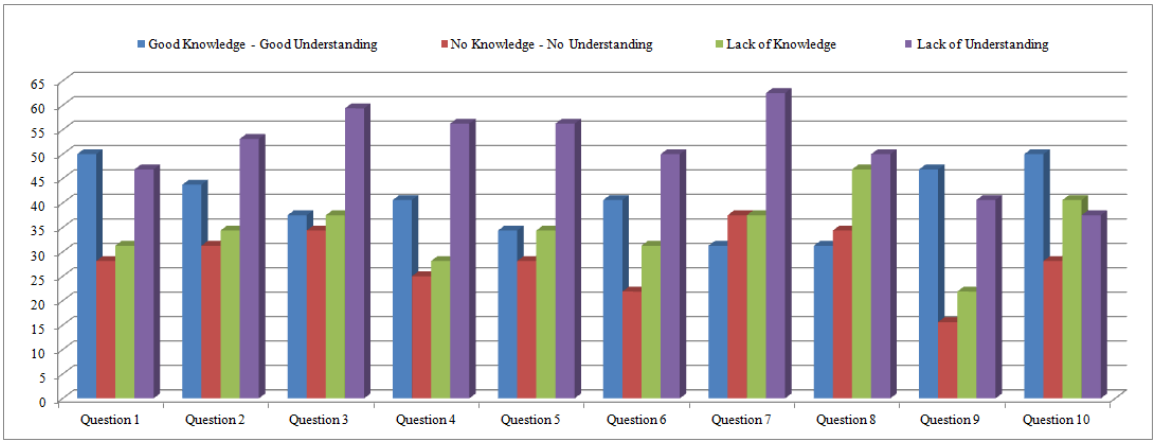

Figure 4.12 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Edinburgh Napier University (MSc-MEng)

4.3.3 BSc-BEng at Edinburgh Napier University, Edinburgh, Scotland

4.3.3.1 Research results analysis based on the average percentages of students' answers

Figure 4.13 presents the average value (for all 10 questions) in percentage format for each of the four research data analysis categories at Edinburgh Napier University.

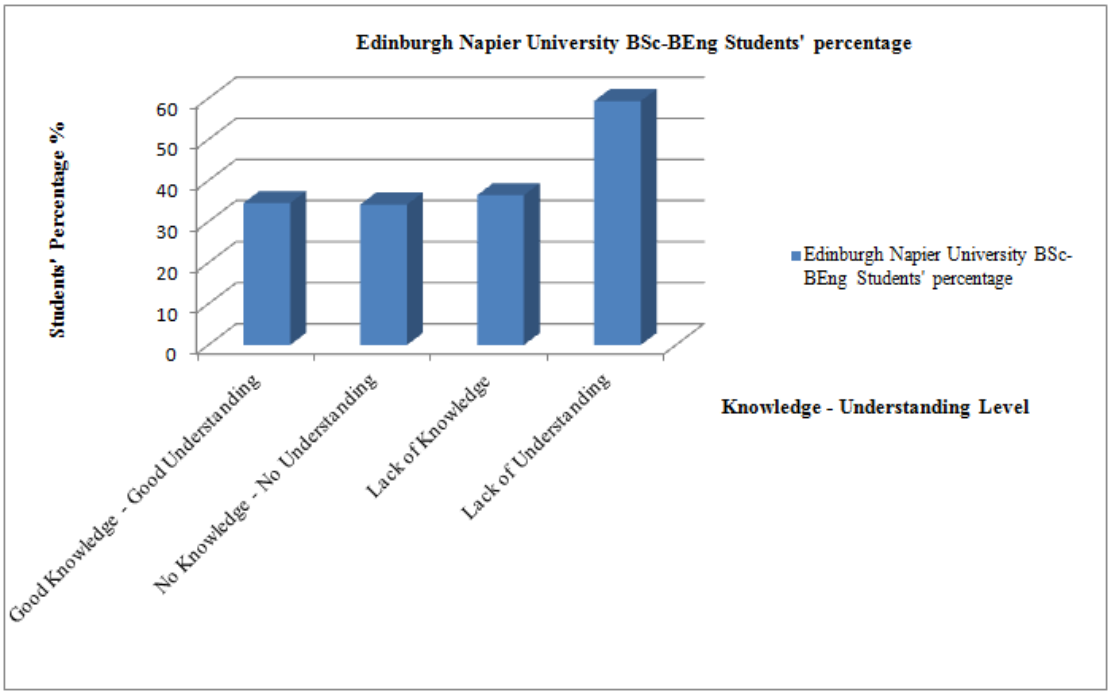

Figure 4.13 - Average percentage value of students' answers in each of the four research data analysis categories at Edinburgh Napier University (BSc-BEng)

4.3.3.2 Research results analysis based on the percentages of students' answers for each research results category

a) Research results analysis based on the percentages of students' answers for the category 'Good Knowledge – Good Understanding'

Tables 4.25 to 4.28 present the number and the percentage value of students that scored in each of the four research data analysis categories for 0 and up to 10 out of the 10 questions of the questionnaire at Edinburgh Napier University.

Table 4.25 - Number and percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (BSc-BEng)

Number and percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	4	0	3	6	10	6	1	1	0	0	0
Percentage of students	12,90	0	9,68	19,36	32,26	19,36	3,23	3,23	0	0	0

b) Research results analysis based on the percentages of students' answers for the category 'No Knowledge – No Understanding'

Table 4.26 - Number and percentage value of students that scored 'No Knowledge – No Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (BSc-BEng)

Number and percentage value of students that scored "No Knowledge – No Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	3	7	7	6	4	4	0	0	0	0
Percentage of students	0	9,68	22,58	22,58	19,35	12,90	12,90	0	0	0	0

c) Research results analysis based on the percentages of students' answers for the category 'Lack of Knowledge'

Table 4.27 - Number and percentage value of students that scored 'Lack of Knowledge' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (BSc-BEng)

Number and percentage value of students that scored "Lack of Knowledge" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	1	4	9	7	5	4	0	1	0	0
Percentage of students	0	3,23	12,90	29,03	22,58	16,13	12,90	0	3,23	0	0

d) Research results analysis based on the percentages of students' answers for the category 'Lack of Understanding'

Table 4.28 - Number and percentage value of students that scored 'Lack of Understanding' in 0 and up to 10 out of 10 questions of the questionnaire at Edinburgh Napier University (BSc-BEng)

Number and percentage value of students that scored "Lack of Understanding" in 0 and up to 10 out of 10 questions of the questionnaire.											
Score	0	1	2	3	4	5	6	7	8	9	10
Number of students	0	0	0	3	2	8	9	4	2	1	2
Percentage of students	0	0	0	9,68	6,45	25,80	29,03	12,90	6,45	3,23	6,45

4.3.3.3 Research results analysis based on the highest and lowest percentages of students' answers

Figure 4.14 presents the percentage of students that answered in each of the four categories analysed in the research data for each of the 10 questions of the questionnaire at Edinburgh Napier University.

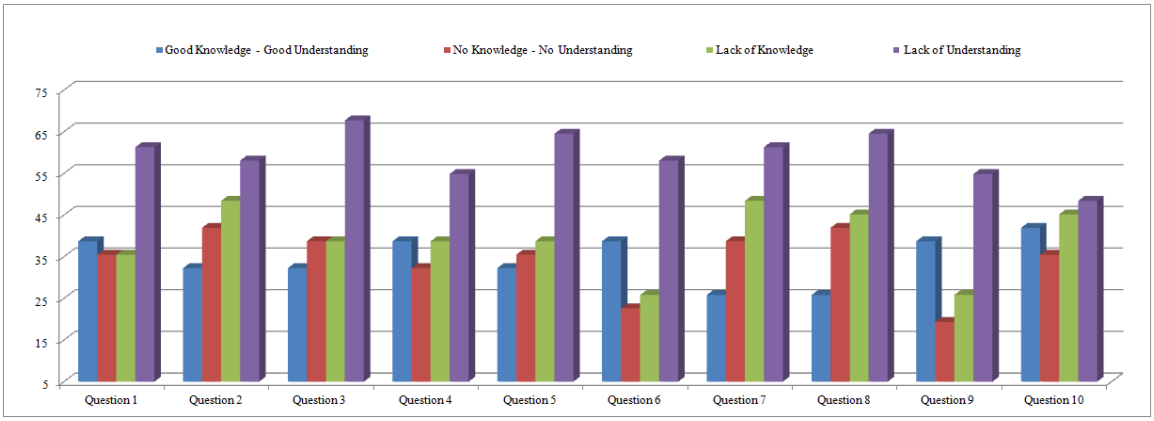

Figure 4.14 - Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Edinburgh Napier University (BSc-BEng)

4.4 Summary

The percentage value of students whose answers were rated as 'Good Knowledge – Good Understanding' is quite low (< 50%) in any of the universities tested. This indicates that students who know and understand in depth most of the basic structural concepts addressed in the research questionnaire in all the universities are less than half of the students tested in the survey. The percentage values of students who scored 'Good Knowledge – Good Understanding' in at least 6 out of the 10 questions of the questionnaire in each university is very low which indicates that there are very few students in each university who know and understand the basic structural concepts. Furthermore, a high percentage of students in each university answered 'Good Knowledge – Good Understanding' in between 0 and up to 4 out of the 10 questions of the questionnaire. This means that the majority of students in each university in this research have a low level of knowledge and understanding as they answered 'Good Knowledge – Good Understanding' in less than half of the questions.

The average value of students in each university whose answers were rated as 'No Knowledge – No Understanding', 'Lack of Knowledge' and 'Lack of Understanding' is quite high. This indicates that there are too many students in each university that do not have a knowledge or understanding or both of the basic structural concepts tested in the research questionnaire. Moreover, there is a very high percentage of students in each university that does not know and/or understand 3 or more out of the 10 basic structural concepts addressed in the questionnaire.

The highest rate in the category 'Good Knowledge – Good Understanding' occurred in Questions 1, 9, and 10 in most/all of the universities tested. All these rates are low enough and reveal that an equally large percentage of students are experiencing problems in knowledge and/or understanding of these concepts.

The highest rate in the categories 'No Knowledge – No Understanding', 'Lack of Knowledge' and 'Lack of Understanding' occurred in Questions 2, 3, 5, 7 and 8 in most/all universities, is quite high and shows that there is quite a high percentage of

students in each university that has no knowledge or/and understanding of the relevant structural concepts in these questions.

CHAPTER 5 A COMPARISON OF THE GAPS IN KNOWLEDGE AND UNDERSTANDING OF STRUCTURAL CONCEPTS ACROSS UNIVERSITIES

In this chapter a comparison of all the universities tested in this research is presented. In more detail, the comparison is first based on the average percentage values of students' answers for each of the four research data analysis categories as they have been described in the third chapter. Following this analysis, a comparison of the universities based on the highest and lowest values of students' answers for each of the above mentioned categories is also presented. Moreover, a comparison of all the universities based on the highest and lowest values of students' answers in each question of the questionnaire used in this research is provided. Finally, a comparison of MSc/MEng and BSc/BEng courses at the universities which were researched is provided.

It will be recalled from Chapter Three that the universities in which students were studying for an MSc/MEng degree were NTUA and The Aristotle University in Greece, and Edinburgh Napier University and Heriot-Watt University in Scotland. The universities in which students were doing a BSc/BEng course were T.E.I. of Serres and of Piraeus in Greece, and Edinburgh Napier University in Scotland.

Using the average percentage values for each of the four research data analysis categories, the universities that were tested throughout this research are listed from the weakest to the strongest in terms of students' 'knowledge' and 'understanding' level of the structural concepts in the questionnaire. The best university, i.e. the one that shows the strongest level of students' knowledge and understanding is assumed to be the one that has the highest average percentage value in the category 'Good Knowledge – Good Understanding,' and at the same time the lowest average percentage values in the categories 'No Knowledge – No Understanding,' 'Lack of Knowledge' and 'Lack of Understanding.'

More specifically, for the university that appears to have the highest average percentage value in the category 'Good Knowledge – Good Understanding,' this means that it has the largest number of students who have both a good knowledge and a good understanding of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

In the same manner, the university that appears to have the lowest average percentage value in the category ‘No Knowledge – No Understanding’ means that it has the smallest number of students who possess both a lack of knowledge and a lack of understanding of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

Moreover, the university that appears to have the lowest average percentage value in the category ‘Lack of Knowledge’ means that it has the smallest number of students who are faced with a lack of knowledge of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

Finally, the university that appears to have the lowest average percentage value in the category ‘Lack of Understanding’ means that it has the smallest number of students who possess a lack of understanding of the structural concepts addressed in the questionnaire of this research (compared to all the other universities tested).

5.1 University Comparison Based on the Average Percentage Values of Students' Answers in Each of the Four Research Results Analysis Categories

Figure 5.1 below presents the average percentage values (for all 10 questions of the questionnaire) for each of the four research data analysis categories and for each of the universities tested.

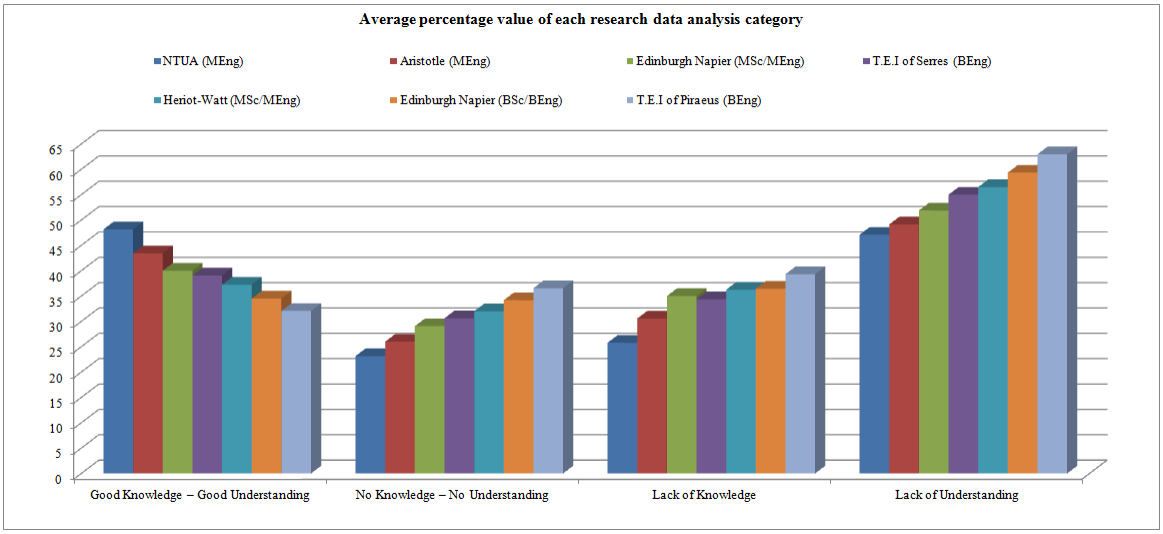

Figure 1 - Average percentage of students' that answered in each research data analysis category for all universities tested

From Figure 5.1 above we can observe that the highest average percentage value of students in the category 'Good Knowledge – Good Understanding' occurred at NTUA (48,16%), whereas the lowest was at T.E.I. of Piraeus (32,07%). Thus, we can conclude that NTUA has the largest number of students who have both a good knowledge and a good understanding of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

As seen from the results, NTUA is the best university in terms of students' knowledge and understanding. One can conclude that even in the case of NTUA the average percentage value of students that scored 'Good Knowledge – Good Understanding' reveals that there is a high percentage of students (> 51%) that either face a problem in their knowledge and/or understanding of some of the structural concepts tested in this

research questionnaire! This result is worrying and, having in mind that NTUA is the best university (compared to the other universities tested), then it is obvious that this phenomenon is more intense in all other universities.

From Figure 5.1 we can also observe that the lowest average percentage value of students in the category 'No Knowledge – No Understanding' occurred at NTUA (23,16%), whereas the highest was at T.E.I. of Piraeus (36,55%). Thus, we can conclude that NTUA has the smallest number of students who are faced with both a lack of knowledge and a lack of understanding of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

It has also been seen that NTUA is the best university in terms of students' knowledge and understanding. One can conclude that even in the case of NTUA the average percentage value of students that scored 'No Knowledge – No Understanding' reveals that there are a lot of students facing problems in both their knowledge and understanding of basic structural concepts tested in this research. This is a worrying result and, having in mind that NTUA is the best university (compared to the other universities tested), then it is obvious that this phenomenon is more intense in all other universities.

Moreover, from Figure 5.1 we can see that the lowest average percentage value of students in the category 'Lack of Knowledge' occurred at NTUA (25,79%), and the highest was at T.E.I. of Piraeus (39,32%). Thus, we can conclude that NTUA has the smallest number of students who are facing a lack of knowledge of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

Even in the case of NTUA the average percentage value of students that scored 'Lack of Knowledge' reveals that there are a lot of students who are facing problems in their knowledge of some of the structural concepts tested in this research. This is cause for concern. Having in mind that NTUA is the best university (compared to the other universities tested), then it is obvious that this phenomenon is more intense in all other universities.

Finally, and again from Figure 5.1 above, we can observe that the lowest average percentage value of students in the category 'Lack of Understanding' occurred at NTUA (47,10%), and the highest at T.E.I. of Piraeus (62,98%). Thus, we can conclude that NTUA has the smallest number of students who are facing a lack of understanding of the structural concepts addressed in the questionnaire of this research (compared to all other universities tested).

One can further conclude that even in the case of NTUA the average percentage value of students that scored 'Lack of Understanding' reveals that there are a lot of students facing problems in their understanding of some of the structural concepts tested in this research. This again is worrying and, having in mind that NTUA is the best university (compared to the other universities tested), then it is obvious that this phenomenon is more intense in all other universities.

By comparing the average percentage values of each of the four research data analysis categories, the universities that were tested throughout this research are listed below from the strongest to the weakest in terms of students' 'Knowledge' and 'Understanding' level of the structural concepts in the questionnaire. This listing can also be seen on the right hand side of the graph in the figure above:

1. NTUA (MEng)
2. Aristotle University of Athens (MEng)
3. Edinburgh Napier University (MSC/MEng)
4. T.E.I. of Serres (BEng)
5. Heriot-Watt University (MSc/MEng)
6. Edinburgh Napier University (BSC/BEng)
7. T.E.I. of Piraeus (BEng)

The only exception appears in the category 'Lack of Knowledge,' whereas Edinburgh Napier University (MSC/MEng) appears to have the fourth highest average percentage

value instead of having the third as in all other categories. In the same category T.E.I. of Serres (BEng) appears to have the third highest average percentage value instead of having the fourth as in all other categories. The figure above also verifies the results.

5.2 University Comparison Based on the Percentage Values of Students' Answers in the Category 'Good Knowledge – Good Understanding'

In the next section an analysis regarding the percentage values of student answers in the category 'Good Knowledge – Good Understanding' for each of the universities tested is provided.

In more detail, the percentage values of students' answers in this category for each university are further analysed into three new categories. The first category regards students that scored in the 'Good Knowledge – Good Understanding' category for between 0 and up to 4 out of the 10 questions in the questionnaire. In this research these students are considered to have a below average level of knowledge and understanding. The second category regards students who scored 'Good Knowledge – Good Understanding' for 5 out of 10 questions in the questionnaire. In this research these students are considered to have an average level of knowledge and understanding. The third category regards students who scored 'Good Knowledge – Good Understanding' in 6 and up to 10 out of the 10 questions in the questionnaire. In this research these students are considered to have a very good level of knowledge and understanding.

The Figure 5.2 below presents the average percentage values of students' answers in the category 'Good Knowledge – Good Understanding,' along with the percentage values of students who scored from 0 to 4, got 5 out of the 10 questions right, or scored 6 and above in the 'Good Knowledge – Good Understanding' category in relation to the questions of the questionnaire for each of the universities tested.

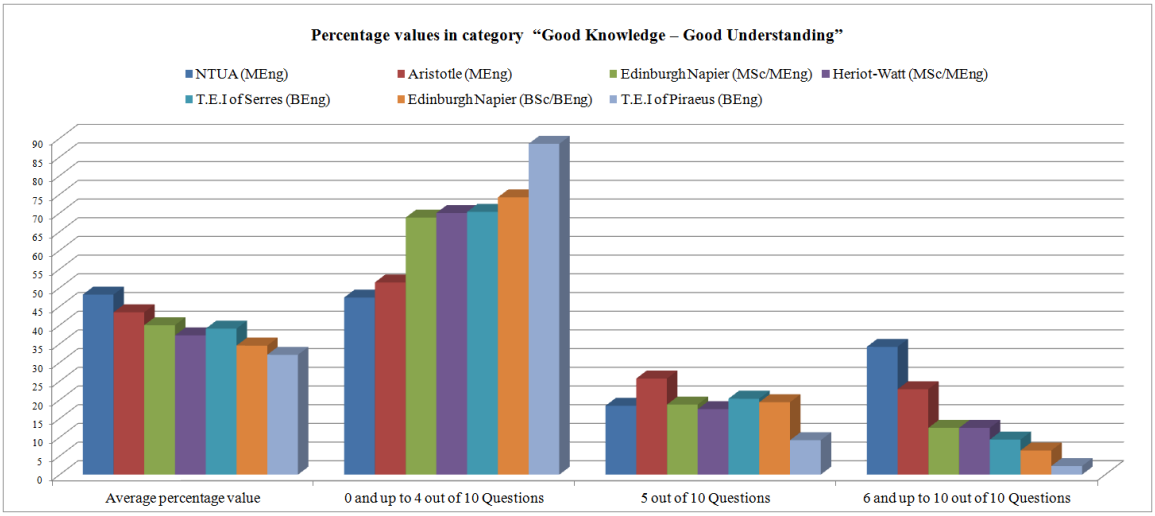

Figure 5.2 - Further analysis of the percentage of students' that answered in category 'Good Knowledge – Good Understanding' for all universities tested

From Figure 5.2, one can see that the university that has the highest average percentage value in the category 'Good Knowledge – Good Understanding' is NTUA (48,16%) and the one that has the lowest is T.E.I. of Piraeus (32,07%).

As described in the previous section, NTUA is the best university in terms of students' knowledge and understanding. From Figure 5.2, one can conclude that even in the case of NTUA the average percentage value of students that scored "Good Knowledge – Good Understanding" reveals that there is a high percentage of students (> 51%) that either face a problem in knowledge or understanding or both of some of the structural concepts tested in this research questionnaire! This is a disturbing result and having in mind that NTUA is the best university (compared to the other universities tested) then it is obvious that this phenomenon is more intense in all other universities.

From the second column of Figure 5.2 we can see that the majority of students scored 0 and up to 4 out of 10 questions in the category "Good Knowledge – Good Understanding", in all the universities.

On the other hand, the percentage of students who scored 5 out of 10 and 6 and up to 10 out of 10 Questions is quite low. So, in all universities tested, the research results show

that there is a very low percentage of students who are considered to have a very good level of knowledge and understanding of the structural concepts.

5.3 University Comparison Based on the Average Percentage Values of Students' Answers in the Category 'No Knowledge – No Understanding'

In the next section an analysis regarding the percentage values of students' answers in the category 'No Knowledge – No Understanding' for each of the universities tested is provided. To be specific, the percentage value of student answers in this category for each university is further analysed into a new category. This category regards students who scored 'No Knowledge – No Understanding' in at least 3 and up to 10 out of the 10 questions in the questionnaire. In this research these students are considered as facing problems in both the knowledge and understanding of the structural concepts tested.

Figure 5.3 presents the average percentage value of students' answers in the category 'No Knowledge – No Understanding', along with the percentage value of students who scored at least 3 out of 10 and above in this category in the questionnaire for each of the universities tested.

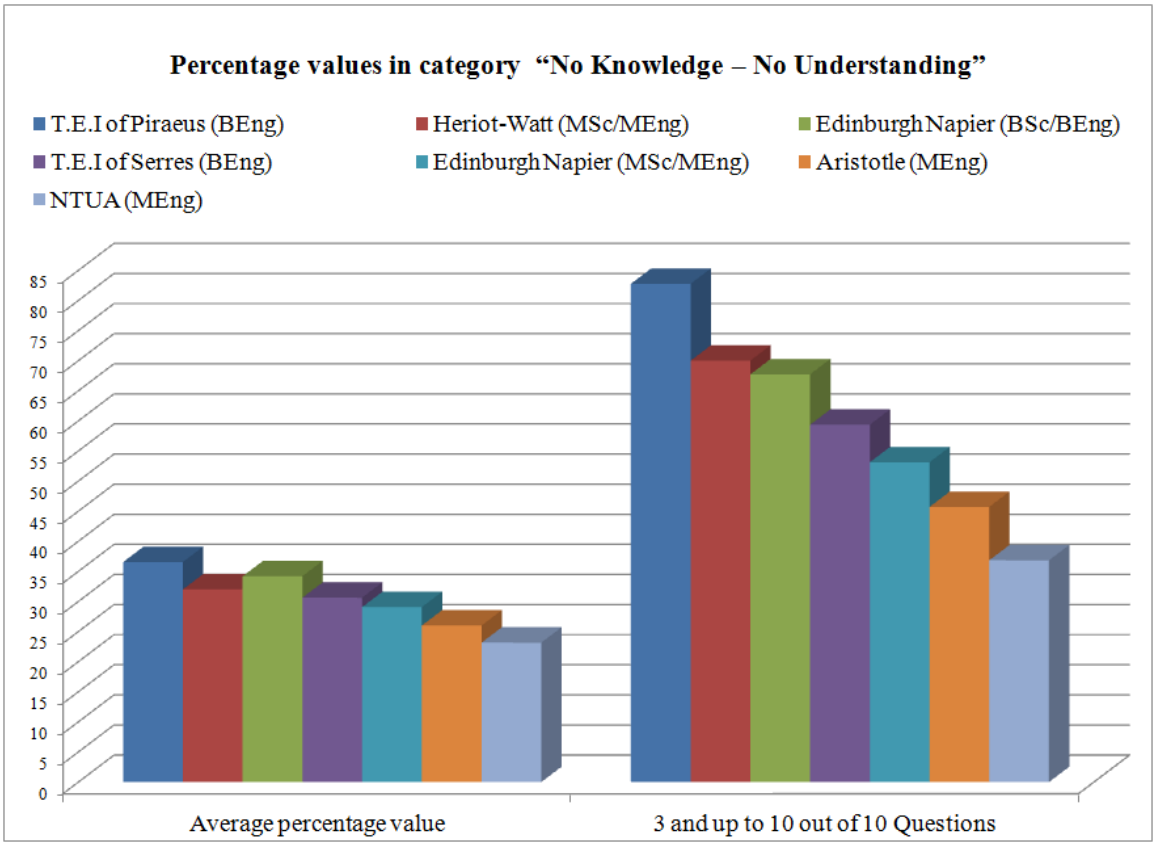

Figure 5.3 - Further analysis of the percentage of students' that answered in category 'No Knowledge – No Understanding' for all universities tested

From Figure 5.3 one can see that the university that has the highest average percentage value in the category 'No Knowledge – No Understanding' is T.E.I. of Piraeus (36,55%) and the one that has the lowest is NTUA (23,16%).

Moreover, from Figure 5.3 one can see that the lowest percentage value of students who scored 'No Knowledge – No Understanding' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at NTUA (36,84%), while the highest value was at T.E.I. of Piraeus (82,77%). Thus one could conclude that even in the case of NTUA, which appears to have the lowest percentage value of students in this category, there are a lot of students facing problems in both knowledge and understanding of more than 3 out of the 10 basic structural concepts tested in this research.

5.4 University Comparison Based on the Average Percentage Values of Students' Answers in the Category 'Lack of Knowledge'

In the next section an analysis regarding the percentage values of students' answers in the category 'Lack of Knowledge' for each of the universities tested is provided. In more detail, the percentage value of student answers in this category for each university is further analysed into a new category. This category considers students who scored 'Lack of Knowledge' in at least 3 and up to 10 out of the 10 questions in the questionnaire. In this research these students are regarded as having gaps in the knowledge of the structural concepts tested.

Figure 5.4 presents the average percentage value of students' answers in the category 'Lack of Knowledge,' along with the percentage value of students who scored 'Lack of Knowledge' in at least 3 and up to 10 out of the 10 questions in the questionnaire for each of the universities tested.

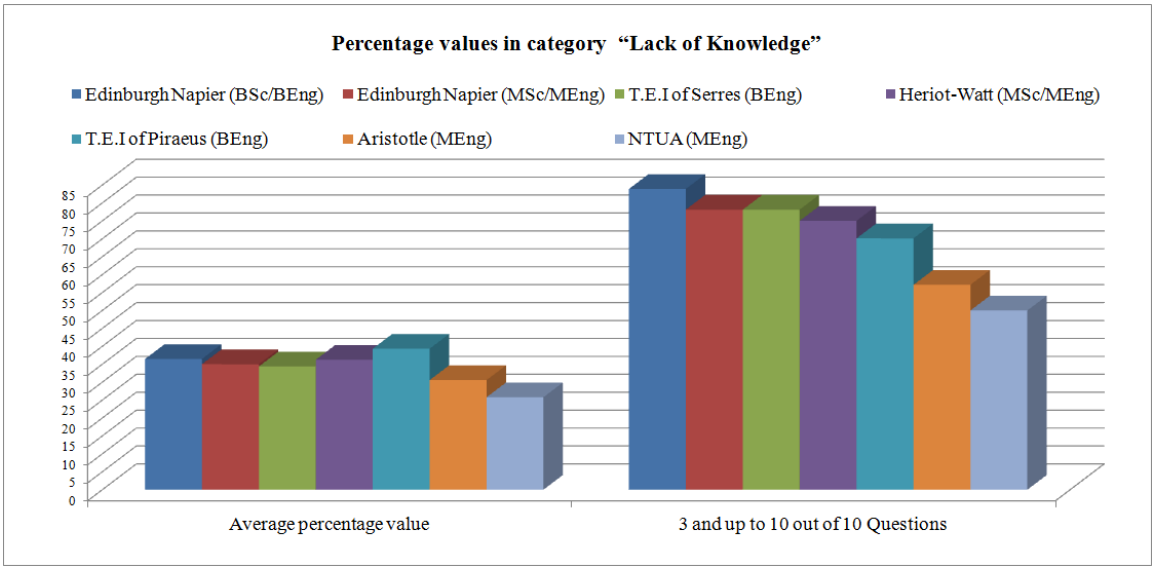

Figure 5.4 - Further analysis of the percentage of students' that answered in category 'Lack of Knowledge' for all universities tested

From Figure 5.4 one can see that the university that has the highest average percentage value in the category ‘Lack of Knowledge’ is T.E.I. of Piraeus (39,32%) and the one that has the lowest is NTUA (25,79%).

Moreover, from Figure 5.4, one can see that the lowest percentage value of students who scored ‘Lack of Knowledge’ in at least 3 out of the 10 questions (that is, 3 and above) occurred at NTUA (50%), while the highest value (83,89%) was at Edinburgh Napier (BSc/BEng). One could thus conclude that even in the case of NTUA which appears to have the lowest percentage value of students in this category, half of the students are facing problems in the knowledge of more than 3 out of the 10 basic structural concepts tested in this research.

5.5 University Comparison Based on the Average Percentage Values of Students' Answers in the Category ‘Lack of Understanding’

In the next section an analysis regarding the percentage values of students' answers in the category ‘Lack of Understanding’ for each of the universities tested is provided. The percentage value of student answers in this category for each university is further analysed into a new category. This category regards students who scored ‘Lack of Understanding’ in at least 3 and up to 10 out of the 10 questions in the questionnaire. In this research these students are considered to be facing problems in understanding the structural concepts which are being tested.

Figure 5.5 presents the average percentage value of students' answers in the category ‘Lack of Understanding’, along with the percentage value of students who scored ‘Lack of Understanding’ in at least 3 out of the 10 questions in the questionnaire for each of the universities tested.

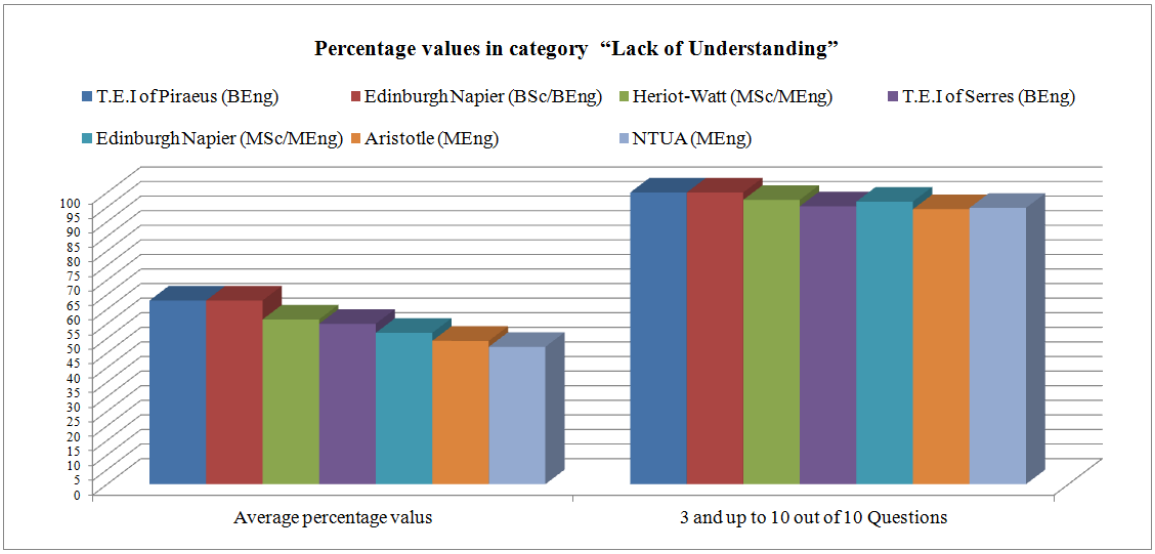

Figure 5.5 - Further analysis of the percentage of students' that answered in category 'Lack of Understanding' for all universities tested

From Figure 5.5 one can see that the university that has the highest average percentage value in the category 'Lack of Understanding' is T.E.I. of Piraeus (62,98%) and the one that has the lowest is NTUA (47,1%).

Moreover, from Figure 5.5 one can see that the lowest percentage value of students who scored 'Lack of Understanding' in at least 3 and up to 10 out of the 10 questions in the questionnaire occurred at Aristotle (94,28%), while the highest values were at T.E.I. of Piraeus (100%) and at Edinburgh Napier (BSc/BEng) (100%). One could thus conclude that even in the case of Aristotle which appears to have the lowest percentage value of students in this category almost all of the students are facing problems in understanding more than 3 out of the 10 basic structural concepts tested in this research.

5.6 University Comparison Based on the Highest and Lowest Percentage Values of Students' Answers for Each of the Four Research Results

5.6.1 University comparison based on the highest and lowest percentage values of students' answers in the category 'Good Knowledge – Good Understanding'

In the next section an analysis of the research results is provided in order to investigate in which university and in which of the ten questions of the questionnaire the highest and lowest percentage value of students' answers in the category 'Good Knowledge – Good Understanding' has occurred.

Table 5.1 illustrates the highest and lowest percentage value of student answers in the category 'Good Knowledge – Good Understanding' for each university tested.

Table 5.1 - University comparison based on the highest and lowest percentage values of students' answers in the category 'Good Knowledge – Good Understanding'

University	Percentage values in category "Good Knowledge – Good Understanding"			
	Maximum value in Question		Minimum value in Question	
	Maximum value	Question	Minimum value	Question
Edinburgh Napier (MSc/MEng)	50,00%	Q1 Q10	31,25%	Q7 Q8
Edinburgh Napier (BSc/BEng)	41,93%	Q10	25,80%	Q7 Q8
Heriot-Watt (MSc/MEng)	47,50%	Q1	25,00%	Q8
Aristotle (MEng)	57,13%	Q1	31,42%	Q5
NTUA (MEng)	60,52%	Q1	36,84%	Q8
T.E.I. of Serres (BEng)	46,87%	Q9 Q10	28,12%	Q8
T.E.I. of Piraeus (BEng)	41,37%	Q10	25,28%	Q2

From Table 5.1 one can see that the highest percentage value of students' answers in this category occurred at NTUA for Question 1 (60,52%) and the lowest value at Heriot-Watt University for Question 8 (25%). As described in section 5.1, NTUA is the best university compared to all others tested in this research in regards to students' knowledge and understanding of the structural concepts addressed in the questionnaire. Taking into consideration that NTUA, compared to all the other universities tested, appears to have the highest percentage value (60,52%) of student answers in this category, one could conclude that even in the case of the best university there is a huge percentage (> 39%) of students that appear to have a serious problem in either knowledge and/or understanding of many of the basic structural concepts tested in this research. In other words, this means that in all other universities the percentage of students that have a serious problem in either knowledge or understanding or both in many of the basic structural concepts tested in this research is even higher.

Moreover, from Table 5.1 it is obvious that the highest percentage values of students who scored in the 'Good Knowledge – Good Understanding' category have occurred in Questions 1, 9 and 10. This suggests that a high number of students have a good level of knowledge and understanding of the structural concepts that these questions are investigating. However, in five universities (out of the seven tested) the percentage value of students who scored 'Good Knowledge – Good Understanding' in these questions is less than 50% and in two universities (out of the seven tested) it is between 57% and 61%. Question 1 examines if the students can identify the right position of the centroid of a cross section along with the definition of the centroid, Question 10 examines if the students can identify the correct placement of the main tension reinforcement at a cantilever beam when a vertical distributed load q is applied on it and Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present.

Furthermore, from the table it can be seen that the lowest percentage values of students that scored in the 'Good Knowledge – Good Understanding' category have occurred in Questions 2, 5, 7 and 8. This means that a low number of students with a good level of knowledge and understanding of the structural concepts that these questions are

investigating exists. Actually, in six universities (out of the seven tested) the percentage value of students that scored ‘Good Knowledge – Good Understanding’ in these questions is less than 32% and in one of the universities (out of the seven tested) it is 36,84%. Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it, Question 8 examines if the students can identify the correct deformed line of a beam which is heated to a certain point, Question 5 examines if the students can identify the axis with the maximum and the minimum second moment of area on an equal-angle section and Question 2 examines if the students can identify the right position of the shear centre of a cross section along with the definition of the shear centre.

5.6.2 University comparison based on the highest and lowest percentage values of students' answers in the category ‘No Knowledge – No Understanding’

In the next section an analysis of the research results is provided in order to investigate in which university and in which of the ten questions of the questionnaire the highest and lowest percentage value of students' answers in the category ‘No Knowledge – No Understanding’ has occurred.

Table 5.2 presents the highest and lowest percentage value of students' answers in the category ‘No Knowledge – No Understanding’ for each university tested.

Table 5.2 - University comparison based on the highest and lowest percentage values of students' answers in the category 'No Knowledge – No Understanding'

University	Percentage values in category "No Knowledge – No Understanding"			
	Maximum value in Question		Minimum value in Question	
	Maximum value	Question	Minimum value	Question
Edinburgh Napier (MSc/MEng)	37,50%	Q7	15,62%	Q9
Edinburgh Napier (BSc/BEng)	41,93%	Q2 Q8	19,35%	Q9
Heriot-Watt (MSc/MEng)	40,00%	Q2 Q3	17,50%	Q9
Aristotle (MEng)	31,42%	Q3 Q8	14,28%	Q9
NTUA (MEng)	31,57%	Q3	15,78%	Q6 Q9
T.E.I. of Serres (BEng)	37,50%	Q8	17,18%	Q9
T.E.I. of Piraeus (BEng)	44,82%	Q8	18,39%	Q9

From Table 5.2 one can see that the highest percentage value of students' answers in this category occurred at T.E.I. of Piraeus in Question 8 (44,82%) and the lowest value at Aristotle University in Question 9 (14,28%).

Moreover, from Table 5.2 it is obvious that the highest percentage values of students that scored 'No Knowledge – No Understanding' have occurred in Questions 2, 3, 7 and 8. This means that a high number of students exists who are facing problems in both the knowledge and the understanding of the structural concepts that these questions are investigating. However, in five universities (out of the seven tested) the percentage value of students that scored 'Good Knowledge – Good Understanding' in these questions is less than 40% and in two universities (out of the seven tested) it is between 41% and 45%. Question 2 examines if the students can identify the right position of the shear centre of a cross section along with the definition of the shear centre, Question 3 examines if the students can identify the major axis of a cross section along with the definition of the major axis, Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it and Question 8 examines if

the students can identify the correct deformed line of a beam which is heated to a certain point.

Furthermore, from the table it is obvious that the lowest percentage values of students that scored ‘No Knowledge – No Understanding’ have occurred in Questions 6 and 9. This means that a low number of students exists who are facing problems in both their knowledge and understanding of the structural concepts that these questions are investigating. Note that in all universities the percentage value of students that scored ‘No Knowledge – No Understanding’ in these questions is between 14% and 19%. Question 6 examines if the students can identify the largest value of the bending resistance on a rectangular plate, when a vertical force F is applied at a certain point on the plate, according to its location in space, and Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present.

5.6.3 University comparison based on the highest and lowest percentage values of students' answers in the category ‘Lack of Knowledge’

In the next section an analysis of the research results is yet again provided in order to investigate in which university and in which of the ten questions of the questionnaire the highest and lowest percentage value of students' answers in the category ‘Lack of Knowledge’ has taken place.

Table 5.3 presents the highest and lowest percentage value of students' answers in the category ‘Lack of Knowledge’ as they have occurred for each university tested.

Table 5.3 - University comparison based on the highest and lowest percentage values of students' answers in the category 'Lack of Knowledge'

University	Percentage values in category "Lack of Knowledge"			
	Maximum value in Question		Minimum value in Question	
	Maximum value	Question	Minimum value	Question
Edinburgh Napier (MSc/MEng)	46,88%	Q8	21,87%	Q9
Edinburgh Napier (BSc/BEng)	48,39%	Q2 Q7	25,80%	Q6 Q9
Heriot-Watt (MSc/MEng)	42,50%	Q2 Q3	27,50%	Q9
Aristotle (MEng)	40,00%	Q8	20,00%	Q9
NTUA (MEng)	34,21%	Q3	18,42%	Q6 Q9
T.E.I. of Serres (BEng)	43,75%	Q8	20,31%	Q9
T.E.I. of Piraeus (BEng)	45,97%	Q3	22,99%	Q9

From Table 5.3 one can see that the highest percentage value of students' answers in this category occurred at Edinburgh Napier (BSc/BEng) in Questions 2 and 7 (48,39%) and the lowest value at NTUA in Questions 6 and 9 (18,42%). However, the lowest figure of students' answers in this category (18,42%) is a considerable percentage value. Having also in mind that all other universities have higher figures, then one could conclude that there is a serious gap regarding knowledge of many of the basic structural concepts tested in this research.

Moreover, from the table it is obvious that the highest percentage values of students that scored in the 'Lack of Knowledge' category have occurred in Questions 2, 3, 7 and 8. This means that a high number of students in all the universities tested are facing gaps in their knowledge of the structural concepts that these questions are investigating. Note also that in five universities (out of the seven tested) the percentage value of students who scored in the 'Lack of Knowledge' category is between 42% and 49% and in two universities (out of the seven tested) it is between 34% and 40%. Question 2 examines if the students can identify the right position of the shear centre of a cross section along

with the definition of the shear centre, Question 3 examines if the students can identify the major axis of a cross section along with the definition of the major axis, Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it, and Question 8 examines if the students can identify the correct deformed line of a beam which is heated to a certain point.

Furthermore, from the table it is also obvious that the lowest percentage values of students that scored in the 'Lack of Knowledge' category have occurred in Questions 6 and 9. This means that a low number of students exists who are facing problems in their knowledge of the structural concepts that these questions are investigating. Note also that in four universities (out of the seven tested) the percentage value of students that scored 'Lack of Knowledge' is between 21% and 28% and in three universities (out of the seven tested) it is between 18% and 21%. Question 6 examines if the students can identify the largest value of the bending resistance on a rectangular plate, when a vertical force F is applied at a certain point on the plate, according to its location in space and Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present.

5.6.4 University comparison based on the highest and lowest percentage values of students' answers in the category 'Lack of Understanding'

In the next section an analysis of the research results is provided in order to investigate in which university and in which of the ten questions of the questionnaire the highest and lowest percentage value of students' answers in the category 'Lack of Understanding' has occurred.

Table 5.4 presents the highest and lowest percentage value of students' answers in the category 'Lack of Understanding' as they have occurred for each university tested.

Table 5.4 - University comparison based on the highest and lowest percentage values of students' answers in the category 'Lack of Understanding'

University	Percentage values in category "Lack of Understanding"			
	Maximum value in Question		Minimum value in Questions	
	Maximum value	Question	Minimum value	Question
Edinburgh Napier (MSc/MEng)	62,50%	Q7	37,50%	Q10
Edinburgh Napier (BSc/BEng)	67,74%	Q3	48,39%	Q10
Heriot-Watt (MSc/MEng)	65,00%	Q5	50,00%	Q6 Q9 Q10
Aristotle (MEng)	57,13%	Q5 Q7	37,13%	Q9 Q10
NTUA (MEng)	55,26%	Q3 Q7 Q8	34,21%	Q1
T.E.I. of Serres (BEng)	62,50%	Q3	46,87%	Q9 Q10
T.E.I. Piraeus (BEng)	75,86%	Q5	52,87%	Q10

From Table 5.4 one can see that the highest percentage value of students' answers in this category occurred at T.E.I. of Piraeus in Question 5 (75,86%) and the lowest value at NTUA in Question 1 (34,21%). However, the lowest figure of students' answers in this category (34,21%) is a very high percentage value. Having also in mind that all other universities have higher figures, then one could conclude that there is a serious gap regarding the understanding of many of the basic structural concepts tested in this research.

Moreover, from Table 5.4 it is obvious that the highest percentage values of students who scored in the 'Lack of Understanding' category have occurred in Questions 3, 5, 7 and 8. The largest value from the column which represents the largest percentage values was found to be for T.E.I. of Piraeus in Question 5 (75,86%), while the smallest was for NTUA (55,26%) in relation to Questions 3, 7 and 8. This means that a high number of

students exists who are facing problems in their understanding of the structural concepts that these questions are investigating. Note also that in four universities (out of the seven tested) the percentage value of students that scored 'Lack of Understanding' in these questions is between 62% and 65%, in two universities (out of the seven tested) it is between 55% and 57% and in one university it is higher than 75%. Question 3 examines if the students can identify the major axis of a cross section along with the definition of the major axis, Question 5 examines if the students can identify the axis with the maximum and the minimum second moment of area on an equal-angle section, Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it and Question 8 examines if the students can identify the correct deformed line of a beam which is heated to a certain point.

Furthermore, from the table above it is obvious that the lowest percentage values of students who were rated in the 'Lack of Understanding' category have occurred in Questions 1, 6, 9 and 10. This suggests that a low number of students exists who are facing problems in their understanding of the structural concepts that these questions are investigating. Note that in all universities the percentage value of students that scored 'Lack of Knowledge' in these questions is between 14% and 19%. Question 1 examines if the students can identify the right position of the centroid of a cross section along with the definition of the centroid, Question 6 examines if the students can identify the largest value of the bending resistance on a rectangular plate, when a vertical force F is applied at a certain point on the plate, according to its location in space, Question 9 examines if the students can identify which part of a frame can be constructed first, without the existence of any of the others present and Question 10 examines if the students can identify the correct placement of the main tension reinforcement at a cantilever beam when a vertical distributed load q is applied on it.

5.7 University Comparison Based on the Highest and Lowest Percentage Values of Students' Answers for Each Question in the Questionnaire

This section presents a quick comparison and analysis of all four research data analysis categories for each question of the questionnaire and for each university tested in this research. More specifically, the highest and lowest percentage value, along with the average percentage value in each question of the questionnaire for each research data analysis category, is presented.

Note that according to the analysis presented in Section 5.1 'University comparison based on the average percentage values of students' answers in each of the four research results analysis categories,' NTUA is the best university compared to all the others tested. This, however, reveals that even the best university in this research shows, in all basic structural concepts of the questionnaire, a very high percentage of students that either present 'No Knowledge – No Understanding' or a 'Lack of Knowledge' or 'Lack of Understanding' as can be seen from the tables. All the other universities present the worst percentage values. What this means is that there is a serious gap in civil engineering education regarding both the knowledge and understanding of the basic structural concepts tested in this research.

5.7.1 University comparison based on the percentage values of students' answers in the category 'Good Knowledge – Good Understanding' for each question

Table 5.5 below presents the percentage values of students in the research data analysis category 'Good Knowledge – Good Understanding,' in each of the 10 questions of the questionnaire for each of the universities tested in this research.

Table 5.5 - University comparison based on the percentage values of students' answers in the category 'Good Knowledge – Good Understanding' for each question

	"Good Knowledge – Good Understanding" percentage totals						
	University						
Question	Edinburgh Napier (BSc-BEng)	Edinburgh Napier (MSc-MEng)	Heriot- Watt (MSc-MEng)	Aristotle (MEng)	NTUA (MEng)	T.E.I. of Serres (BEng)	T.E.I. of Piraeus (BEng)
Q1	38,70	50,00	47,50	57,17	60,52	45,31	33,33
Q2	32,25	43,75	40,00	42,85	47,36	39,06	25,28
Q3	32,25	37,50	35,00	40,00	42,10	37,50	27,58
Q4	38,70	40,62	40,00	40,00	47,36	40,62	35,63
Q5	32,25	34,37	32,50	31,42	42,10	35,93	29,88
Q6	38,70	40,62	37,50	48,57	52,63	39,06	40,22
Q7	25,80	31,25	27,50	34,28	39,47	31,25	26,43
Q8	25,80	31,25	25,00	34,28	36,84	28,12	26,43
Q9	38,70	46,87	40,00	51,42	55,26	46,87	35,63
Q10	41,93	50,00	45,00	54,28	57,89	46,87	41,37

From the Table 5.5 one can also calculate the average percentage value of each question in the questionnaire by adding the percentages of all seven universities in each table line and dividing by 7. A list of all average percenatge values in each of the ten questions of the questionnaire is provided below:

- Question 1 – 47,48%
- Question 2 – 38,65%
- Question 3 – 35,99%
- Question 4 – 40,42%
- Question 5 – 34,06%
- Question 6 – 42,47%
- Question 7 – 30,85%
- Question 8 – 29,67%
- Question 9 – 44,96%
- Question 10 – 48,19%

From the above list one could conclude that all the values of the average percentages of all the questions in the category 'Good Knowledge – Good Understanding' are less than 50%, and for some questions the figures are even less than 40%. This means that for all the universities tested in this research, the students that present a 'Good Knowledge' and 'Good Understanding' in any of the basic structural concepts addressed in the questionnaire are few and far between. In other words, one could conclude that there is a serious gap in civil engineering education.

5.7.2 University comparison based on the percentage values of students' answers in the category 'No Knowledge – No Understanding'

Table 5.6 below presents the percentage values of students in the research data analysis category 'No Knowledge – No Understanding,' in each of the 10 questions of the questionnaire for each of the universities tested in this research.

Table 5.6 - University comparison based on the percentage values of students' answers in the category 'No Knowledge – No Understanding' for each question

	"No Knowledge – No Understanding" percentage totals						
	University						
Question	Edinburgh Napier (BSc-BEng)	Edinburgh Napier (MSc-MEng)	Heriot- Watt (MSc-MEng)	Aristotle (MEng)	NTUA (MEng)	T.E.I. of Serres (BEng)	T.E.I. of Piraeus (BEng)
Q1	35,48	28,12	30,00	28,57	23,68	29,68	40,22
Q2	41,93	31,25	40,00	28,57	26,32	35,93	43,67
Q3	38,70	34,37	40,00	31,42	31,57	35,93	42,52
Q4	32,25	25,00	30,00	25,71	21,05	28,12	34,48
Q5	35,48	28,12	32,50	25,71	23,68	32,81	37,93
Q6	22,58	21,87	22,50	20,00	15,78	23,43	25,28
Q7	38,70	37,50	37,50	28,57	28,94	35,93	41,37
Q8	41,93	34,37	37,50	31,42	26,32	37,50	44,82
Q9	19,35	15,62	17,50	14,28	15,78	17,18	18,39
Q10	35,48	28,12	35,00	25,71	18,42	29,68	36,78

From the Table 5.6 one can also calculate the average percentage value of each question in the questionnaire by adding the percentages of all seven universities in each table line and dividing by 7. A list of all average percentage values for the research data analysis category ‘No Knowledge – No Understanding’ in each of the ten questions of the questionnaire is provided below:

- Question 1 – 30,82%
- Question 2 – 35,38%
- Question 3 – 36,36%
- Question 4 – 28,09%
- Question 5 – 30,89%
- Question 6 – 21,63%
- Question 7 – 35,50%
- Question 8 – 36,27%
- Question 9 – 16,87%
- Question 10 – 29,88%

From the above list one can conclude that all the average percentage values of all the questions in this category are higher than 28%, with the only exceptions being in Questions 6 (21,63%) and 9 (16,87%). However, in some questions the average percentage value is even higher than 35%! Thus, it is obvious that in all the universities tested, the number of students that present with ‘No Knowledge’ and ‘No Understanding’ in almost every basic structural concept of the questionnaire is quite high. Thus, one could conclude, once more, that there is a serious gap in civil engineering education regarding both the knowledge and understanding of the basic structural concepts tested in this research.

5.7.3 University comparison based on the percentage values of students' answers in the category ‘Lack of Knowledge’

Table 5.7 below presents the percentage values of students for the research data analysis category ‘Lack of Knowledge’ in each of the 10 questions of the questionnaire for each of the universities tested in this research.

Table 5.7 - University comparison based on the percentage values of students' answers in the category 'Lack of Knowledge' for each question

	"Lack of Knowledge" percentage totals						
	University						
Question	Edinburgh Napier (BSc-BEng)	Edinburgh Napier (MSc-MEng)	Heriot- Watt (MSc-MEng)	Aristotle (MEng)	NTUA (MEng)	T.E.I. of Serres (BEng)	T.E.I. of Piraeus (BEng)
Q1	35,48	31,25	30,00	28,57	26,32	31,25	42,52
Q2	48,39	34,37	42,50	28,57	26,32	40,63	43,67
Q3	38,70	37,50	42,50	37,13	34,21	35,94	45,97
Q4	38,70	28,12	35,00	31,42	23,68	31,25	37,93
Q5	38,70	34,37	32,50	31,42	26,32	40,63	41,38
Q6	25,80	31,25	35,00	25,71	18,42	26,56	27,58
Q7	48,39	37,50	40,00	28,57	31,58	41,19	42,52
Q8	45,16	46,88	40,00	40,00	28,95	43,75	44,82
Q9	25,80	21,87	27,50	20,00	18,42	20,31	22,99
Q10	45,16	40,62	40,00	34,28	23,68	35,94	42,52

From the Table 5.7 one can also calculate the average percentage value for each question in the questionnaire by adding the percentages of all seven universities in each table line and dividing by 7. A list of all the average percentage values for the research data analysis category ‘Lack of Knowledge’ in each of the ten questions of the questionnaire is provided below:

- Question 1 – 32,20%
- Question 2 – 37,78%
- Question 3 – 38,85%
- Question 4 – 32,3%
- Question 5 – 35,05%
- Question 6 – 27,18%
- Question 7 – 38,54%
- Question 8 – 41,37%
- Question 9 – 22,41%
- Question 10 – 37,46%

From the above list one can conclude that all the average percentage values of all the questions in this category are higher than 32%, with the only exceptions being in Questions 6 (27,18%) and 9 (22,41%). However, in some questions the average percentage value is even higher than 35%! Thus, it is obvious that in all the universities tested, the number of students that present with ‘’Lack of Knowledge’ in almost every basic structural concept of the questionnaire is quite high. Thus, one could conclude, once more, that there is a serious gap in civil engineering education Lack of Knowledge of the basic structural concepts tested in this research.

5.7.4 University comparison based on the percentage values of students' answers in the category ‘Lack of Understanding’

Table 5.8 below presents the percentage values for students in the research data analysis category ‘Lack of Understanding,’ in each of the 10 questions of the questionnaire for each of the universities tested in this research.

Table 5.8 - University comparison based on the percentage values of students' answers in the category 'Lack of Knowledge' for each question

	"Lack of Understanding" percentage totals						
	University						
Question	Edinburgh Napier (BSc-BEng)	Edinburgh Napier (MSc-MEng)	Heriot- Watt (MSc-MEng)	Aristotle (MEng)	NTUA (MEng)	T.E.I. of Serres (BEng)	T.E.I. of Piraeus (BEng)
Q1	61,29	46,88	52,50	40,00	34,21	51,56	63,21
Q2	58,06	53,12	57,50	54,28	50,00	56,25	71,26
Q3	67,74	59,38	62,50	54,28	55,26	62,50	68,96
Q4	54,84	56,25	55,00	54,28	50,00	56,25	60,92
Q5	64,52	56,25	65,00	57,13	50,00	56,25	75,86
Q6	58,06	50,00	50,00	45,71	44,74	57,81	57,47
Q7	61,29	62,50	62,50	57,13	55,26	57,81	68,96
Q8	64,52	50,00	62,50	54,26	55,26	57,81	67,81
Q9	54,84	40,62	50,00	37,13	39,47	46,87	54,02
Q10	48,39	37,50	50,00	37,13	36,84	46,87	52,87

From the Table 5.8 yet again one can also calculate the average percentage value of each question in the questionnaire by adding the percentages of all seven universities in each table line and dividing by 7. A list of all average percentage values for the research data analysis category ‘Lack of Understanding’ in each of the ten questions of the questionnaire is provided below:

- Question 1 – 49,95%
- Question 2 – 57,21%
- Question 3 – 61,51%
- Question 4 – 55,36%
- Question 5 – 60,72%
- Question 6 – 51,79%
- Question 7 – 60,77%
- Question 8 – 58,88%
- Question 9 – 46,14%
- Question 10 – 44,22%

From the above list one can conclude that all the average percentage values of all the questions in this category are higher than 49% with the only exceptions being for Question 9 (46,14%) and Question 10 (44,22%). However, in some questions the average percentage value is even higher than 60%! Thus, it is obvious that in all universities tested, the students that present with ‘Lack of Understanding in almost every basic structural concept of the questionnaire are quite high. Thus, one could conclude that there is a serious gap in civil engineering education regarding the understanding of the basic structural concepts tested in this research.

5.8 A Comparison of MSc/MEng and BSc/BEng Courses at the Researched Universities

5.8.1 University comparison, regarding BSc/BEng courses, based on the average percentage values of students' answers in each of the four research results analysis categories

In the next section a comparison of BSc/BEng courses at the researched universities is provided through an examination of the average percentage values of students' answers in each of the four research data analysis categories.

From Figure 5.1 we have seen that, compared to the other two universities in which students were studying for a BSc/BEng degree, T.E.I. of Serres is the one that has the highest average percentage value of students' answers in the category ‘Good Knowledge – Good Understanding.’ The percentage value for T.E.I. of Serres is 39,06%. In the same manner, the lowest value occurred at T.E.I. of Piraeus (32,07%). The second highest average percentage value of students' answers in this category occurred at Edinburgh Napier University (34,52%). The same exact listing appears in the other three categories ‘No Knowledge – No Understanding,’ ‘Lack of Knowledge’ and ‘Lack of Understanding.’ This means that T.E.I. of Serres is the best university compared to the other two in terms of both knowledge and understanding of the structural concepts addressed in the research questionnaire. In other words, T.E.I. of Serres has the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested and, at the same time, the lowest number of students that are either faced with a lack of knowledge (category ‘Lack of Knowledge’) or a lack of understanding (category ‘Lack of Understanding’) or both (category ‘No Knowledge – No Understanding’) of these structural concepts.

Furthermore, it can be seen that the difference in the average percentage values at these universities in all four categories is not great, ranging from 5 to 7% between the best university and the worst university. Taking into consideration that the best university (T.E.I. of Serres) appears to have an average percentage value of 39,06% in the category ‘Good Knowledge – Good Understanding’ one can conclude that even in the case of the best university there is a huge percentage (> 60%) of students that

appear to have a serious problem in either knowledge or understanding or both of many of the basic structural concepts tested in this research.

Finally, regarding the Greek universities one can conclude that T.E.I. of Serres appears to have better percentages in all four categories compared to T.E.I. of Piraeus.

5.8.2 University comparison, regarding MSc/MEng courses, based on the average percentage values of students' answers in each of the four research results analysis categories

In the next section a comparison of MSc/MEng courses for the research universities is provided by examining the average percentage values of students' answers in each of the four research data analysis categories.

From Figure 5.1 it can be seen that compared to the other three universities in which students were doing an MSc/MEng course, NTUA is the one that has the highest average percentage value of students' answers in the category 'Good Knowledge – Good Understanding.' The percentage value for NTUA is 48,16%. In the same manner, the lowest value occurred at Heriot-Watt University (37,25%). The second highest average percentage value of student answers in this category occurred at Aristotle University (43,43%), and the third highest value was at Edinburgh Napier University (40%). The same exact listing appears in the other three categories 'No Knowledge – No Understanding,' 'Lack of Knowledge' and 'Lack of Understanding.' NTUA has the lowest average percentage values in these three categories whereas Heriot-Watt University has the highest ones. This means that NTUA is the best university compared to the other three in terms of both knowledge and understanding of the structural concepts addressed in the research questionnaire. In other words, NTUA has the highest number of students who have a good knowledge and a good understanding level of the structural concepts tested and, at the same time, the lowest number of students who are either lacking in knowledge (category 'Lack of Knowledge) or in understanding (category 'Lack of Understanding') or both (category 'No Knowledge – No Understanding') of these structural concepts.

Furthermore, it appears that the Greek universities have better average percentage values in all four categories compared to Scottish universities. However, the difference in the average percentage values at all universities in all four categories is not great, ranging from 9 to 11% between the best and the worst university. Taking into consideration that the best university (NTUA) appears to have an average percentage value of 48,16% in the category 'Good Knowledge – Good Understanding,' one can conclude that even in the case of the best university there is a huge percentage (> 50%) of students that appear to have a serious problem in either knowledge or understanding or both of many of the basic structural concepts tested in this research.

Finally, regarding the Greek universities one can conclude that NTUA appears to have better percentages in all four categories compared to Aristotle University. As regards the Scottish universities, Edinburgh Napier University appears to have better percentages in all four categories compared to Heriot-Watt University.

5.8.3 University comparison, regarding MSc/MEng and BSc/BEng courses, based on the percentage values of students' answers in the category 'Good Knowledge – Good Understanding'

a) University comparison based on the percentage values of students who scored from 0 to 4 in the questionnaire

From Figure 5.2 it can be seen that compared to the other two universities in which students were doing a BSc/BEng course, the lowest percentage value of students that scored 'Good Knowledge – Good Understanding' in 0 to a maximum of 4 out of the 10 questions of the questionnaire occurred at T.E.I. of Serres (70,31%) and the highest at T.E.I. of Piraeus (88,51%). Edinburgh Napier University appears to have a percentage value of 74,20%. This means that T.E.I. of Piraeus, compared to the other two universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in 0 and up to 4 out of the ten questions of the questionnaire. It is noteworthy, however, that all

three universities appear to have quite high percentage values of students that are considered to have a below average level of knowledge and understanding of some of the structural concepts tested in this research.

From the figure it can also be seen that compared to the other three universities in which students were studying an MSc/MEng course, the lowest percentage value of students that scored "Good Knowledge – Good Understanding" in 0 and up to 4 out of the 10 questions of the questionnaire occurred at NTUA (47,37%), and the highest was at Heriot-Watt University (70%). This means that Heriot-Watt University, compared to the other three universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in 0 and up to 4 out of the ten questions of the questionnaire. Moreover, it appears that the Greek universities have better percentage values in this category compared to the Scottish universities. Note, however, that all four universities appear to have quite high percentage values (> 47%) of students that are considered to have a below average level of knowledge and understanding of some of the structural concepts tested in this research.

b) University comparison based on the percentage values of students who answered 5 out of the 10 questions of the questionnaire

From Figure 5.2 it can be seen that compared to the other two universities in which students were studying for a BSc/BEng course, the lowest percentage value of students who scored 'Good Knowledge – Good Understanding' in 5 out of the 10 questions of the questionnaire occurred at T.E.I. of Piraeus (9,20%), whereas the highest was at T.E.I. of Serres (20,31%). Edinburgh Napier University appears to have a percentage value of 19,36%. This means that T.E.I. of Serres, compared to the other two universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in 5 out of the ten questions of the questionnaire. It is worthy to note, however, that all three universities appear to have quite low (< 21%) percentage values of students that are considered to have an average level of knowledge and understanding of half of the

structural concepts tested in this research. Furthermore, it appears that T.E.I. of Serres has a similar percentage value to Edinburgh Napier University.

From the figure it can be seen that compared to the other three universities in which students were studying for a MSc/MEng course, the lowest percentage value of students who scored 5 out of the 10 questions of the questionnaire correctly occurred at Heriot-Watt University (17,5%), and the highest was at Aristotle University (25,71%). This means that Aristotle University, compared to the other three universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in 5 out of the ten questions of the questionnaire. Note, however, that all four universities appear to have quite low percentage values (< 26%) of students that are considered to have an average level of knowledge and understanding of half of the structural concepts tested in this research. Furthermore, it appears that NTUA has a similar percentage value to both Edinburgh Napier University and Heriot-Watt University (around 18%).

c) University comparison based on the percentage values of students who got at least 6 out of the 10 questions correct

From Figure 5.2 it can be seen that compared to the other two universities in which students were studying for a BSc/BEng course, the lowest percentage value of students who got at least 6 out of the 10 questions correct occurred at T.E.I. of Piraeus (2,30%), whereas the highest was at T.E.I. of Serres (9,38%). Edinburgh Napier University appears to have a percentage value of 6,46%. This means that T.E.I. of Serres, compared to the other two universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in 6 and up to 10 out of the ten questions of the questionnaire. Note, however, that all three universities appear to have quite low percentage values of students that are considered to have a very good level of knowledge and understanding of the structural concepts tested in this research.

From the figure it can be seen that compared to the other three universities in which students were studying for an MSc/MEng course, the lowest percentage value of

students who scored 6 and above in the questionnaire occurred at Heriot-Watt University (12,5%) and at Edinburgh Napier University (12,5%), while the highest value was at NTUA (34,20%). This means that NTUA, compared to the other three universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in 6 and up to 10 out of the 10 questions of the questionnaire. Moreover, it appears that the Greek universities have better percentage values in this category compared to the Scottish universities. Note, however, that all universities apart from NTUA appear to have low percentage values (< 23%) of students that are considered to have a very good level of knowledge and understanding of the structural concepts tested in this research.

5.8.4 University comparison, regarding MSc/MEng and BSc/BEng courses, based on the average percentage values of students' answers in the category 'No Knowledge – No Understanding'

From the aforementioned figure it can be seen that compared to the other two universities in which students were studying for a BSc/BEng course, the lowest percentage value of students who scored 'No Knowledge – No Understanding' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at T.E.I. of Serres (59,36%), and the highest was at T.E.I. of Piraeus (82,77%). Edinburgh Napier University appears to have a percentage value of 67,73%. This means that T.E.I. of Piraeus, compared to the other two universities, appears to have the highest number of students facing problems in both knowledge and understanding of more than 3 out of the 10 basic structural concepts tested in this research. Note, however, that all three universities appear to have quite high percentage values in this category (> 59%).

From Figure 5.3 it can be seen that compared to the other three universities in which students were studying for an MSc/MEng course, the lowest percentage value of students who scored 'No Knowledge – No Understanding' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at NTUA (36,84%), whereas the highest was at Heriot-Watt University (70%). This means that Heriot-Watt University, compared to the other three universities, appears to have the highest number of

students facing problems in both knowledge and understanding of more than 3 out of the 10 basic structural concepts tested in this research. Note, however, that all four universities appear to have quite high percentage values in this category (> 36%).

The above findings reveal a gap in civil Engineering education regarding both students' knowledge and understanding of the basic structural concepts tested in this research.

5.8.5 University comparison, regarding MSc/MEng and BSc/BEng courses, based on the average percentage values of students' answers in the category 'Lack of Knowledge'

From the Figure 5.4 it can be seen that compared to the other two universities in which students were studying for a BSc/BEng course, the lowest percentage value of students who scored 'Lack of Knowledge' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at T.E.I. of Piraeus (70,11%), whereas the highest was at Edinburgh Napier University (83,89%). T.E.I. of Serres appears to have a percentage value of 78,12%. This means that Edinburgh Napier University, compared to the other two universities, appears to have the highest number of students facing problems in their knowledge of more than 3 out of the 10 basic structural concepts tested in this research. Note, however, that all three universities appear to have quite high percentage values in this category (> 70%).

From the Figure 5.4 it can be seen that compared to the other three universities in which students were studying for a MSc/MEng course, the lowest percentage value of students who scored 'Lack of Knowledge' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at NTUA (50%), whereas the highest was at Edinburgh Napier University (78,13%). This means that Edinburgh Napier University, compared to the other three universities, appears to have the highest number of students facing problems in knowledge of more than 3 out of the 10 basic structural concepts tested in this research. Note, however, that all four universities appear to have quite high percentage values in this category (> 50%).

The above findings once again reveal a gap in civil engineering education regarding students' knowledge of the basic structural concepts tested in this research.

5.8.6 University comparison based on the average percentage values of students' answers in the category 'Lack of Understanding' (regarding MSc/MEng and BSc/BEng courses)

From Figure 5.5 it can be seen that compared to the other two universities in which students were studying for a BSc/BEng course, the lowest percentage value of students who scored 'Lack of Understanding' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at T.E.I. of Serres (95,29%), whereas the highest was at T.E.I. of Piraeus (100%) and also at Edinburgh Napier University (100%). This means that almost all students studying at T.E.I. of Piraeus and also Edinburgh Napier University appear to be facing problems in understanding more than 3 out of the 10 basic structural concepts tested in this research. Note, however, that all three universities appear to have quite high percentage values in this category (> 95%).

Compared to the other three universities in which students were studying for an MSc/MEng degree, the lowest percentage value of students that scored 'Lack of Understanding' in at least 3 and up to 10 out of the 10 questions of the questionnaire occurred at Aristotle University (94,28%), whereas the highest occurred at Heriot-Watt University (97,5%). This means that compared to the other three universities, Heriot-Watt University appears to have the highest number of students facing problems in their understanding of more than 3 out of the 10 basic structural concepts tested in this research. It is significant to note, however, that all four universities appear to have quite high percentage values in this category (> 94%).

The above findings reveal a gap in civil engineering education regarding students' understanding of the basic structural concepts tested in this research.

5.8.7 University comparison based on the highest and lowest percentage values of students' answers for each of the four research results analysis categories (regarding MSc/MEng and BSc/BEng courses)

a) University comparison based on the highest and lowest percentage values of students' answers in the category 'Good Knowledge – Good Understanding'

From the Table 5.1 it can be seen that compared to the other two universities in which students were doing a BSc/BEng course, the lowest percentage value of students that scored 'Good Knowledge – Good Understanding' occurred at T.E.I. of Piraeus for Question 2 (25,28%), and the highest at T.E.I. of Serres for Question 9 and Question 10 (46,87%). This means that T.E.I. of Serres, compared to the other two universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in Questions 9 and 10 of the questionnaire. However, in all three universities the percentage value of students that scored 'Good Knowledge – Good Understanding' in these questions is less than 47%.

Compared to the other three universities in which students were studying for an MSc/MEng course, the lowest percentage value of students that scored 'Good Knowledge – Good Understanding' occurred at Heriot-Watt university for Question 8 (25%) and the highest value at NTUA for Question 1 (60,52%). This means that NTUA, compared to the other three universities, appears to have the highest number of students that have a good knowledge and a good understanding level of the structural concepts tested in Question 1 of the questionnaire. However, in all four universities the percentage value of students that scored 'Good Knowledge – Good Understanding' in Questions 7 and 8 is less than 37%.

b) University comparison based on the highest and lowest percentage values of students' answers in the category 'No Knowledge – No Understanding'

Compared to the other two universities in which students were studying a BSc/BEng course, the lowest percentage value of students that scored "No Knowledge – No Understanding" occurred at T.E.I. of Serres for Question 9 (17,18%) and the highest at T.E.I. of Piraeus for Question 8 (44,82%). This means that T.E.I. of Serres, compared to the other two universities, appears to have the lowest number of students facing problems at both knowledge and understanding of the structural concept addressed in Question 9. In the same manner, T.E.I. of Piraeus, compared to the other two universities, appears to have the highest number of students facing problems at both knowledge and understanding of the structural concept addressed in Question 8.

Compared to the other three universities in which students were studying for an MSc/MEng course, the lowest percentage value of students that scored 'No Knowledge – No Understanding' occurred at Aristotle University for Question 9 (14,28%), and the highest value was at Heriot-Watt University for Question 2 and Question 3 (40%). This means that Aristotle University, compared to the other three universities, appears to have the lowest number of students facing problems in both knowledge and understanding of the structural concept addressed in Question 9. In the same manner, Heriot-Watt University, compared to the other three universities, appears to have the highest number of students facing problems in both knowledge and understanding of the structural concept addressed in Question 2 and Question 3.

c) University comparison based on the highest and lowest percentage values of students' answers in the category 'Lack of Knowledge'

Compared to the other two universities in which students were studying for a BSc/BEng course, the lowest percentage value of students who scored 'Lack of Knowledge' occurred at T.E.I. of Serres for Question 6 (20,31%), whereas the highest was at Edinburgh Napier University for Question 2 (48,39%). This means that T.E.I. of Serres, compared to the other two universities, appears to have the lowest number

of students facing problems in their knowledge of the structural concept addressed in Question 6. In the same manner, Edinburgh Napier University, compared to the other two universities, appears to have the highest number of students facing knowledge gaps in relation to the structural concept addressed in Question 2.

Compared to the other three universities in which students were studying for an MSc/MEng course, the lowest percentage value of students that scored 'Lack of Knowledge' occurred at NTUA for Question 6 (18,42%), and the highest value was at Edinburgh Napier University for Question 8 (46,88%). This means that NTUA, compared to the other three universities, appears to have the lowest number of students facing problems in their knowledge of the structural concept addressed in Question 6. In the same manner, Edinburgh Napier University, as compared to the other three universities, appears to have the highest number of students facing problems in their knowledge of the structural concept addressed in Question 8.

d) University comparison based on the highest and lowest percentage values of students' answers in the category 'Lack of Understanding'

Compared to the other two universities in which students were studying for a BSc/BEng degree, the lowest percentage value of students that scored 'Lack of Understanding' occurred at T.E.I. of Serres for Question 9 and Question 10 (46,87%), and the highest was at T.E.I. Piraeus for Question 5 (75,86%). This means that T.E.I. of Serres, compared to the other two universities, appears to have the lowest number of students facing problems in their understanding of the structural concept addressed in Questions 9 and 10. In the same manner, T.E.I. of Piraeus, as compared to the other two universities, appears to have the highest number of students facing problems in their understanding of the structural concept addressed in Question 5.

Compared to the other three universities in which students were doing an MSc/MEng course, the lowest percentage value of students that scored 'Lack of Understanding' occurred at NTUA for Question 1 (34,21%), whereas the highest value was at Heriot-Watt University for Question 5 (65%). This means that NTUA, compared to the other

three universities, appears to have the lowest number of students facing problems in their understanding of the structural concept addressed in Question 1.

In the same manner, Heriot-Watt University, compared to the other three universities, appears to have the highest number of students who face problems in their understanding of the structural concept addressed in Question 5.

5.9 Discussion of the Research Results

5.9.1 A brief discussion based on students' feedback regarding the research questionnaire

After the collection of students' answers, a series of personal interviews took place with a sample of students from all the universities tested. The purpose of these interviews was to collect valuable feedback for future work but also to make remarks on the research findings. The foundation, the figures and the general format of the research questionnaire were discussed.

Almost all students mentioned that the first section of each question (knowledge) was the easiest to answer since multiple choice answers were provided. However, they were facing difficulties in deciding the correct answer as they are used to using equations or mathematics to come to a conclusion. Regarding the second section of the questions (understanding), a lot of students said that even in the case where they knew a structural concept very well, they faced problems in trying to explain their reasoning in section one (knowledge). As a general remark, students mentioned that the way that the questionnaire was constructed was very different from any kind of university exam they had ever taken. This was based on the fact that university exams rarely ask students to explain their thinking in any kind of exam question. They also said that if the questionnaire was constructed in such a way that a mathematical explanation was required then they believed that they wouldn't make many mistakes in any of the concepts tested.

Moreover, students remarked that Questions 6 and 10 were the easiest to answer and the reason was that they didn't have to write any explanation of their thinking or

provide a definition as an answer. They also mentioned that Question 9 was easy as well. Question 8 was voted as the most difficult question to answer. Moreover, Questions 3, 5 and 7 were also considered to be very difficult to answer and the main reason was, according to students, that they had never been asked to answer similar questions before.

A common student request, in almost all universities tested, was for the questionnaire to be rewritten in such a way as to reduce the time needed to answer all of the questions. Some of them suggested that each question should have multiple choice answers in both sections.

Note also that a huge percentage of students found the whole procedure of answering the questionnaire quite pleasant and wanted to know the correct answers, along with the explanation for and reasoning behind these answers for all of the questions.

5.9.2 A brief discussion regarding the most common questions which were incorrectly answered

As a general remark it has been observed that in the second section of the questions where the definition of a concept or the reasoning behind students' choice in section one was asked for, most students provided the equation they had been taught in order to compute values associated with the appropriate concepts. i.e. in Question 1 students provided as an answer the equation for the centroid of a cross-section. Moreover, other students provided answers to explain their reasoning in section one in some of the questions such as: "It looks right in [my] brain," "Guess," "Intuition," "Logic" etc. These student answers reveal that a lot of students have not achieved an in-depth understanding of the concepts addressed in these questions as they are not able to explain their train of thought in answering the first section (knowledge) of the questions. Finally, other students provided wrong definitions or definitions from other structural concepts and not the ones tested in some of the questions. This also reveals that some students are not even able to distinguish the difference between some of the concepts addressed in this research questionnaire.

More specifically, regarding the second section of the questions in the research questionnaire, a list of common student mistakes (in all universities tested) in some of the questions is provided below.

In Question 1 a lot of students studying in Greek universities provided as an answer that the centroid of a cross-section is actually the point where one can calculate the second moment of inertia of the cross-section.

In Question 2 a lot of students could not explain their thinking and provided answers to both sections of the question based on an educated guess.

For Question 3 a lot of students, instead of providing the definition of the major axis, provided as an answer the equation of the second moment of inertia of a cross-section and explained that the major axis of a cross-section is the one that has the smallest calculated value from the equation. Other students provided as an answer the definition of the second moment of inertia of a cross-section or an answer such as: "the major is the weakest axis of a cross section."

In Question 4 a lot of students provided as an answer the equation of the second moment of inertia of a cross-section and explained that the minor axis of a cross-section is the one that has the largest calculated value from the equation. They also provided answers such as: "the minor axis is the strongest axis of a cross-section" or "the minor axis has the least area closest to the axis."

In Question 5 a lot of students provided the definition of the second moment of inertia of a cross-section and explained that the I_{max} has the most area closest to the axis and I_{min} has the least area closest to the axis.

In Questions 6, 7, 8 and 9 a lot of students provided answers such as: "It looks right in [my] brain," "Guess," "Intuition," "Logic", etc.

In Question 8 some students provided as an answer that they have never been taught the deformed line of a beam which is heated at a certain point or that "they imagine it melts that way."

In Question 10 a lot of students provided wrong answers to both sections of the question.

5.9.3 A brief discussion regarding the research findings and similar research findings in Civil Engineering education

In this work the research results comply with the findings of the research carried out by Cowan (1981). The author has concluded that many graduates have developed unique quantitative competencies but they lack in developing qualitative understanding of the phenomena associated with civil engineering. He has also remarked that the content of modules in higher civil engineering education focus on exercises with mathematical methods. In other words, this shows that they do not focus on allowing the students to develop a critical approach and reflection of their object of study.

In the same manner, Addis (1986) has mentioned that students of civil engineering courses focus on statistical and theoretical aspects of engineering but not on the reasons why a construct will develop an actual behaviour.

Moreover, Brohn and Cowan (1977) mention that most examinations on higher civil engineering education rely on questions where the student will have to show his ability to make the appropriate calculations. However, students do not have the ability to manage the 'unknown' variables that may come up during the project and they do not have the ability to cope with uncertainties that may come up during the process. This is actually related to students' lack of in-depth understanding of civil engineering concepts.

According to the research results, it seems that in all the universities tested, students appear to have a problem in their knowledge and/or understanding of the structural concepts addressed in Questions 2, 3, 5, 7 and 8 of the questionnaire. Note that Questions 2, 3 and 5 are investigating fundamental structural concepts related to the Mechanics module. Thus, the research results regarding these questions comply with the findings of the research conducted by May and Johnson (2008). The authors conducted a survey which points to the fact that many Civil Engineering students come to their courses with a limited understanding of mechanics. Moreover, in his book 'Understanding Structural Analysis' Brown (1990) has also observed that many students have gaps in relation to this module.

Note also that Questions 7 and 8 are investigating fundamental structural concepts related to the Structural Analysis module. Thus, the research results regarding these questions comply with the findings of the research by Brown and Cowan (1977), who tested Civil Engineering graduates and came to the conclusion that they do not have a sound understanding of structural analysis. Furthermore, Brown (1990) emphasizes in his book 'Understanding Structural Analysis' that for the understanding of the Structural Analysis module it is required for students to have achieved a conceptual understanding of the Mechanics module.

Note, however, that in all the questions of the questionnaire a considerable percentage of students exist who are facing problems in their knowledge or understanding of the concepts addressed in the questionnaire.

Thus, the research results comply with the suggestion made by Ji and Bell (2006) that academia must find new ways of helping the students to understand the structural concepts of civil engineering. Moreover, the research results comply with the findings of the research undertaken by May and Johnson (2008), which has revealed that students come to their courses with a limited understanding of mechanics. Finally, it can be seen that the research results also comply with the findings of the research by Brown and Cowan (1977), who tested Civil Engineering graduates and came to the conclusion that they do not have a sound understanding of structural analysis.

CHAPTER 6 CONCLUSIONS AND FUTURE WORK

6.1 Conclusions

The results of this research work show that NTUA, compared to all other universities tested, appears to have the largest number of students that have both a good level of knowledge and understanding but also the lowest number of students facing either a lack of knowledge or lack of understanding or both of the structural concepts addressed in the research questionnaire.

In a descending order, NTUA has noted 48,16% which is the highest average percentage value of students' answers in the category "Good Knowledge – Good Understanding". Aristotle University of Thessaloniki (MEng) has noted 43,43%, Edinburgh Napier University (MSc/MEng) has noted 40,00%, T.E.I. of Serres (BEng) has noted 39,06%, Heriot-Watt University (MSc/MEng) has noted 37,25%, Edinburgh Napier University (BSc/BEng) has noted 34,52% and finally T.E.I. of Piraeus (BEng) has noted 32,07%, which is the lowest average percentage value of students' answers in category "Good Knowledge – Good Understanding".

All the above average percentage values of students' answers in the category "Good Knowledge – Good Understanding" in all universities tested are quite low. This means that independently of the course (Master's or Bachelor's) or in which university (Greek or Scottish) students are studying, the number of students that appear to have a good level of knowledge and understanding of the structural concepts addressed in the research questionnaire is quite low.

On the other hand, the average percentage values of students' answers in the other three research data analysis categories ("No Knowledge-No Understanding", "Lack of Knowledge" and "Lack of Understanding") are considered high. This means that independently of the course (Master's or Bachelor's) or in which university (Greek or Scottish) students are studying, there are a lot of students facing problems in their knowledge or understanding or both of some of the structural concepts tested in this research.

Note that the biggest problem, in all universities tested, appears in the category "Lack of Understanding" where the average percentage value of students' answers is quite high. Even in the case of NTUA which in this research work is considered as the best

university compared to all other universities tested, the average percentage value of students that scored 'Lack of Understanding' is 47,10% and this result reveals that there are a lot of students facing problems in their understanding of the structural concepts addressed in the research questionnaire.

The above findings are a cause for concern since the figures in all the research data analysis categories reveal that even in the case of the best university in terms of students' knowledge and understanding, a considerable number of students are facing problems in their knowledge and/or understanding of some of the structural concepts tested throughout this research. Hence, it is obvious that this phenomenon is more intense in all other universities tested.

Furthermore, from the research results one can see that the majority of students, in all universities tested, scored in the category "Good Knowledge – Good Understanding" 0 and up to 4 out of the 10 questions of the questionnaire. This means that the largest number of students tested in this research have a below average level of knowledge and understanding of the structural concepts addressed in the questionnaire. Moreover, the percentage of students, in all universities tested, that scored in the category "Good Knowledge – Good Understanding" 5 out of the 10 or 6 and up to 10 out of the 10 questions of the questionnaire is quite low. Thus, in all universities tested, the research results show that there are not a lot of students that are considered to have an average or a very good level of knowledge and understanding of the structural concepts tested in this research respectively.

Moreover, from the research results it is obvious that the majority of students, in all universities tested, scored in the categories "No Knowledge – No Understanding", "Lack of Knowledge" and "Lack of Understanding" in at least 3 and up to 10 out of the 10 questions of the questionnaire. In other words, this means that in all universities tested there are a lot of students that are considered to be facing problems in either knowledge or understanding or both in at least 3 out of the 10 basic structural concepts tested in this research. Having in mind that in this research the questionnaire examines basic structural concepts this finding should raise an alarm as it reveals a serious gap in civil engineering education.

Examining the research data from the perspective of the basic structural concepts tested in this research, it is obvious that in all universities tested the lowest percentage values of student answers in the category "Good Knowledge – Good Understanding" occurred in Questions 2, 5, 7 and 8 of the research questionnaire. Moreover, the highest percentage values of student answers in the categories "Lack of Knowledge" and "No Knowledge – No Understanding" occurred in Questions 2, 3, 7 and 8. Finally, the highest percentage values of student answers in the category 'Lack of Understanding' occurred in Questions 3, 5, 7 and 8. Thus, in all universities tested it seems that students appear to have a more intense problem in their knowledge and/or understanding of the structural concepts addressed in Questions 2, 3, 5, 7 and 8 of the questionnaire. More specifically, Questions 7 and 8 appear to be the ones where the most serious problems presented themselves. Questions 3, 2 and 5 follow on in rapid succession.

In more detail, Question 7 examines if the students can identify the correct deformed line of a beam when a vertical load is applied on it and Question 8 examines if the students can identify the correct deformed line of a beam which is heated to a certain point. Question 3 examines if the students can identify the major axis of a cross section along with the definition of the major axis. Question 2 examines if the students can identify the right position of the shear centre of a cross section along with the definition of the shear centre. Finally, Question 5 examines if the students can identify the axis with the maximum and the minimum second moment of area on an equal-angle section.

Moreover, from the research data analysis, one can see that in all universities tested, the highest percentage value of student answers in the category 'Good Knowledge – Good Understanding' has occurred in university NTUA, in Question 1 and it is 60,52%. Note that question 1 of the questionnaire examines if the students can identify the right position of the centroid of a cross section along with the definition of the centroid. This means that even in the case of the best university (in terms of the number of students with a good level of knowledge but also understanding of the structural concepts tested) the highest figure of student answers in the category 'Good Knowledge – Good Understanding' reveals that there is a huge percentage (> 39%) of students that appear to have a serious problem in either their knowledge or

understanding or both of the relevant concept tested in this question of the questionnaire. Note also that this phenomenon is more intense in all other questions of the questionnaire or, in other words, in all other concepts that have been examined and in all other universities tested throughout this research. Thus, one can conclude that the number of students that present a 'Good Knowledge - Good Understanding' in any of the basic structural concepts addressed in the questionnaire are few and far between.

On the other hand, in all universities tested, the number of students that present 'No Knowledge - No Understanding', ''Lack of Knowledge' and ''Lack of Understanding' in almost every basic structural concept of the questionnaire is quite high. Thus, one could conclude that there is a serious gap in civil engineering education regarding both knowledge and understanding of the basic structural concepts tested in this research.

6.2 Future Work

This research work reveals that the percentage of students (in all the universities tested) who are facing problems in their knowledge and/or understanding of fundamental structural concepts addressed in the research questionnaire is quite high.

Future work could focus on the suggestions made by students regarding the construction of the questionnaire. This would lead to an improved version of the questionnaire including multiple choice answers in both sections of the questions so that students wouldn't need to write any explanation for their thinking or provide a definition as an answer. It would also allow the researcher to improve the design of the questionnaire in order to reduce the time needed to answer to all the questions.

Moreover, reducing the time needed to answer the all questions would allow the researcher to add more fundamental structural concepts in the questionnaire in the future. Note that as described in Chapter 3, throughout the personal interviews with professors/lecturers, heads of human resource departments in construction companies and students, the researcher managed to track down a list of widely accepted basic/fundamental structural concepts. Thus, future work could be based on adding

principal concepts from different modules in Civil Engineering in the questionnaire such as viscosity from the module of Fluid Mechanics, Isotropic-Anisotropic-Orthotropic materials from the module of Civil Engineering Materials or Construction Materials, strength-failure-ultimate stages of the failure criteria from the module Mechanics of Materials, and the degrees of freedom and the mass matrix of a dynamic system from the module Structural Dynamics.

Furthermore, my future research will aim to compare all other universities which are on the same level or quality of ranking. When comparing universities within Greece my future work will compare and comment on the quality of intake regarding students.

Finally, future work could also focus on testing a sample of students in higher Civil Engineering education in other countries. This would allow the researcher to investigate if the findings of the current research can be validated in other countries and if gaps in knowledge and/or understanding of fundamental structural concepts are a global phenomenon.

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APPENDIX A RESEARCH QUESTIONNAIRE

Questionnaires on Civil Engineering Study

for the project "Investigating Gaps in Higher Civil Engineering Education regarding Students' Level of Knowledge and Understanding of Basic Structural Concepts"

Please indicate the following :

Your Programme: BSc, BEng, MSc, MEng or Others

Your Stage: 1st Year ☐ 2nd Year ☐ 3nd Year ☐ 4th Year ☐ 5th Year ☐

Your Gender: Male ☐ Female ☐

Your Nationality: UK ☐ Foreigner ☐

Your Working Status: Working ☐ Not Working ☐

Eleni Tsechelidou (06013658)

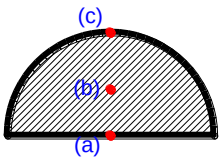
School of Engineering and the Built Environment

Edinburgh Napier University

March 2011

Question 1

(i) Which one of the (a), (b) and (c) points is the right position of the centroid in the cross-sections underneath? Please choose your answers by ticking the appropriate boxes provided under each cross-section.



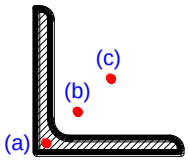
a.

Answers :

(a) ☐

(b) ☐

(c) ☐



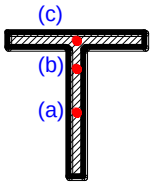
b.

Answers :

(a) ☐

(b) ☐

(c) ☐



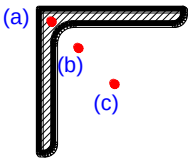
c.

Answers :

(a) ☐

(b) ☐

(c) ☐



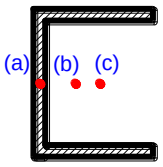
d.

Answers :

(a) ☐

(b) ☐

(c) ☐



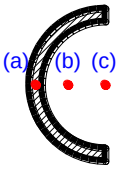
e.

Answers :

(a) ☐

(b) ☐

(c) ☐



f.

Answers :

(a) ☐

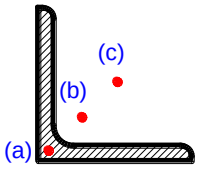
(b) ☐

(c) ☐

(ii) Please provide a brief definition to indicate what the centroid means.

Question 2

(i) Which one of the (a), (b) and (c) points is the right position of the shear-centre in the cross-sections underneath? Please choose your answers by ticking the appropriate boxes provided under each cross-section.



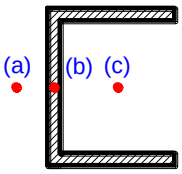
a.

Answers :

(a) ☐

(b) ☐

(c) ☐



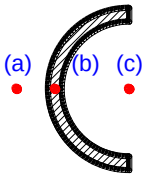
b.

Answers :

(a) ☐

(b) ☐

(c) ☐



c.

Answers :

(a) ☐

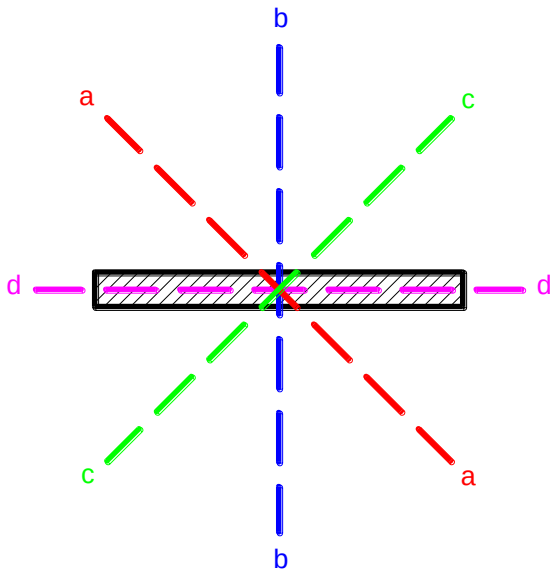
(b) ☐

(c) ☐

(ii) Please provide a brief definition to indicate what the shear-centre means.

Question 3

(i) In the figure below there is a rectangular section with 4 different axes marked on it. Can you identify which one is the major axis of the section? Please choose your answer by ticking the appropriate box provided under the figure.



Answers :

(a) Axis a-a ☐

(b) Axis b-b ☐

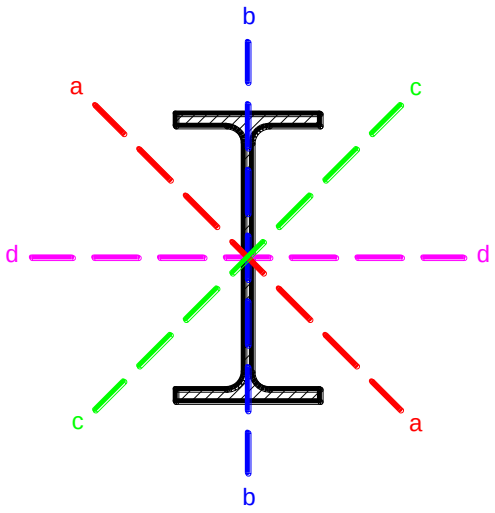
(c) Axis c-c ☐

(d) Axis d-d ☐

(ii) Please provide a brief definition to indicate what the major axis means.

Question 4

(i) In the figure below there is an I-section with four different axes marked on it. Can you identify which one is the minor axis of the I-section? Please choose your answer by ticking the appropriate box provided under the figure.



Answers :

(a) Axis a-a ☐

(b) Axis b-b ☐

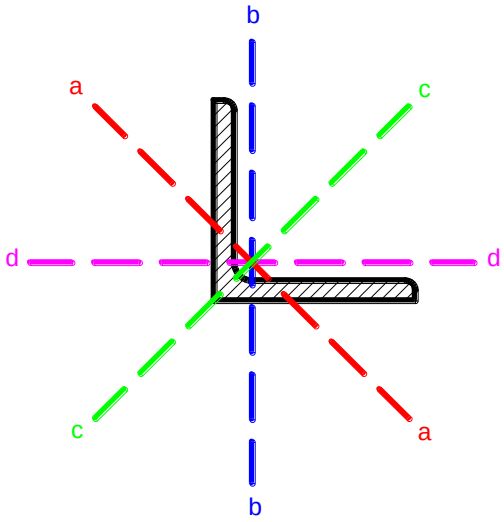
(c) Axis c-c ☐

(d) Axis d-d ☐

(ii) Please provide a brief definition to indicate what the minor axis means.

Question 5

(i) In the figure below there is an equal-angle section with four different axes marked on it. Can you identify which axis has the maximum second moment of area, I_{max}, and which axis has the minimum second moment of area, I_{min}? Please choose your answers by ticking the appropriate boxes provided under the figure for both I_{max} and I_{min}.



Answers : I_{max}		Answers : I_{min}	
(a) Axis a-a	☐	(a) Axis a-a	☐
(b) Axis b-b	☐	(b) Axis b-b	☐
(c) Axis c-c	☐	(c) Axis c-c	☐
(d) Axis d-d	☐	(d) Axis d-d	☐

(ii) Please provide a brief explanation of your answer for both I_{max} and I_{min}.

Question 6

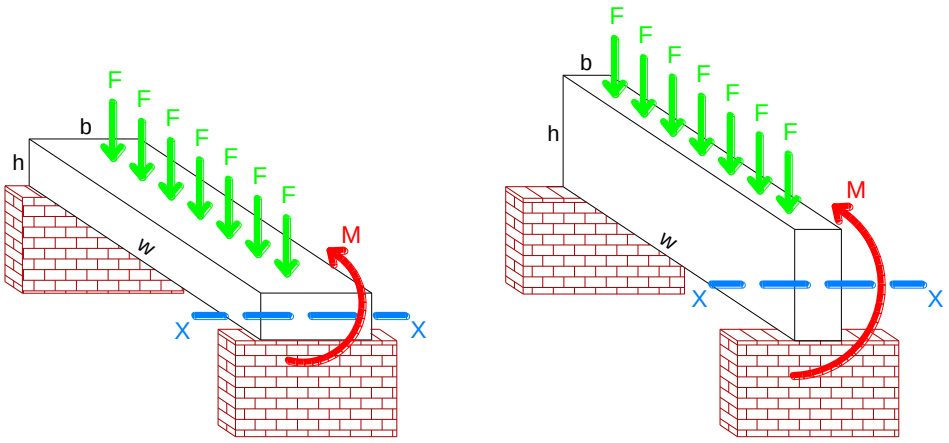
(i) In Figures (a) and (b) below there are two different placements of **exactly the same** rectangular plate in space. This rectangular plate is supported on two masonry walls. Figure (a) illustrates the plate placed horizontally in space (horizontal relative to the ground) and Figure (b) illustrates **exactly the same** plate placed vertically in space (vertical relative to the ground). Assuming that for both cases **exactly the same** vertical force *F* is applied and at **exactly the same point** on the plate, which of the following statements is true? Please choose your answer by ticking the appropriate box provided underneath the figure.

Statements:

(a) The horizontal placement of the rectangular plate (horizontal relative to the ground) has the maximum bending resistance about axis X-X as shown in Figure (a) compared to the vertical placement of the plate (vertical relative to the ground) about axis X-X as shown in Figure (b).

(b) The vertical placement of the rectangular plate (vertical relative to the ground) has the maximum bending resistance about axis X-X as shown in Figure (b) compared to the horizontal placement of the plate (horizontal relative to the ground) about axis X-X as shown in Figure (a).

(c) Both the horizontal and vertical placements of the rectangular plate (horizontal and vertical relative to the ground), as shown in Figures (a) and (b) respectively, have exactly the same bending resistance about axis X-X.



Answers :

(a) ☐ (b) ☐ (c) ☐

(ii) In order to scientifically explain the answer you have provided in Question 6(i), please choose **at least one** of the following statements you think is true. Please choose your answer/answers by ticking the appropriate box/boxes provided underneath the provided statements.

Statements:

(a) The two placements of the rectangular plate in space, as shown in Figures (a) and (b), have exactly the same bending resistance about axis X-X. This happens as the plate is exactly the same in both cases so it has the same area and same dimensions. Furthermore, exactly the same vertical force *F* is applied at exactly the same point on the plate for both cases.

(b) In the case of the horizontal placement of the rectangular plate as illustrated in Figure (a) (horizontal relative to the ground), the vertical force *F* is applied to a bigger surface of the plate compared to the vertical placement of the plate as illustrated in Figure (b) (vertical relative to the ground).

(c) In the case of the vertical placement of the rectangular plate as illustrated in Figure (b) (vertical relative to the ground), the vertical force *F* is applied to a smaller surface of the plate compared to the horizontal placement of the plate as illustrated in Figure (a) (horizontal relative to the ground).

(d) In the case of the vertical placement of the rectangular plate as illustrated in Figure (b) (vertical relative to the ground), the second moment of area (I_x) about axis X-X is bigger compared to the second moment of area (I_x) about axis X-X in Figure (a). Note that Figure (a) illustrates the plate placed horizontally in space (horizontal relative to the ground).

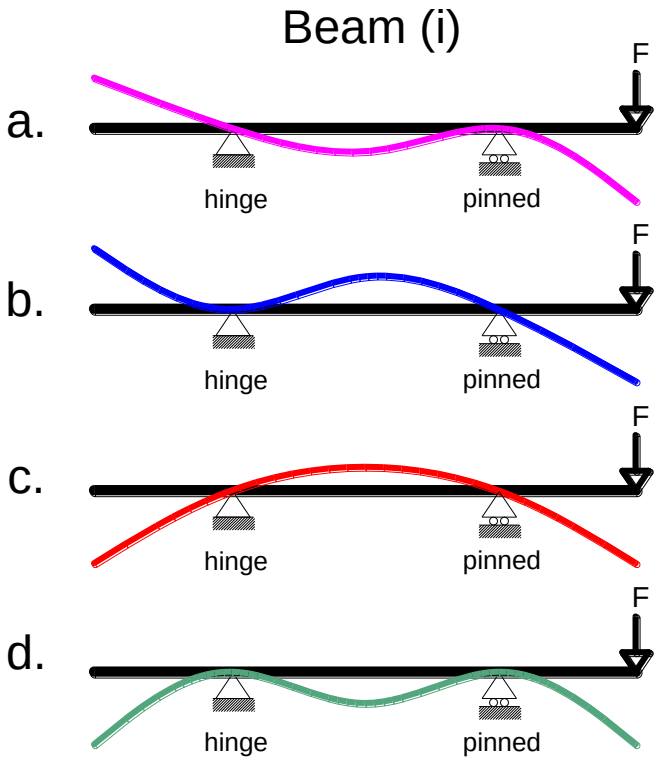
(e) In the case of the horizontal placement of the rectangular plate as illustrated in Figure (a) (horizontal relative to the ground), the second moment of area (I_x) about axis X-X is bigger compared to the second moment of area (I_x) about axis X-X in Figure (b). Note that Figure (b) illustrates the plate placed vertically in space (vertical relative to the ground).

Answers :

(a) ☐ (b) ☐ (c) ☐ (d) ☐ (e) ☐

Question 7

(i) In each of the figures below there are four different cases, namely (a), (b), (c) and (d), and each case illustrates four different shapes of the deformed line of a beam. In each case exactly the same vertical force *F* is applied at the end of the beam. In the first figure the illustrated beam is named as Beam (i), in the second figure the illustrated beam is named as Beam (ii), and in the third figure the illustrated beam is named as Beam (iii). Which one of the cases (a), (b), (c) or (d) is the right shape of the deformed line of the Beam (i), Beam (ii) and Beam (iii) accordingly? Please choose your answers by ticking the appropriate boxes provided under each figure (Beam (i), Beam (ii) and Beam (iii)).

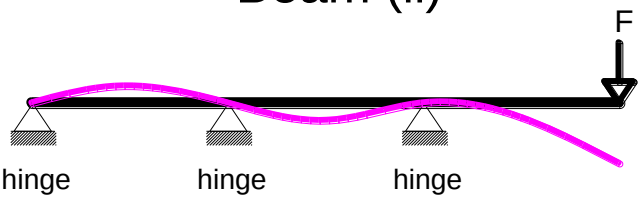


Answers :

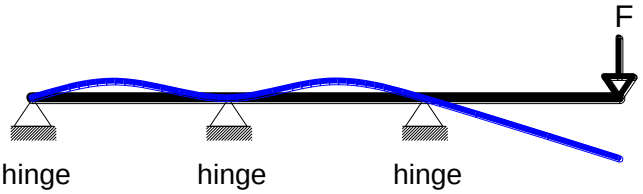
(a) ☐ (b) ☐ (c) ☐ (d) ☐

Beam (ii)

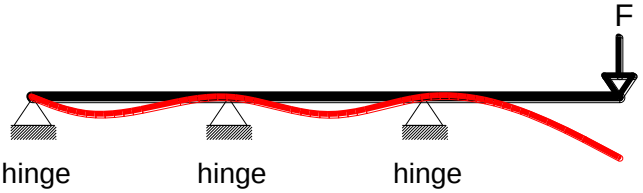
a.



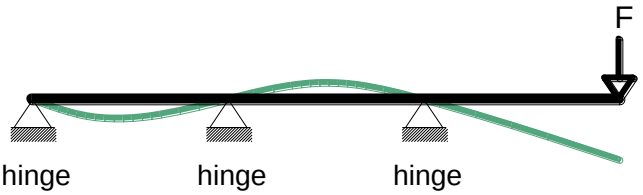
b.



c.



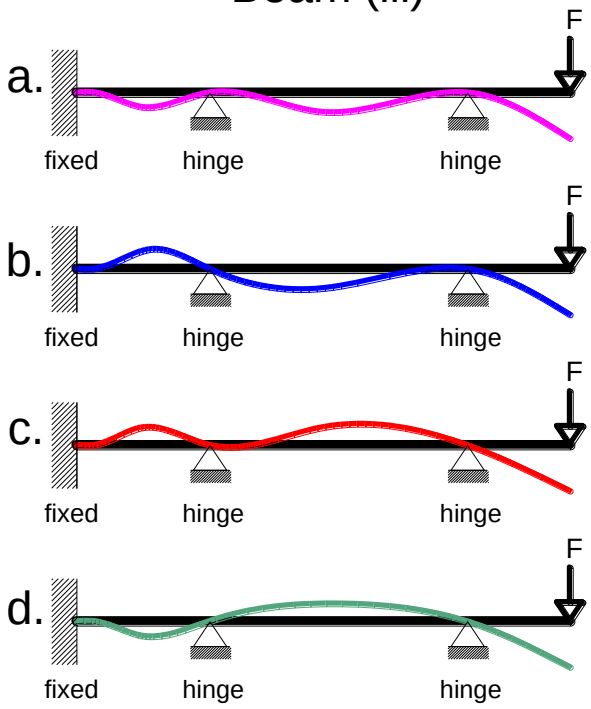
d.



Answers :

(a) ☐ (b) ☐ (c) ☐ (d) ☐

Beam (iii)



Answers :

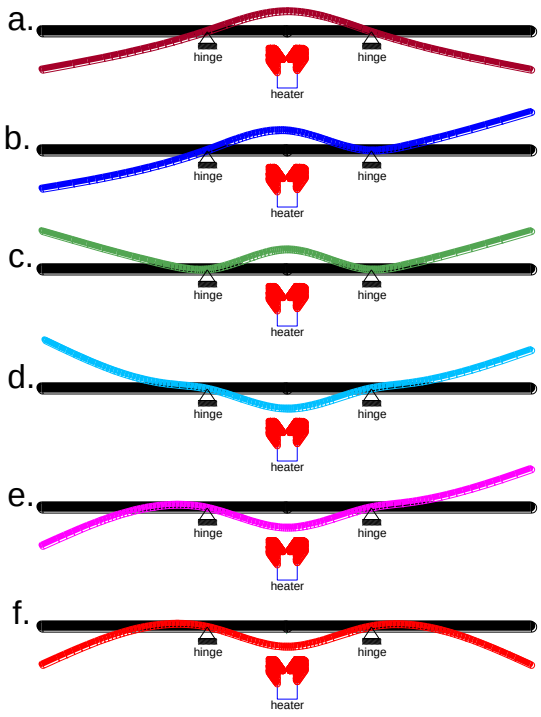
(a) ☐ (b) ☐ (c) ☐ (d) ☐

(ii) Please provide a brief explanation of your answers in Question 7(i) only for the Beam (i).

Question 8

(i) In each of the three figures below there are six different cases, namely (a), (b), (c), (d), (e) and (f) and each one illustrates six different shapes of the deformed line of a beam whose bottom part is being heated up at the exact point where the heater is located as demonstrated in the figure. In the first figure the illustrated beam is named as Beam (i), in the second figure the illustrated beam as Beam (ii), and in the third Figure the illustrated beam named as Beam (iii). Which one of the cases (a), (b), (c), (d), (e) and (f) is the right shape of the deformed line of the Beam (i), Beam (ii) and Beam (iii) accordingly? Please choose your answers by ticking the appropriate boxes provided under each figure (Beam (i), Beam (ii) and Beam (iii)).

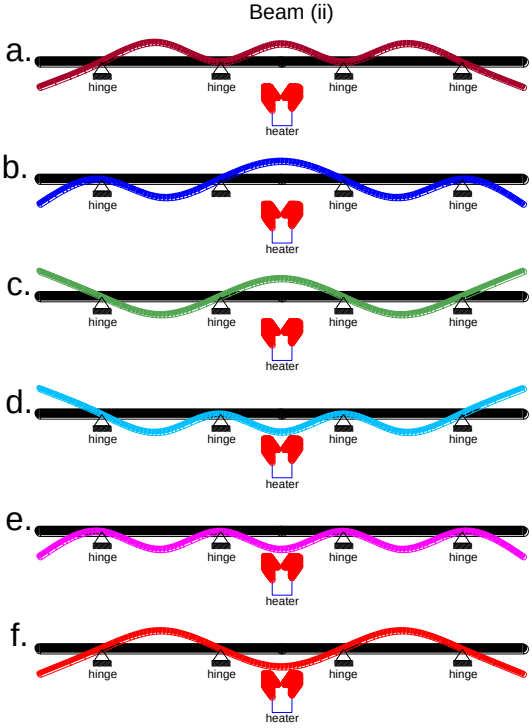
Beam (i)



Answers :

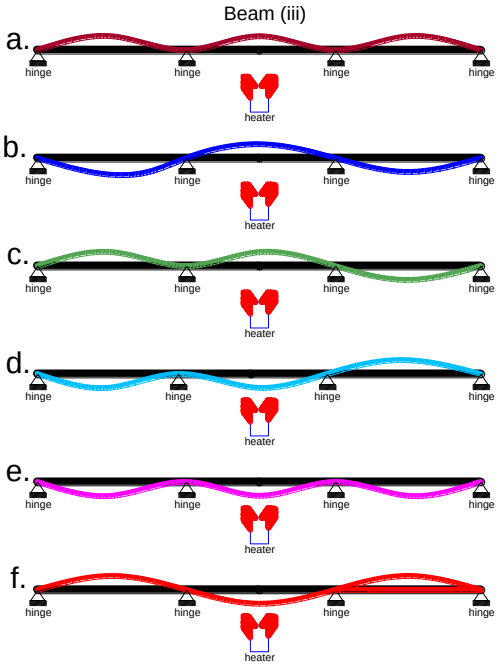
(a) ☐ (b) ☐ (c) ☐ (d) ☐ (e) ☐ (f) ☐

Beam (ii)



Answers :

(a) ☐ (b) ☐ (c) ☐ (d) ☐ (e) ☐ (f) ☐



Answers :

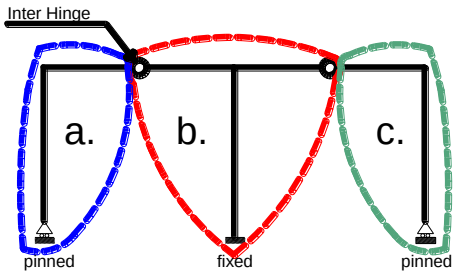
(a) ☐ (b) ☐ (c) ☐ (d) ☐ (e) ☐ (f) ☐

(ii) Please provide a brief explanation of your answers in Question 8(i) only for the Beam (i).

Question 9

(i) In each of the three figures below three parts of the frame are named as (a), (b), and (c), as illustrated. Which one of the frame parts of (a), (b), or (c) can be constructed first, without the existence of any of the others? Please choose your answers by ticking the appropriate boxes provided under each figure.

Frame 1



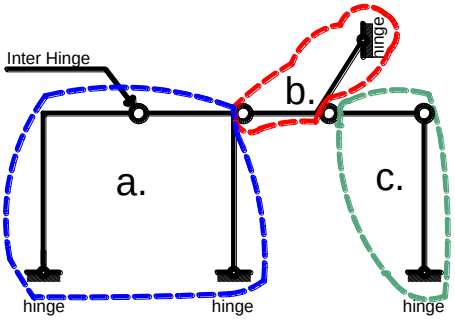
Answers :

(a) ☐

(b) ☐

(c) ☐

Frame 2



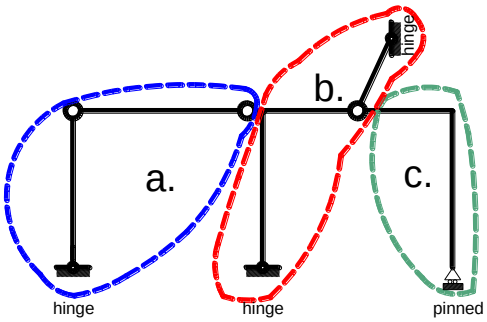
Answers :

(a) ☐

(b) ☐

(c) ☐

Frame 3



Answers :

(a) ☐

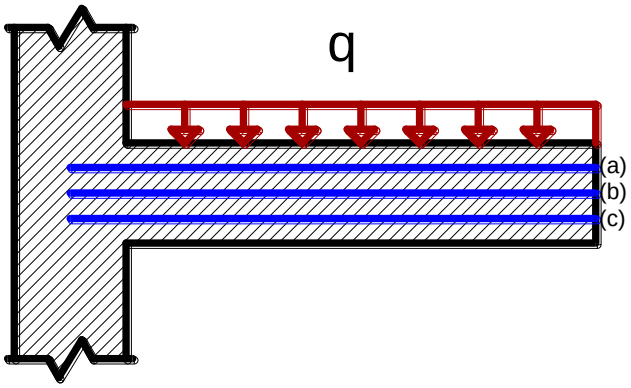
(b) ☐

(c) ☐

(ii) Please provide a brief explanation of your answers in Question 9(i) only for the Frame 1.

Question 10

(i) In the figure below, a cantilever beam with three different parts marked on it named as (a), (b) and (c) is shown. It is assumed that a vertical distributed load q is applied on it. In which of the parts (a), (b) or (c) do you believe that the main tension reinforcement should be placed on the beam? Please choose your answer by ticking the appropriate box provided under the figure.



Answers :

(a) ☐

(b) ☐

(c) ☐

(ii) In order to scientifically explain the answer you have provided in Question 10(i), please choose at least one of the following statements you think is true. Please choose your answer/answers by ticking the appropriate box/boxes provided underneath the provided statements.

Statements:

(a) According to design rules the main tension reinforcement on any cantilever beam should be placed on the middle of the beam.

(b) The compressive stresses due to the vertical distributed load q appear on the top part of the beam.

(c) The tensile stresses due to the vertical distributed load q appear on the bottom part of the beam.

(d) The tensile stresses due to the vertical distributed load q appear on the top part of the beam.

Answers :

(a) ☐ (b) ☐ (c) ☐ (d) ☐

APPENDIX B RESULTS FROM ARISTOTLE UNIVERSITY OF THESSALONIKI (MEng)

Table B.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Aristotle University of Thessaloniki

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	GG	GG	GN	GN	GG	GG	PG	GN	GG	GG	Greek	Male	YES	60%	10%	30%	0%	0%	0%	30%	0%
2	GG	GG	GN	NN	GG	GN	GG	NG	PN	GG	Greek	Male	YES	50%	0%	20%	10%	10%	10%	40%	20%
3	GG	NN	GG	NN	GN	GG	PN	GG	GG	GN	Greek	Male	YES	50%	0%	20%	10%	20%	0%	50%	20%
4	NN	GG	GN	GG	PG	NN	GG	GN	GG	GG	Greek	Male	YES	50%	10%	20%	0%	20%	0%	40%	20%
5	GG	GG	GN	GG	PN	GN	GN	GN	GG	NG	Greek	Male	YES	40%	0%	40%	0%	0%	10%	50%	10%
6	GG	NN	GG	NN	NN	GG	PG	NN	GN	GG	Greek	Female	YES	40%	10%	10%	0%	40%	0%	50%	40%
7	GG	PN	NN	GN	NN	GG	GG	GG	PN	GG	Greek	Female	YES	50%	0%	10%	20%	20%	0%	50%	20%
8	GN	GG	GG	GG	GG	GG	PN	NN	GG	GG	Greek	Male	NO	70%	0%	10%	10%	10%	0%	20%	10%
9	GG	NN	NN	GN	NN	GN	PG	GG	PN	GG	Greek	Male	NO	30%	10%	20%	10%	30%	0%	60%	30%
10	GG	GG	GG	GG	NN	GG	GG	NN	GG	GG	Greek	Male	NO	80%	0%	0%	0%	20%	0%	20%	20%
11	GG	NN	NG	GG	GG	GG	NN	GN	GG	GG	Greek	Male	NO	60%	0%	10%	0%	20%	10%	30%	30%
12	GN	GG	GG	GN	PN	NG	NN	GG	GN	GG	Greek	Male	NO	40%	0%	30%	10%	10%	10%	50%	20%
13	GN	GG	GG	NN	PN	NN	GN	PN	NN	GG	Greek	Male	NO	30%	0%	20%	20%	30%	0%	70%	30%
14	GG	GN	GN	GG	GG	GG	NN	GG	GG	NG	Greek	Male	NO	60%	0%	20%	0%	10%	10%	30%	20%
15	PG	GG	GG	NN	NN	NN	GG	PN	NN	GG	Greek	Male	NO	40%	10%	0%	10%	40%	0%	50%	40%
16	GG	GN	GN	GG	GG	GG	NN	NN	GG	GG	Greek	Male	NO	60%	0%	20%	0%	20%	0%	40%	20%
17	NN	GG	GG	GN	PN	GN	NN	GG	NN	NN	Greek	Male	NO	30%	0%	20%	10%	40%	0%	70%	40%
18	GG	GN	NN	GG	GG	GG	GG	NN	GG	GG	Greek	Male	NO	70%	0%	10%	0%	20%	0%	30%	20%
19	NN	GG	GG	GN	NN	GN	GN	PN	NN	NN	Greek	Male	NO	20%	0%	30%	10%	40%	0%	80%	40%
20	GG	PG	GN	GG	NG	GG	GG	NN	GG	GG	Greek	Male	NO	60%	10%	10%	0%	10%	10%	20%	20%
21	NN	GG	GG	NN	GG	NN	GG	GG	PG	NN	Greek	Male	NO	50%	10%	0%	0%	40%	0%	40%	40%
22	GG	GN	GN	GG	NG	NN	GG	NN	NG	GG	Greek	Male	NO	40%	0%	20%	0%	20%	20%	40%	40%
23	NN	GG	GG	NG	GG	GG	PN	NG	GG	NN	Greek	Male	NO	50%	0%	0%	10%	20%	20%	30%	40%
24	GG	GN	NN	GG	PG	NN	GG	GG	NG	GG	Greek	Male	NO	50%	10%	10%	0%	20%	10%	30%	30%
25	NN	GG	GG	NG	NN	GG	NN	NN	PG	GG	Greek	Female	NO	40%	10%	0%	0%	40%	10%	40%	50%
26	GG	PN	NN	GG	GG	GN	GG	NN	GG	GN	Greek	Female	NO	50%	0%	20%	10%	20%	0%	50%	20%
27	PN	GG	GG	GN	GN	NN	GN	GG	NN	GG	Greek	Female	NO	40%	0%	30%	10%	20%	0%	60%	20%
28	GG	PN	NN	GG	GG	GG	NN	NN	GG	NG	Greek	Female	NO	50%	0%	0%	10%	30%	10%	40%	40%

Table B.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Aristotle University of Thessaloniki (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
29	GG	NN	NN	GG	NN	GN	PN	GG	GN	NN	Foreigner	Male	YES	30%	0%	20%	10%	40%	0%	70%	40%
30	NN	NN	GG	NN	GN	NG	NN	NN	GG	NN	Foreigner	Male	NO	20%	0%	10%	0%	60%	10%	70%	70%
31	GG	NN	NG	GN	NN	GG	GN	PN	GN	NN	Foreigner	Male	NO	20%	0%	30%	10%	30%	10%	70%	40%
32	NN	NN	NN	NN	GN	GN	NN	GG	GG	NN	Foreigner	Male	NO	20%	0%	20%	0%	60%	0%	80%	60%
33	NN	NN	NN	NN	GN	GG	GG	PG	GG	GN	Foreigner	Male	NO	30%	10%	20%	0%	40%	0%	60%	40%
34	NN	GN	NN	GN	GN	GN	NN	GG	GG	GN	Foreigner	Female	NO	20%	0%	50%	0%	30%	0%	80%	30%
35	GG	NN	NN	GN	GN	GG	GN	NG	GN	NN	Foreigner	Female	NO	20%	0%	40%	0%	30%	10%	70%	40%

Table B.1 - Demographic data of students' tested at Aristotle University of Thessaloniki in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MEng	5th Year	28	Greek	22 Male	5
					6 Female	2
			7	Foreigners	5 Male	1
					2 Female	0
Total	MEng	5th Year	35	28 Greek 22 Male – 6 Female 7 Foreigners 5 Male – 2 Female		8

Table B.3 - Demographic data of students' tested at Aristotle University of Thessaloniki in percentage format

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MEng	5th Year	80%	Greek	62,86% Male	14,29%
					17,14% Female	5,71%
			20%	Foreigners	14,29% Male	2,86%
					5,71% Female	0
Total	MEng	5th Year	100%	80% Greek 62,86% Male – 17,14% Female 20% Foreigners 14,28% Male – 5,71% Female		22,86%

Table B.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at Aristotle University of Thessaloniki

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	20	15	14	14	11	17	12	12	18	19
PG	1	1	0	0	2	0	3	1	2	0
PN	1	3	0	0	4	0	4	4	3	0
GN	3	6	8	10	7	9	6	4	5	4
NG	0	0	2	2	2	2	0	3	2	3
NN	10	10	11	9	9	7	1	11	5	9

Table B.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at Aristotle University of Thessaloniki

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	57,13	42,85	40	40	31,42	48,57	34,28	34,28	51,42	54,28
PG	2,85	2,85	0,00	0,00	5,71	0,00	8,57	2,85	5,71	0,00
PN	2,85	8,57	0,00	0,00	11,42	0,00	11,42	11,42	8,57	0,00
GN	8,57	17,14	22,85	28,57	20,00	25,71	17,14	11,42	14,28	11,42
NG	0,00	0,00	5,71	5,71	5,71	5,71	0,00	8,57	5,71	8,57
NN	28,57	28,57	31,42	25,71	25,71	20,00	28,57	31,42	14,28	25,71

Table B.6 - Average percentage of students' answers in each of the six student answer categories at Aristotle University of Thessaloniki

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	43,43%
GN	"Good Knowledge – No Understanding"	17,71%
PG	"Poor Knowledge – Good Understanding"	2,85%
PN	"Poor Knowledge – No Understanding"	5,43%
NG	"No Knowledge – Good Understanding"	4,57%
NN	"No Knowledge – No Understanding"	26,00%

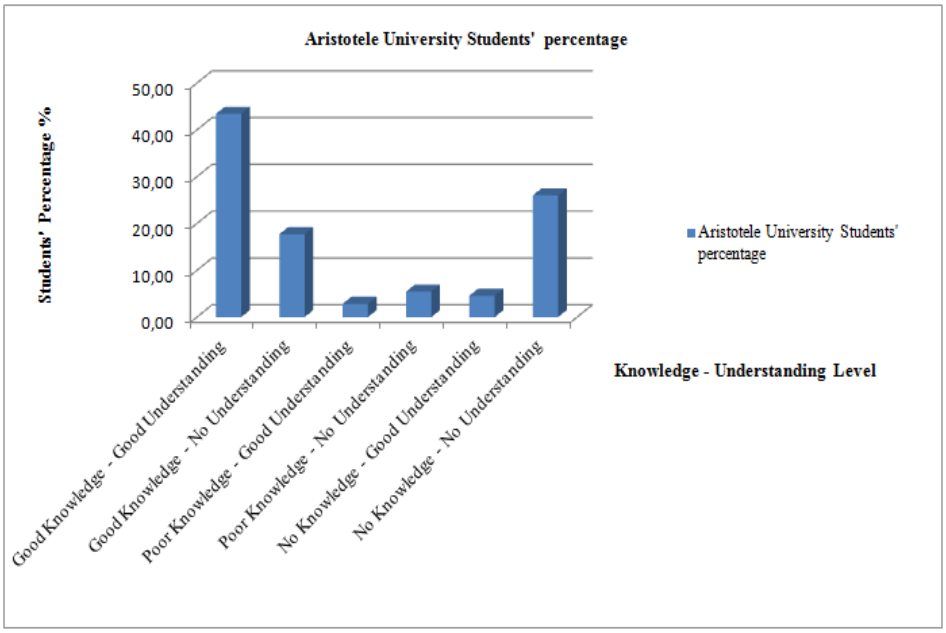


Figure B.1 - Average percentage of students' answers in each of the six student answer categories at Aristotle University of Thessaloniki

Table B.7 – Average percentage value of students' answers in each of the four research data analysis categories at Aristotle University of Thessaloniki

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	43,43%
"No Knowledge – No Understanding"	26,00%
"Lack of Knowledge"	30,57%
"Lack of Understanding"	49,14%

Table B.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at Aristotle University of Thessaloniki

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	20	15	14	14	11	17	12	12	18	19
No Knowledge – No Understanding	10	10	11	9	9	7	10	11	5	9
Lack of Knowledge	10	10	13	11	11	9	10	14	7	12
Lack of Understanding	14	19	19	19	20	16	20	19	13	13

Table B.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Aristotle University of Thessaloniki

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	57,13	42,85	40,00	40,00	31,42	48,57	34,28	34,28	51,42	54,28
No Knowledge – No Understanding	28,57	28,57	31,42	25,71	25,71	20,00	28,57	31,42	14,28	25,71
Lack of Knowledge	28,57	28,57	37,13	31,42	31,42	25,71	28,57	40,00	20,00	34,28
Lack of Understanding	40,00	54,28	54,28	54,28	57,13	45,71	57,13	54,28	37,13	37,13

APPENDIX C RESULTS FROM NATIONAL TECHNICAL UNIVERSITY OF ATHENS (MEng)

Table C.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at NTUA

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	GG	GG	GN	GG	GG	GG	GG	GG	NN	GN	Greek	Male	YES	70%	0%	20%	0%	10%	0%	30%	10%
2	GG	PG	GG	NN	GG	GG	NN	GG	GG	GN	Greek	Male	YES	60%	10%	10%	0%	20%	0%	30%	20%
3	GG	NN	GG	GG	GG	GG	GG	NN	NN	GG	Greek	Male	YES	70%	0%	0%	0%	30%	0%	30%	30%
4	NG	GG	NN	NN	GG	GN	GN	PN	GG	GN	Greek	Male	YES	30%	0%	30%	10%	20%	10%	60%	30%
5	GG	NN	GG	GG	GG	GG	PN	PN	NN	GG	Greek	Male	YES	60%	0%	0%	20%	20%	0%	40%	20%
6	GN	GG	NN	NN	GN	GG	GG	NN	GG	GN	Greek	Male	YES	40%	0%	30%	0%	30%	0%	60%	30%
7	PG	GG	GN	NG	GG	NN	GG	NN	GG	GN	Greek	Male	YES	40%	10%	20%	0%	20%	10%	40%	30%
8	GG	PN	GN	GN	GG	GN	GN	PN	GG	GG	Greek	Female	YES	40%	0%	40%	20%	0%	0%	60%	0%
9	GG	GG	GG	GG	GN	GG	PN	GG	NN	GG	Greek	Female	YES	70%	0%	10%	10%	10%	0%	30%	10%
10	GG	NN	NN	GG	GN	GG	NN	PG	NN	GG	Greek	Female	YES	40%	10%	10%	0%	40%	0%	50%	40%
11	GG	GG	NN	GG	NN	GN	GG	PN	PN	GG	Greek	Male	NO	50%	0%	10%	20%	20%	0%	50%	20%
12	NN	GG	GG	GN	NN	GN	PG	GG	GG	GG	Greek	Male	NO	50%	10%	20%	0%	20%	0%	40%	20%
13	GG	NN	GG	GN	NN	GN	GG	NN	NN	GG	Greek	Male	NO	40%	0%	20%	0%	40%	0%	60%	40%
14	NN	GG	GG	GG	GG	GG	NN	GG	GG	GG	Greek	Male	NO	80%	0%	0%	0%	20%	0%	20%	20%
15	GG	GN	GG	GG	GN	GG	GN	GG	NG	GG	Greek	Male	NO	60%	0%	30%	0%	0%	10%	30%	10%
16	GG	GN	GG	GN	GG	GG	NN	PN	GG	GN	Greek	Male	NO	50%	0%	30%	10%	10%	0%	50%	10%
17	GG	GG	GN	GG	PN	GG	PN	PN	PN	GG	Greek	Male	NO	50%	0%	10%	40%	0%	0%	50%	0%
18	PN	PN	NN	GN	GN	GG	NN	GG	GG	GN	Greek	Male	NO	30%	0%	30%	20%	20%	0%	70%	20%
19	GG	GN	GG	GG	GG	GG	PN	NG	GN	GG	Greek	Male	NO	60%	0%	20%	10%	0%	10%	30%	10%
20	GN	GN	NN	GN	NN	NG	GG	GG	GG	NG	Greek	Male	NO	30%	0%	30%	0%	20%	20%	50%	40%
21	GG	GG	GG	GG	PN	GG	NN	GN	PG	GG	Greek	Male	NO	60%	10%	10%	10%	10%	0%	30%	10%
22	GG	NN	GN	GG	GG	NN	GG	NN	GG	GG	Greek	Male	NO	60%	0%	10%	0%	30%	0%	40%	30%
23	GG	GG	NN	GG	PG	GN	GN	PN	GG	GG	Greek	Male	NO	50%	10%	20%	10%	10%	0%	40%	10%
24	GG	GN	GG	GN	GG	GG	NN	PN	GN	GG	Greek	Female	NO	50%	0%	30%	10%	10%	0%	50%	10%
25	GG	GN	GG	GG	NN	GG	GG	GG	GG	GG	Greek	Female	NO	80%	0%	10%	0%	10%	0%	20%	10%

Table C.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at NTUA (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
26	GG	GG	NN	GG	GG	NN	GG	NN	GN	GG	Greek	Female	NO	60%	0%	10%	0%	30%	0%	40%	30%
27	GG	PN	NG	GG	PG	GN	GG	GN	GN	GG	Greek	Female	NO	40%	10%	30%	10%	0%	10%	40%	10%
28	NN	GG	GG	GG	NG	GG	GN	GG	GG	NN	Greek	Female	NO	60%	0%	10%	0%	20%	10%	30%	30%
29	GG	NN	GG	GN	GN	NN	GG	NN	GG	GG	Greek	Female	NO	50%	0%	20%	0%	30%	0%	50%	30%
30	NN	NN	GN	GN	GN	GN	NN	GG	GG	NN	Foreigner	Male	YES	20%	0%	40%	0%	40%	0%	80%	40%
31	NN	NN	GN	GN	GN	GN	GG	GG	PN	NN	Foreigner	Female	YES	20%	0%	40%	10%	30%	0%	80%	30%
32	NN	GG	NN	NN	NN	GG	NN	GG	GG	NN	Foreigner	Male	NO	40%	0%	0%	0%	60%	0%	60%	60%
33	GN	NN	GG	GN	NN	GN	NG	GG	GG	NG	Foreigner	Male	NO	30%	0%	30%	0%	20%	20%	50%	40%
34	NN	GG	GN	NN	GG	GG	NN	PN	GG	NN	Foreigner	Male	NO	40%	0%	10%	10%	40%	0%	60%	40%
35	GG	GG	GN	GG	NN	NN	GN	PG	GN	GG	Foreigner	Male	NO	40%	10%	30%	0%	20%	0%	50%	20%
36	NN	GG	NN	NN	GG	GG	NN	NN	GG	NN	Foreigner	Male	NO	40%	0%	0%	0%	60%	0%	60%	60%
37	GG	NN	NN	NN	NN	NN	GG	NN	GN	GG	Foreigner	Male	NO	30%	0%	10%	0%	60%	0%	70%	60%
38	NN	GG	NN	NN	GG	GN	GG	NN	GG	NN	Foreigner	Male	NO	40%	0%	10%	0%	50%	0%	60%	40%

Table C.2 - Demographic data of students' tested at NTUA in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MEng	5th Year	29	Greek	20 Male	7
					9 Female	3
			9	Foreigners	8 Male	1
					1 Female	1
Total	MEng	5th Year	38	29 Greek 20 Male – 9 Female 9 Foreigners 8 Male – 1 Female		12

Table C.3 - Demographic data of students' tested at NTUA in percentage format

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MEng	5th Year	76,32%	Greek	52,63% Male	18,42%
					23,68% Female	7,89%
			23,68%	Foreigners	21,05% Male	2,63%
					2,63% Female	2,63%
Total	MEng	5th Year	100%	76,32% Greek 52,64% Male – 23,68% Female 23,68% Foreigners 21,04% Male – 2,63% Female		31,57%

Table C.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at NTUA

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	23	18	16	18	16	20	15	14	21	22
PG	1	1	0	0	2	0	1	2	1	0
PN	1	3	0	0	2	0	4	9	3	0
GN	3	6	9	11	8	11	6	2	6	7
NG	1	0	1	1	1	1	1	1	1	2
NN	9	10	12	8	9	6	11	10	6	7

Table C.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at NTUA

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	60,52	47,36	42,1	47,36	42,1	52,63	39,47	36,84	55,26	57,89
PG	2,63	2,63	0,00	0,00	5,26	0,00	2,63	5,26	2,63	0,00
PN	2,63	7,89	0,00	0,00	5,26	0,00	10,52	23,68	7,89	0,00
GN	7,89	15,78	23,68	28,94	21,05	28,94	15,78	5,26	15,78	18,42
NG	2,63	0,00	2,63	2,63	2,63	2,63	2,63	2,63	2,63 U	5,26
NN	23,68	26,31	31,57	21,05	23,68	15,78	28,94	26,31	15,78	18,42

Table C.6 - Average percentage of students' answers in each of the six student answer categories at NTUA

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	48,16%
GN	"Good Knowledge – No Understanding"	18,16%
PG	"Poor Knowledge – Good Understanding"	2,10%
PN	"Poor Knowledge – No Understanding"	5,79%
NG	"No Knowledge – Good Understanding"	2,63%
NN	"No Knowledge – No Understanding"	23,16%

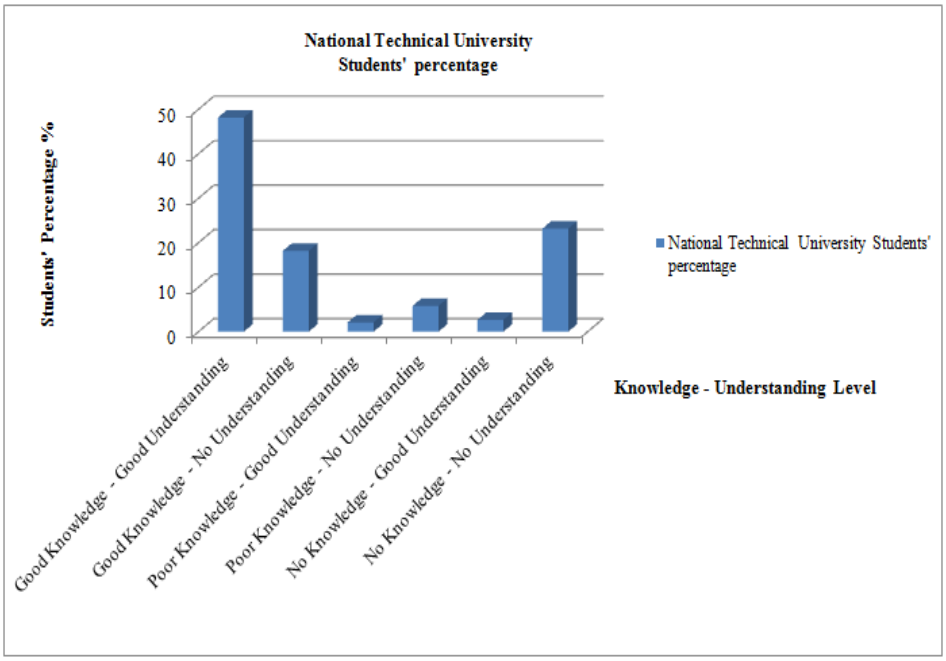


Figure C.1 - Average percentage of students' answers in each of the six student answer categories at NTUA

Table C.7 – Average percentage value of students' answers in each of the four research data analysis categories at NTUA

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	48,16%
"No Knowledge – No Understanding"	23,16%
"Lack of Knowledge"	25,79%
"Lack of Understanding"	47,10%

Table C.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at NTUA

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	23	18	16	18	16	20	15	14	21	22
No Knowledge – No Understanding	9	10	12	8	9	6	11	10	6	7
Lack of Knowledge	10	10	13	9	10	7	12	11	7	9
Lack of Understanding	13	19	21	19	19	17	21	21	15	14

Table C.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at NTUA

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	60,52	47,36	42,10	47,36	42,10	52,63	39,47	36,84	55,26	57,89
No Knowledge – No Understanding	23,68	26,32	31,57	21,05	23,68	15,78	28,94	26,32	15,78	18,42
Lack of Knowledge	26,32	26,32	34,21	23,68	26,32	18,42	31,58	28,95	18,42	23,68
Lack of Understanding	34,21	50,00	55,26	50,00	50,00	44,74	55,26	55,26	39,47	36,84

APPENDIX D RESULTS FROM T.E.I. OF PIRAEUS (BEng)

Table D.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Piraeus

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	GG	PG	GN	GG	PN	GN	PN	GG	PN	NG	Greek	Male	YES	30%	10%	20%	30%	0%	10%	50%	10%
2	GN	GG	GN	GN	GN	NN	PN	PN	PG	NN	Greek	Male	YES	10%	10%	40%	20%	20%	0%	80%	20%
3	GG	GG	NN	GG	NG	GN	PN	GG	NN	NN	Greek	Male	YES	40%	0%	10%	10%	30%	10%	50%	40%
4	GG	GG	GN	NN	PG	GG	NN	PN	GG	NN	Greek	Male	YES	40%	10%	10%	10%	30%	0%	50%	30%
5	GN	PN	NN	GG	NN	NN	GG	PG	PN	NN	Greek	Male	YES	20%	10%	10%	20%	40%	0%	70%	40%
6	PN	GG	GG	NN	NG	NN	NN	NN	GG	NN	Greek	Male	YES	30%	0%	0%	10%	50%	10%	60%	60%
7	GG	PN	GN	GG	GN	GN	PN	GG	PN	GG	Greek	Male	YES	40%	0%	30%	30%	0%	0%	60%	0%
8	GN	PN	NN	GG	NN	GN	PG	NN	GG	NN	Greek	Male	YES	20%	10%	20%	10%	40%	0%	70%	40%
9	GG	NN	NN	GG	NG	GN	NN	GG	GN	NN	Greek	Male	YES	30%	0%	20%	0%	40%	10%	60%	50%
10	NN	GG	GN	NN	GN	NN	PN	NN	GN	GG	Greek	Male	YES	20%	0%	30%	10%	40%	0%	80%	40%
11	GG	GG	NN	NN	NN	GG	GN	PG	PG	NN	Greek	Male	YES	30%	20%	10%	0%	40%	0%	50%	40%
12	NN	GN	GN	NN	NN	GG	PN	NN	GN	GG	Greek	Male	YES	20%	0%	30%	10%	40%	0%	80%	40%
13	NN	GG	GG	GG	GN	GN	NN	PN	GG	NN	Greek	Male	YES	40%	0%	20%	10%	30%	0%	60%	30%
14	NN	GG	GN	NN	NN	GG	PG	NN	PG	NN	Greek	Male	YES	20%	20%	10%	0%	50%	0%	60%	50%
15	GG	PN	GN	GG	GN	GN	GG	NN	NN	GG	Greek	Male	YES	40%	0%	30%	10%	20%	0%	60%	20%
16	NN	GG	NN	NN	GG	NN	NN	PN	GG	NN	Greek	Male	YES	30%	0%	0%	10%	60%	0%	70%	60%
17	GG	NN	GG	NN	NN	GG	GN	PN	NN	NG	Greek	Male	YES	30%	0%	10%	10%	40%	10%	60%	50%
18	PN	PN	GG	NG	PN	NN	NN	PG	GG	NG	Greek	Female	YES	20%	10%	0%	30%	20%	20%	50%	40%
19	NN	GG	GG	NN	PN	NN	PN	NN	GG	NN	Greek	Female	YES	30%	0%	0%	20%	50%	0%	70%	50%
20	GG	NN	GG	GG	PN	GN	NN	GG	GG	NN	Greek	Female	YES	50%	0%	10%	10%	30%	0%	50%	30%
21	NN	GG	NN	GG	NN	NN	PN	NN	GN	GG	Greek	Female	YES	30%	0%	10%	10%	50%	0%	70%	50%
22	GG	NN	GG	GG	GN	NN	GG	PG	GG	NG	Greek	Female	YES	50%	10%	10%	0%	20%	10%	30%	30%
23	NN	PN	GG	GG	NN	GN	PG	NN	NN	GG	Greek	Female	YES	30%	10%	10%	10%	40%	0%	60%	40%
24	GG	GN	GN	NN	NN	GG	NN	PG	GN	NG	Greek	Female	YES	20%	10%	30%	0%	30%	10%	60%	40%
25	GG	GG	NN	GG	GN	GN	PN	NN	GN	NN	Greek	Female	YES	30%	0%	30%	10%	30%	0%	70%	30%
26	GG	PN	GN	GG	GN	GN	PN	GG	NN	GG	Greek	Female	YES	40%	0%	30%	20%	10%	0%	60%	10%

Table D.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Piraeus (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
27	GN	NN	GG	GN	NN	GG	NG	NN	PG	NN	Greek	Male	NO	20%	10%	20%	0%	40%	10%	60%	50%
28	GN	NN	NN	GG	NN	GG	PN	NN	NN	GG	Greek	Male	NO	30%	0%	10%	10%	50%	0%	70%	50%
29	GG	NN	GG	NN	GG	GN	GN	NN	GN	NN	Greek	Male	NO	30%	0%	30%	0%	40%	0%	70%	40%
30	GG	NN	GG	NG	GG	NN	NN	PN	PN	GG	Greek	Male	NO	40%	0%	0%	20%	30%	10%	50%	40%
31	PN	PG	NN	NN	GG	GG	GG	NN	NN	GG	Greek	Male	NO	40%	10%	0%	10%	40%	0%	50%	40%
32	GN	PN	NN	GG	NN	GN	GG	NN	GN	GN	Greek	Male	NO	20%	0%	40%	10%	30%	0%	80%	30%
33	GG	PN	GN	GN	GN	GG	GN	NN	PN	GG	Greek	Male	NO	30%	0%	40%	20%	10%	0%	70%	10%
34	PN	NN	NN	GG	NN	GG	PN	NN	GG	NN	Greek	Male	NO	30%	0%	0%	20%	50%	0%	70%	50%
35	PN	PN	NN	GG	GG	GN	NN	NN	GG	GG	Greek	Male	NO	40%	0%	10%	20%	30%	0%	60%	30%
36	GN	PN	GN	GN	NN	GG	PN	GG	GN	GN	Greek	Male	NO	20%	0%	50%	20%	10%	0%	80%	10%
37	NN	GG	GN	NN	GG	GN	GG	NN	GG	NN	Greek	Male	NO	40%	0%	20%	0%	40%	0%	60%	40%
38	NN	GG	NN	GN	NN	GG	PN	NN	GG	NN	Greek	Male	NO	30%	0%	10%	10%	50%	0%	70%	50%
39	GG	NN	GN	NN	GG	GN	GN	NN	NN	GG	Greek	Male	NO	30%	0%	30%	0%	40%	0%	70%	40%
40	NN	GG	GG	GN	GG	GN	GG	GN	GG	GG	Greek	Male	NO	60%	0%	30%	0%	10%	0%	40%	10%
41	GG	NN	NN	GG	GN	GG	NN	PN	PN	NN	Greek	Male	NO	30%	0%	10%	20%	40%	0%	70%	40%
42	NN	GG	NN	NN	GG	NN	NN	GG	NN	GG	Greek	Male	NO	40%	0%	0%	0%	60%	0%	60%	60%
43	GG	NN	GG	GN	NN	GG	GG	GN	GG	GG	Greek	Male	NO	60%	0%	20%	0%	20%	0%	40%	20%
44	NN	GG	NN	GG	GG	NN	GG	PN	NN	GG	Greek	Male	NO	50%	0%	0%	10%	40%	0%	50%	40%
45	GG	NN	NN	NN	NN	GG	NN	GG	PN	GN	Greek	Male	NO	30%	0%	10%	10%	50%	0%	70%	50%
46	PN	NN	GG	GN	GG	GN	GG	NN	GG	GG	Greek	Male	NO	50%	0%	20%	10%	20%	0%	50%	20%
47	GG	PN	NG	GG	NN	GG	NN	GG	GN	NN	Greek	Male	NO	40%	0%	10%	10%	30%	10%	50%	40%
48	PN	NN	GG	NN	GG	NN	GG	PN	NG	GG	Greek	Male	NO	40%	0%	0%	20%	30%	10%	50%	40%
49	NG	NN	GG	GN	GG	GN	GG	PN	PN	GG	Greek	Male	NO	40%	0%	20%	20%	10%	10%	50%	20%
50	GG	PN	NG	GN	NN	GG	NN	GG	PN	NN	Greek	Male	NO	30%	0%	10%	20%	30%	10%	60%	40%
51	GN	NN	GN	NN	GG	GN	GG	PN	GG	GG	Greek	Male	NO	40%	0%	30%	10%	20%	0%	60%	20%
52	GG	NN	NN	GN	NN	GG	NN	GG	NG	NN	Greek	Male	NO	30%	0%	10%	0%	50%	10%	60%	60%
53	NN	GG	GN	GG	NN	GG	PN	NN	PG	NN	Greek	Female	NO	30%	10%	10%	10%	40%	0%	60%	40%
54	NN	GG	NN	GG	NN	NG	PN	GG	GN	GG	Greek	Female	NO	40%	0%	10%	10%	30%	10%	50%	40%

Table D.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Piraeus (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
55	GG	NN	GN	GN	NN	GG	PN	NN	PN	NN	Greek	Female	NO	20%	0%	20%	20%	40%	0%	80%	40%
56	NN	GG	GN	NN	GG	GN	NN	GG	PN	NN	Greek	Female	NO	30%	0%	20%	10%	40%	0%	70%	40%
57	GG	PN	GN	GG	NN	NN	GG	GG	NN	GG	Greek	Female	NO	50%	0%	10%	10%	30%	0%	50%	30%
58	GG	NN	GN	GG	NN	NN	NN	NN	GN	NN	Greek	Female	NO	20%	0%	20%	0%	60%	0%	80%	60%
59	GG	PN	NN	GG	NN	GG	NN	GG	GG	NN	Greek	Female	NO	50%	0%	0%	10%	40%	0%	50%	40%
60	GG	NN	NG	GG	NN	GG	NN	PN	PN	NN	Greek	Female	NO	30%	0%	0%	20%	40%	10%	60%	50%
61	NN	NN	GG	GG	GN	GN	NN	NN	GG	GG	Greek	Female	NO	40%	0%	20%	0%	40%	0%	60%	40%
62	NN	GN	GN	NN	GG	NN	GG	GN	GG	GG	Greek	Female	NO	40%	0%	30%	0%	30%	0%	60%	40%
63	NN	NN	NN	GN	GN	GG	NN	GG	NN	NN	Greek	Female	NO	20%	0%	20%	0%	60%	0%	80%	60%
64	NN	GN	NN	NN	GG	GN	GG	PN	GG	GG	Greek	Female	NO	40%	0%	20%	10%	30%	0%	60%	30%
65	NN	GG	GN	NN	NN	GG	PN	PN	GN	NN	Greek	Female	NO	20%	0%	20%	20%	40%	0%	80%	40%
66	GG	NN	NN	NN	GG	GN	GN	NN	PN	NN	Greek	Female	NO	20%	0%	20%	10%	50%	0%	80%	50%
67	PN	PN	NN	NG	PG	GG	NN	NN	PN	GN	Greek	Female	NO	10%	10%	10%	30%	30%	10%	70%	40%
68	NN	GG	GN	GG	NN	NG	NN	PN	GN	GG	Greek	Female	NO	30%	0%	20%	10%	30%	10%	60%	40%
69	PG	NN	NN	GN	NN	GG	NN	GG	NG	GG	Foreigner	Male	YES	30%	10%	10%	0%	40%	10%	50%	50%
70	NN	NN	GG	GN	GG	NN	GG	PN	GG	GN	Foreigner	Male	YES	40%	0%	20%	10%	30%	0%	60%	30%
71	NN	GN	GG	NN	GG	GN	NN	GG	GG	GN	Foreigner	Male	YES	40%	0%	30%	0%	30%	0%	60%	30%
72	NN	NN	NN	GN	GN	GG	NN	GG	NN	GG	Foreigner	Female	YES	30%	0%	20%	0%	50%	0%	70%	50%
73	NN	NN	NN	GG	NN	GG	NN	NN	GG	GN	Foreigner	Male	NO	30%	0%	10%	0%	60%	0%	70%	60%
74	PN	NN	NN	GN	GN	NN	GG	NN	PN	GG	Foreigner	Male	NO	20%	0%	20%	20%	40%	0%	80%	40%
75	NG	NN	NN	GG	NN	GG	NN	NN	GG	GN	Foreigner	Male	NO	30%	0%	10%	0%	50%	10%	60%	60%
76	NN	PN	NN	GN	GN	GG	GG	NN	NN	GG	Foreigner	Male	NO	30%	0%	20%	10%	40%	0%	70%	40%
77	NN	PG	GG	NN	GG	NN	NN	NN	GG	GN	Foreigner	Male	NO	30%	10%	10%	0%	50%	0%	60%	50%
78	PN	NN	NN	GN	GN	GN	GG	NN	GG	GG	Foreigner	Male	NO	20%	0%	30%	10%	30%	0%	70%	30%
79	NN	NN	NN	GN	NN	GG	NN	PN	NN	GG	Foreigner	Male	NO	20%	0%	10%	10%	60%	0%	80%	60%

Table D.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Piraeus (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
80	PN	NN	NN	NN	GG	NN	NN	NN	GG	GN	Foreigner	Male	NO	20%	0%	10%	10%	60%	0%	80%	60%
81	NN	PN	NN	NN	GG	GN	NN	GG	NN	GN	Foreigner	Female	NO	20%	0%	20%	10%	50%	0%	80%	50%
82	NN	PN	GG	GN	PN	GG	GG	NN	GG	GG	Foreigner	Female	NO	50%	0%	10%	20%	20%	0%	50%	20%
83	NN	NN	NN	NN	GG	NN	GG	GG	PN	GN	Foreigner	Female	NO	30%	0%	10%	10%	50%	0%	70%	50%
84	PN	NN	GG	GN	PN	GG	NN	NN	GG	GG	Foreigner	Female	NO	40%	0%	10%	20%	30%	0%	60%	30%
85	NN	NN	NN	NN	PN	GG	NN	GG	NG	GN	Foreigner	Female	NO	20%	0%	10%	10%	50%	10%	70%	60%
86	NN	NN	GG	NN	GG	NN	GG	NN	GG	GG	Foreigner	Female	NO	50%	0%	0%	0%	50%	0%	50%	50%
87	NN	NN	GG	GN	GG	GN	NN	NN	PN	GN	Foreigner	Female	NO	20%	0%	30%	10%	40%	0%	80%	40%

Table D.2 - Demographic data of students' tested at T.E.I. of Piraeus in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	BEng	4th Year	68	Greek	43 Male	17
					25 Female	9
			19	Foreigners	11 Male	3
					8 Female	1
Total	BEng	4th Year	87	68 Greek 43 Male – 25 Female 19 Foreigners 11 Male – 8 Female		30

Table 2 - Demographic data of students' tested at T.E.I. of Piraeus in percentage format

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	BEng	4th Year	78,16%	Greek	49,43% Male	19,54%
					28,73% Female	10,34%
			21,84%	Foreigners	12,64% Male	3,45%
					9,20% Female	1,15%
Total	BEng	4th Year	100%	78,16% Greek 49,43% Male – 28,73% Female 21,84% Foreigners 12,64% Male – 9,20% Female		34,48%

Table D.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at T.E.I. of Piraeus

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	29	22	24	31	26	35	23	23	31	36
PG	1	3	0	0	2	0	3	5	5	0
PN	12	19	0	0	7	0	18	17	17	0
GN	8	5	23	23	16	28	6	3	14	14
NG	2	0	3	3	3	2	1	0	4	5
NN	35	38	37	30	33	22	36	39	16	32

Table D.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at T.E.I. of Piraeus

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	33,33	25,28	27,58	35,63	29,88	40,22	26,43	26,43	35,63	41,37
PG	1,14	3,44	0,00	0,00	2,29	0,00	3,44	5,74	5,74	0,00
PN	13,79	21,83	0,00	0,00	8,04	0,00	20,68	19,54	19,54	0,00
GN	9,19	5,74	26,43	26,43	18,39	32,18	6,89	3,44	16,09	16,09
NG	2,29	0,00	3,44	3,44	3,44	2,29	1,14	0,00	4,59	5,74
NN	40,22	43,67	42,52	34,48	37,93	25,28	41,37	44,82	18,39	36,78

Table D.6 - Average percentage of students' answers in each of the six student answer categories at T.E.I. of Piraeus

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	32,07%
GN	"Good Knowledge – No Understanding"	16,09%
PG	"Poor Knowledge – Good Understanding"	2,18%
PN	"Poor Knowledge – No Understanding"	10,34%
NG	"No Knowledge – Good Understanding"	2,77%
NN	"No Knowledge – No Understanding"	36,55%

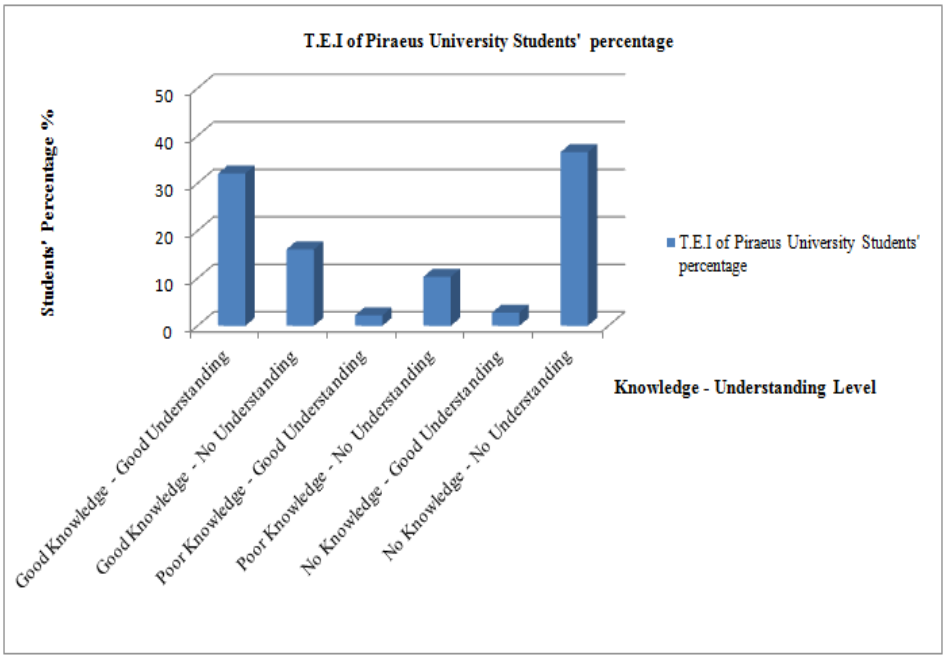


Figure D.1 - Average percentage of students' answers in each of the six student answer categories at T.E.I. of Piraeus

Table D.7 – Average percentage value of students' answers in each of the four research data analysis categories at T.E.I. of Piraeus

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	32,07%
"No Knowledge – No Understanding"	36,55%
"Lack of Knowledge"	39,32%
"Lack of Understanding"	62,98%

Table D.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at T.E.I. of Piraeus

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	29	22	24	31	26	35	23	23	31	36
No Knowledge – No Understanding	35	38	37	30	33	22	36	39	16	32
Lack of Knowledge	37	38	40	33	36	24	37	39	20	37
Lack of Understanding	55	62	60	53	66	50	60	59	47	46

Table D.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at T.E.I. of Piraeus

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	33,33	25,28	27,58	35,63	29,88	40,22	26,43	26,43	35,63	41,37
No Knowledge – No Understanding	40,22	43,67	42,52	34,48	37,93	25,28	41,37	44,82	18,39	36,78
Lack of Knowledge	42,52	43,67	45,97	37,93	41,38	27,58	42,52	44,82	22,99	42,52
Lack of Understanding	63,21	71,26	68,96	60,92	75,86	57,47	68,96	67,81	54,02	52,87

APPENDIX E RESULTS FROM T.E.I. OF SERRES (BEng)

Table E.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Serres

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (K)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (K + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	GG	GN	GN	GG	PN	GG	NG	NN	GG	GN	Greek	Male	YES	40%	0%	30%	10%	10%	10%	50%	20%
2	NN	GG	GN	GN	GG	NN	GG	NG	GG	NN	Greek	Male	YES	40%	0%	20%	0%	30%	10%	50%	40%
3	GG	NN	GG	NN	GG	GN	GG	PN	GG	GN	Greek	Male	YES	50%	0%	20%	10%	20%	0%	50%	20%
4	NN	GG	NN	GG	NN	GN	GG	PN	GG	NN	Greek	Male	YES	40%	0%	10%	10%	40%	0%	60%	40%
5	GN	GG	GN	NG	GG	GN	GG	NN	GG	NN	Greek	Male	YES	40%	0%	30%	0%	20%	10%	50%	30%
6	NN	GG	NN	GG	NN	GG	NN	GG	NG	GG	Greek	Male	YES	50%	0%	0%	0%	40%	10%	40%	50%
7	GG	NN	GG	NN	GG	GN	NG	GG	PN	GG	Greek	Male	YES	50%	0%	10%	10%	20%	10%	40%	30%
8	GG	NG	NN	GG	GN	GG	GN	GG	NN	GN	Greek	Male	YES	40%	0%	30%	0%	20%	10%	50%	30%
9	PN	GN	NN	GG	NN	GG	NG	GG	PN	NG	Greek	Male	YES	30%	0%	10%	20%	20%	20%	50%	40%
10	GG	NN	GG	NN	GG	GN	GG	NN	GG	GG	Greek	Male	YES	60%	0%	10%	0%	30%	0%	40%	30%
11	PN	GG	GG	GN	GG	GG	NN	PN	GG	NN	Greek	Male	YES	50%	0%	10%	20%	20%	0%	50%	20%
12	GN	GG	GG	NN	GG	NN	GG	GN	GG	GG	Greek	Male	YES	60%	0%	20%	0%	20%	0%	40%	20%
13	NN	GG	GN	GN	NN	GG	NN	GG	GN	GG	Greek	Female	YES	40%	0%	30%	0%	30%	0%	60%	30%
14	GG	NG	GG	NN	GG	NG	GG	GG	PN	GG	Greek	Female	YES	60%	0%	0%	10%	10%	20%	20%	30%
15	PG	GG	GN	GG	NN	GG	NN	PN	PG	GG	Greek	Female	YES	40%	20%	10%	10%	20%	0%	40%	20%
16	GG	GG	GG	GN	GG	NG	GG	NN	GG	GG	Greek	Female	YES	70%	0%	10%	0%	10%	10%	20%	20%
17	GG	NN	GG	NN	GN	GG	GG	NN	GG	GN	Greek	Female	YES	50%	0%	20%	0%	30%	0%	50%	30%
18	GG	NG	NN	GG	PN	GN	GN	GG	NN	GG	Greek	Female	YES	40%	0%	20%	10%	20%	10%	50%	30%
19	NN	GG	NN	GG	NN	GG	GN	NN	GG	NN	Greek	Female	YES	40%	0%	10%	0%	50%	0%	60%	50%
20	GN	GG	GG	GN	GN	GG	NN	GG	PG	GG	Greek	Female	YES	50%	10%	30%	0%	10%	0%	40%	10%
21	GG	NN	GG	GG	NN	GN	GG	NN	GN	GG	Greek	Male	NO	50%	0%	20%	0%	30%	0%	50%	30%
22	GN	GG	NN	GG	NN	GG	NN	GN	GN	NN	Greek	Male	NO	30%	0%	30%	0%	40%	0%	70%	40%
23	GG	NN	GN	GN	GG	GN	GG	PN	GG	GG	Greek	Male	NO	50%	0%	30%	10%	10%	0%	50%	10%
24	GG	GG	NN	GN	GG	GN	GG	GG	GG	GG	Greek	Male	NO	70%	0%	20%	0%	10%	0%	30%	10%
25	GG	NN	GN	GG	NN	GG	NN	NG	GG	NN	Greek	Male	NO	40%	0%	10%	0%	40%	10%	50%	50%
26	NN	GG	NN	NG	GN	GN	GG	PG	NG	GG	Greek	Male	NO	30%	10%	20%	0%	20%	20%	40%	40%

Table E.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Serres (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (K)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (K + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
27	GG	PN	GG	GG	NG	GG	NN	GN	GG	NN	Greek	Male	NO	50%	0%	10%	10%	20%	10%	40%	30%
28	NN	NN	NN	NN	GN	NN	GG	NN	GG	GG	Greek	Male	NO	30%	0%	10%	0%	60%	0%	70%	60%
29	GG	NN	GG	GG	NN	GG	NN	GG	GN	NN	Greek	Male	NO	50%	0%	10%	0%	40%	0%	50%	40%
30	GG	NN	GG	NN	PN	NN	GG	NN	GG	GG	Greek	Male	NO	50%	0%	0%	10%	40%	0%	50%	40%
31	GN	GG	NN	GN	GG	GG	GN	GG	GN	NN	Greek	Male	NO	40%	0%	40%	0%	20%	0%	60%	20%
32	GG	NN	GN	GN	NN	GG	NN	GG	PN	GG	Greek	Male	NO	40%	0%	20%	10%	30%	0%	60%	30%
33	GG	PN	GG	GN	NN	NN	NN	GN	NN	GN	Greek	Male	NO	20%	0%	30%	10%	40%	0%	80%	40%
34	NN	GG	GN	NN	NN	GG	NN	PG	NN	GG	Greek	Male	NO	30%	10%	10%	0%	50%	0%	60%	50%
35	GG	NN	GG	GN	NN	NN	GG	NN	NN	NN	Greek	Male	NO	30%	0%	10%	0%	60%	0%	70%	60%
36	PN	GG	NN	NN	GG	GN	NN	NN	PN	GN	Greek	Male	NO	20%	0%	20%	20%	40%	0%	80%	40%
37	PN	NN	GG	GN	NN	GG	GN	GG	NN	GG	Greek	Male	NO	40%	0%	20%	10%	30%	0%	60%	30%
38	GG	NN	NN	NN	GG	NN	NN	NN	NN	GG	Greek	Male	NO	30%	0%	0%	0%	70%	0%	70%	70%
39	NN	PN	GN	GG	NN	GG	NN	NN	PN	NN	Greek	Male	NO	20%	0%	10%	20%	50%	0%	80%	50%
40	NN	GN	NN	GG	NN	GG	NN	NN	NN	GG	Greek	Male	NO	30%	0%	10%	0%	60%	0%	70%	60%
41	GG	NN	GN	NN	GN	GN	GN	NN	GG	NN	Greek	Male	NO	20%	0%	40%	0%	40%	0%	80%	40%
42	GN	NN	GG	GG	PN	GN	NN	NN	GN	GG	Greek	Male	NO	30%	0%	30%	10%	30%	0%	70%	30%
43	NN	NN	NN	GN	NN	GN	PN	GG	GG	GN	Greek	Female	NO	20%	0%	30%	10%	40%	0%	80%	40%
44	GG	PN	NN	GG	PN	GN	GG	GN	PN	NN	Greek	Female	NO	30%	0%	20%	30%	20%	0%	70%	20%
45	NN	GG	GN	GG	NN	GG	NN	GG	PN	NG	Greek	Female	NO	40%	0%	10%	10%	30%	10%	50%	40%
46	NN	GG	NN	GN	NN	GG	GG	NN	GG	GN	Greek	Female	NO	40%	0%	20%	0%	40%	0%	60%	40%
47	NN	NN	GG	NN	PN	GG	GG	NN	GG	GG	Greek	Female	NO	40%	0%	10%	10%	40%	0%	60%	40%
48	NN	GG	NN	NN	GG	GN	GG	NG	GG	NN	Greek	Female	NO	40%	0%	10%	0%	40%	10%	50%	40%
49	GN	GG	NN	GG	NG	GG	GN	PN	GG	NN	Greek	Female	NO	40%	0%	20%	10%	20%	10%	50%	20%
50	GG	GN	GG	GG	GG	GG	NG	NN	GG	GG	Greek	Female	NO	70%	0%	10%	0%	10%	10%	20%	10%
51	GN	NN	GG	GN	GN	NN	GN	PG	GG	NN	Greek	Female	NO	20%	10%	40%	0%	30%	0%	70%	30%
52	GG	PN	NN	NN	GG	NN	PN	GG	GG	GN	Foreigner	Male	YES	40%	0%	10%	20%	30%	0%	60%	30%
53	GG	NN	GN	GG	PN	NN	PN	PG	GG	NG	Foreigner	Male	YES	30%	10%	10%	20%	20%	10%	50%	30%

Table E.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at T.E.I. of Serres (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (K)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (K + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
54	NN	NN	GN	GN	NG	GN	GN	GN	GN	GG	Foreigner	Female	YES	10%	0%	60%	0%	20%	10%	80%	30%
55	PN	PN	GG	NN	GG	NN	NN	NN	PN	GG	Foreigner	Male	NO	30%	0%	0%	30%	40%	0%	70%	40%
56	NN	GG	NN	GG	GG	GN	PG	NN	GG	GG	Foreigner	Male	NO	50%	10%	10%	0%	30%	0%	40%	30%
57	GG	GG	NN	NN	GG	GN	NN	NN	NN	GG	Foreigner	Male	NO	40%	0%	10%	0%	50%	0%	60%	50%
58	PN	NN	GG	GN	NG	NN	PG	PG	GG	GN	Foreigner	Male	NO	20%	20%	20%	10%	20%	10%	50%	30%
59	GG	NN	GG	GG	GG	GN	GN	GN	NN	GG	Foreigner	Male	NO	50%	0%	30%	0%	20%	0%	50%	20%
60	NN	GG	GN	GG	NN	GN	PG	GG	NN	NG	Foreigner	Male	NO	30%	10%	20%	0%	30%	10%	50%	40%
61	GG	GN	NN	GG	PN	NN	NN	GG	GN	GG	Foreigner	Male	NO	40%	0%	20%	10%	30%	0%	60%	30%
62	GG	GN	GG	GN	GG	NN	NN	NN	GG	NN	Foreigner	Female	NO	40%	0%	20%	0%	40%	0%	60%	40%
63	NG	PN	GN	NN	GG	NN	NN	NN	GG	NN	Foreigner	Female	NO	20%	0%	10%	10%	50%	10%	70%	60%
64	NN	GG	GN	GG	NG	GN	GN	NG	GN	GN	Foreigner	Female	NO	20%	0%	50%	0%	10%	20%	60%	30%

Table E.2 - Demographic data of students' tested at T.E.I. of Serres in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	BEng	4th Year	51	Greek	35 Male	13
					16 Female	7
			13	Foreigners	9 Male	2
					4 Female	1
Total	BEng	4th Year	64	51 Greek 35 Male – 16 Female 13 Foreigners 9 Male – 4 Female		23

Table E.3 - Demographic data of students' tested at T.E.I. of Serres in percentage format.

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	BEng	4th Year	79,69%	Greek	54,69% Male	20,31%
					25% Female	10,94%
			20,31%	Foreigners	14,06% Male	3,13%
					6,25% Female	1,56%
Total	BEng	4th Year	100%	79,69% Greek 54,69% Male – 25% Female 20,31% Foreigners 14,06% Male – 6,25% Female		35,94%

Table E.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at T.E.I. of Serres

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	29	25	24	26	23	25	20	18	30	30
PG	1	0	0	0	0	0	3	5	2	0
PN	6	7	0	0	8	0	3	6	9	0
GN	8	6	17	18	7	22	11	7	10	11
NG	1	3	0	2	5	2	4	4	2	4
NN	19	23	23	18	21	15	23	24	11	19

Table E.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at T.E.I. of Serres

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	45,31	39,06	37,5	40,62	35,93	39,06	31,25	28,12	46,87	46,87
PG	1,56	0,00	0,00	0,00	0,00	0,00	4,68	7,81	3,12	0,00
PN	9,37	10,93	0,00	0,00	12,5	0,00	4,68	9,37	14,06	0,00
GN	12,5	9,37	26,56	28,12	10,93	34,37	17,18	10,93	15,62	17,18
NG	1,56	4,68	0,00	3,12	7,81	3,12	6,25	6,25	3,12	6,25
NN	29,68	35,93	35,93	28,12	32,81	23,43	35,93	37,5	17,18	29,68

Table E.6 - Average percentage of students' answers in each of the six student answer categories at T.E.I. of Serres

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	39,06%
GN	"Good Knowledge – No Understanding"	18,28%
PG	"Poor Knowledge – Good Understanding"	1,72%
PN	"Poor Knowledge – No Understanding"	6,09%
NG	"No Knowledge – Good Understanding"	4,22%
NN	"No Knowledge – No Understanding"	30,63%

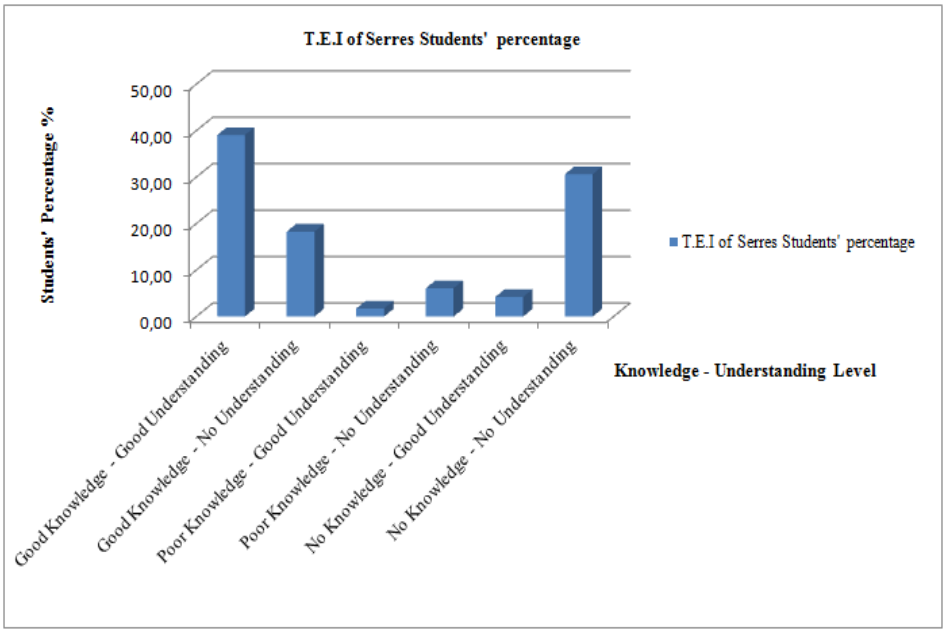


Figure E.2 - Average percentage of students' answers in each of the six student answer categories at T.E.I. of Serres

Table E.7 – Average percentage value of students' answers in each of the four research data analysis categories at T.E.I. of Serres

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	39,06%
"No Knowledge – No Understanding"	30,63%
"Lack of Knowledge"	34,38%
"Lack of Understanding"	55,00%

Table E.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at T.E.I. of Serres

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	29	25	24	26	23	25	20	18	30	30
No Knowledge – No Understanding	19	23	23	18	21	15	23	24	11	19
Lack of Knowledge	20	26	23	20	26	17	27	28	13	23
Lack of Understanding	33	36	40	36	36	37	37	37	30	30

Table E.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at T.E.I. of Serres

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	45,31	39,06	37,50	40,62	35,93	39,06	31,25	28,12	46,87	46,87
No Knowledge – No Understanding	29,68	35,93	35,93	28,12	32,81	23,43	35,93	37,50	17,18	29,68
Lack of Knowledge	31,25	40,63	35,94	31,25	40,63	26,56	41,19	43,75	20,31	35,94
Lack of Understanding	51,56	56,25	62,50	56,25	56,25	57,81	57,81	57,81	46,87	46,87

APPENDIX F RESULTS FROM HERIOT-WATT UNIVERSITY (MSc-MEng)

Table F.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Heriot-Watt University

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	GG	NN	GN	GG	PG	GG	GN	NN	GG	GG	UK	Male	NO	50%	10%	20%	0%	20%	0%	40%	20%
2	GN	GG	GN	GN	NN	GG	PN	GG	NN	GN	UK	Male	NO	30%	0%	40%	10%	20%	0%	70%	20%
3	GG	GN	NN	GG	NN	NN	GG	PG	GG	NG	UK	Male	YES	40%	10%	10%	0%	30%	10%	40%	40%
4	GN	NG	NN	GN	PN	GN	NN	NN	NN	GN	UK	Male	YES	0%	0%	40%	10%	40%	10%	90%	50%
5	GG	GG	NN	GG	GG	GN	PN	NN	GG	NN	UK	Male	YES	50%	0%	10%	10%	30%	0%	50%	30%
6	GN	GG	NN	GN	GG	NN	GG	GG	GN	GN	UK	Male	YES	40%	0%	40%	0%	20%	0%	60%	20%
7	GG	NN	GN	GG	NN	GN	PG	NN	GG	GG	UK	Male	YES	40%	10%	20%	0%	30%	0%	50%	30%
8	NN	GG	GN	NG	GG	NN	NN	NN	GN	GG	UK	Male	YES	30%	0%	20%	0%	40%	10%	60%	50%
9	NN	GG	GG	GN	PN	GN	GG	PG	GG	NN	UK	Male	YES	40%	10%	20%	10%	20%	0%	50%	20%
10	NN	GG	NN	NN	GG	GN	NN	NN	NG	NN	UK	Male	YES	20%	0%	10%	0%	60%	10%	70%	70%
11	GG	NN	GN	NN	NN	NN	GG	GG	GG	GG	UK	Male	YES	50%	0%	10%	0%	40%	0%	50%	40%
12	NN	GG	NN	GN	GN	GG	NN	NN	NG	GG	UK	Male	YES	30%	0%	20%	0%	40%	10%	60%	50%
13	GG	NN	GG	NN	NN	NG	GG	PN	PN	GG	UK	Male	YES	40%	0%	0%	20%	30%	10%	50%	40%
14	GG	GG	GG	NN	GG	GG	PG	GG	NN	GG	UK	Male	YES	70%	10%	0%	0%	20%	0%	20%	20%
15	NN	GN	GN	NN	GG	NN	PN	PG	PN	GG	UK	Male	YES	20%	10%	20%	20%	30%	0%	70%	30%
16	GN	GG	NN	GG	GG	GN	GG	GN	NN	GG	UK	Male	YES	50%	0%	30%	0%	20%	0%	50%	20%
17	GG	NN	GG	NN	NN	GG	NN	GG	PN	GG	UK	Male	YES	50%	0%	0%	10%	40%	0%	50%	40%
18	PN	PN	NN	NN	PN	NN	NN	GN	GN	NN	UK	Male	YES	0%	0%	20%	30%	50%	0%	100%	50%
19	GG	GG	NN	GG	GG	GG	GG	GN	GN	GN	UK	Male	YES	60%	0%	30%	0%	10%	0%	40%	10%
20	GG	NN	GN	GG	NN	NG	PN	NN	GN	GG	UK	Male	YES	30%	0%	20%	10%	30%	10%	60%	40%
21	GG	PN	NN	GG	GN	NN	GN	NN	GG	GN	UK	Female	YES	30%	0%	30%	10%	30%	0%	70%	30%
22	GN	GG	GN	GG	NN	GN	GN	PG	NG	NN	Foreigner	Male	NO	20%	10%	40%	0%	20%	10%	60%	30%
23	GG	PN	GG	GG	GG	GG	GG	GN	GG	NG	Foreigner	Male	NO	60%	0%	20%	10%	0%	10%	30%	10%
24	NN	GG	GN	GG	GN	GG	PG	PN	PN	GG	Foreigner	Male	NO	40%	10%	20%	20%	10%	0%	50%	10%
25	NN	NN	GG	NN	NN	GG	NN	NG	PN	NN	Foreigner	Male	NO	20%	0%	0%	10%	60%	10%	70%	70%
26	PN	GG	NN	GG	PN	GG	GG	GN	GG	GG	Foreigner	Male	NO	60%	0%	10%	20%	10%	0%	40%	10%

Table F.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Heriot-Watt University (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
27	GG	NN	GG	GN	GG	NN	GN	GG	NN	NN	Foreigner	Male	NO	40%	0%	20%	0%	40%	0%	60%	40%
28	GG	GG	NN	GG	NN	GN	NN	GG	GG	NN	Foreigner	Male	NO	50%	0%	10%	0%	40%	0%	50%	40%
29	GG	PN	GG	GN	NN	NG	GN	GG	PN	NN	Foreigner	Male	NO	30%	0%	20%	20%	20%	10%	60%	30%
30	PN	NN	GG	NN	PN	GG	NN	PN	GG	NN	Foreigner	Male	NO	40%	0%	0%	30%	40%	0%	70%	40%
31	GG	NN	NN	GG	PN	GG	NN	PN	GG	NN	Foreigner	Female	NO	40%	0%	0%	20%	40%	0%	60%	40%
32	NN	NN	GG	GG	NN	GG	GN	PN	PN	GG	Foreigner	Female	NO	40%	0%	10%	20%	30%	0%	60%	30%
33	GG	NN	GG	GN	GN	GN	NN	GG	NN	GN	Foreigner	Female	NO	30%	0%	40%	0%	30%	0%	70%	30%
34	NN	GG	NN	GG	GN	GG	GG	NN	GG	GG	Foreigner	Female	NO	60%	0%	10%	0%	30%	0%	40%	30%
35	GG	GN	NN	NN	GN	NN	NN	NN	GG	NN	Foreigner	Female	NO	20%	0%	20%	0%	60%	0%	80%	60%
36	NN	NN	GG	NN	GG	GN	NG	GG	GG	NN	Foreigner	Female	NO	40%	0%	10%	0%	40%	10%	50%	50%
37	GN	NN	NG	NG	GN	NG	NN	NN	NG	GG	Foreigner	Male	YES	10%	0%	20%	0%	30%	40%	50%	70%
38	NN	NN	GG	NN	GG	NG	NN	NN	GG	GG	Foreigner	Male	YES	40%	0%	0%	0%	50%	10%	50%	60%
39	NN	GG	NN	GG	NN	GN	GG	NN	GG	GG	Foreigner	Female	YES	50%	0%	10%	0%	40%	0%	50%	40%
40	GG	NN	GG	GN	GG	GG	NN	NN	GN	NN	Foreigner	Female	YES	40%	0%	20%	0%	40%	0%	60%	40%

Table F.2 - Demographic data of students' tested at Heriot-Watt University in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MSc MEng	4th Year 5th Year	21	UK	20 Male	18
					1 Female	1
			19	Foreigners	11 Male	2
					8 Female	2
Total	MSc 21 MEng 19	4th Year 5th Year	40	21 UK 20 Male – 1 Female 19 Foreigners 11 Male – 8 Female		23

Table F.3 - Demographic data of students' tested at Heriot-Watt University in percentage format

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MSc MEng	4th Year 5th Year	52,5%	UK	50% Male	45%
					2,5% Female	2,5%
			47,5 %	Foreigners	27,5% Male	5%
					20% Female	5%
Total	MSc 52,5 % MEng 47,5 %	4th Year 5th Year	100%	52,5% UK 50% Male – 2,5% Female 47,5% Foreigners 27,5% Male – 20% Female		57,5%

Table F.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at Heriot-Watt University

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	19	16	14	16	13	15	11	10	16	18
PG	0	0	0	0	1	0	3	4	0	0
PN	3	4	0	0	6	0	4	5	7	0
GN	6	3	9	10	7	11	6	5	6	6
NG	0	1	1	2	0	5	1	1	4	2
NN	12	16	16	12	13	9	15	15	7	14

Table F.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at Heriot-Watt University

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	47,5	40,00	35,00	40,00	32,5	37,5	27,5	25,00	40,00	45,00
PG	0,00	0,00	0,00	0,00	2,50	0,00	7,50	10,00	0,00	0,00
PN	7,50	10,00	0,00	0,00	15,00	0,00	10,00	12,5	17,50	0,00
GN	15,0	7,50	22,50	25,0	17,5	27,5	15,0	12,5	15,00	15,00
NG	0,00	2,50	2,50	5,0	0,00	12,5	2,50	2,50	10,00	5,00
NN	30,00	40,00	40,00	30,00	32,5	22,5	37,5	37,5	17,50	35,00

Table F.6 - Average percentage of students' answers in each of the six student answer categories at Heriot-Watt University

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	37,25%
GN	"Good Knowledge – No Understanding"	17,25%
PG	"Poor Knowledge – Good Understanding"	2,00%
PN	"Poor Knowledge – No Understanding"	7,25%
NG	"No Knowledge – Good Understanding"	4,25%
NN	"No Knowledge – No Understanding"	32,00%

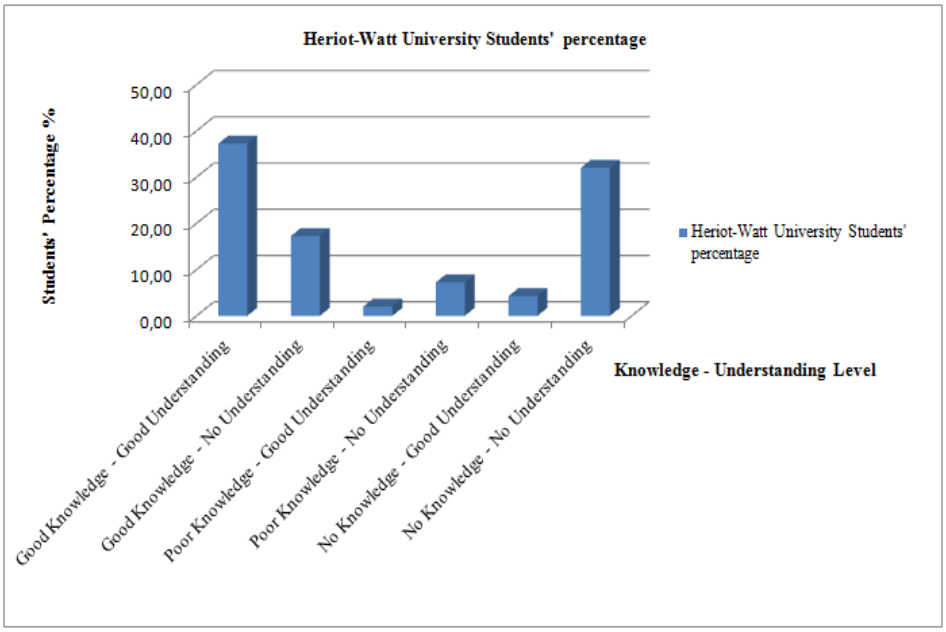


Figure F.1 - Average percentage of students' answers in each of the six student answer categories at Heriot-Watt University

Table F.7 – Average percentage value of students' answers in each of the four research data analysis categories at Heriot-Watt University

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	37,25%
"No Knowledge – No Understanding"	32,00%
"Lack of Knowledge"	36,25%
"Lack of Understanding"	56,50%

Table F.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at Heriot-Watt University

Student Answers	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	19	16	14	16	13	15	11	10	16	18
No Knowledge – No Understanding	12	16	16	12	13	9	15	15	7	14
Lack of Knowledge	12	17	17	14	13	14	16	16	11	16
Lack of Understanding	21	23	25	22	26	20	25	25	20	20

Table F.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Heriot-Watt University

Student Answers	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	47,50	40,00	35,00	40,00	32,50	37,50	27,50	25,00	40,00	45,00
No Knowledge – No Understanding	30,00	40,00	40,00	30,00	32,50	22,50	37,50	37,50	17,50	35,00
Lack of Knowledge	30,00	42,50	42,50	35,00	32,50	35,00	40,00	40,00	27,5	40,00
Lack of Understanding	52,50	57,50	62,50	55,00	65,00	50,00	62,50	62,50	50,00	50,00

APPENDIX G RESULTS FROM EDINBURGH NAPIER UNIVERSITY (MSc-MEng)

Table G.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Edinburgh Napier University (MSc-MEng)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	NN	GG	NN	GG	GG	GN	GN	PN	NN	GG	UK	Male	NO	40%	0%	20%	10%	30%	0%	60%	30%
2	GG	NN	GG	GN	NN	GG	NN	GG	NG	GG	UK	Male	NO	50%	0%	10%	0%	30%	10%	40%	40%
3	GN	GG	NN	NG	GG	GG	GG	NN	GG	NG	UK	Male	YES	50%	0%	10%	0%	20%	20%	30%	40%
4	GG	GN	GG	GN	NN	GG	GN	NN	GG	NN	UK	Male	YES	40%	0%	30%	0%	30%	0%	60%	30%
5	GN	GG	NN	GN	GG	NG	GG	NG	GG	NG	UK	Male	YES	40%	0%	20%	0%	10%	30%	30%	40%
6	GG	GN	GG	GN	NN	GG	GN	NG	GG	NN	UK	Male	YES	40%	0%	30%	0%	20%	10%	50%	30%
7	NG	GG	NN	GN	GG	GN	GG	NG	GG	NG	UK	Male	YES	40%	0%	20%	0%	10%	30%	30%	40%
8	GG	NG	GG	GN	NN	GG	GG	GG	GG	GG	UK	Male	YES	70%	0%	10%	0%	10%	10%	20%	20%
9	NN	GG	NN	GN	GG	GN	GN	GN	PG	GN	UK	Male	YES	20%	10%	50%	0%	20%	0%	70%	20%
10	GG	GG	GG	GN	NN	GG	GN	GN	PG	GG	UK	Male	YES	50%	10%	30%	0%	10%	0%	40%	10%
11	NN	GG	NN	GN	GG	GN	NN	GN	GN	GN	UK	Male	YES	20%	0%	50%	0%	30%	0%	80%	30%
12	GG	NN	GG	GG	NN	GG	NN	GG	PN	GG	UK	Male	YES	60%	0%	0%	10%	30%	0%	40%	30%
13	PN	GG	NN	NN	GG	NN	GG	NN	GG	NN	Foreigner	Male	NO	40%	0%	0%	10%	50%	0%	60%	50%
14	GG	PN	GG	NN	PN	GG	GG	GG	GG	GG	Foreigner	Male	NO	70%	0%	0%	20%	10%	0%	30%	10%
15	GN	GG	NN	NN	GG	NN	GG	NN	GG	NN	Foreigner	Male	NO	40%	0%	10%	0%	50%	0%	60%	50%
16	GG	PN	GG	NN	NN	NN	PN	NN	GG	NN	Foreigner	Male	NO	30%	0%	0%	20%	50%	0%	70%	50%
17	GN	GG	NN	NN	GG	GG	GG	NN	GG	NG	Foreigner	Male	NO	50%	0%	10%	0%	30%	10%	40%	40%
18	GG	PN	GG	NN	PG	GG	PG	GG	GG	NN	Foreigner	Male	NO	50%	20%	0%	10%	20%	0%	30%	20%
19	PN	NN	NN	NN	GG	NN	PG	NN	GG	NN	Foreigner	Male	NO	20%	10%	0%	10%	60%	0%	70%	60%
20	GG	PN	GG	GG	PN	GG	PN	NN	GG	NN	Foreigner	Male	NO	50%	0%	0%	30%	20%	0%	50%	20%
21	NN	NN	GN	GG	GN	NN	NN	NN	GN	GG	Foreigner	Male	NO	20%	0%	30%	0%	50%	0%	80%	50%
22	NN	NN	GN	GG	PN	GN	NN	NN	PN	NN	Foreigner	Male	NO	10%	0%	20%	20%	50%	0%	90%	50%
23	GG	NN	GN	GG	GN	GN	NN	NG	NN	GG	Foreigner	Female	NO	30%	0%	30%	0%	30%	10%	60%	40%
24	NN	NN	GN	GG	PN	NN	NN	GG	NN	NN	Foreigner	Female	NO	20%	0%	10%	10%	60%	0%	80%	60%
25	NN	GG	NN	GG	GG	GN	NN	PN	NN	GG	Foreigner	Male	YES	40%	0%	10%	10%	40%	0%	60%	40%
26	GG	NN	GG	GN	NN	GG	NN	PG	GN	GG	Foreigner	Male	YES	40%	10%	20%	0%	30%	0%	50%	30%

Table G.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Edinburgh Napier University (MSc-MEng) (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
27	NN	GG	NG	GG	NG	GG	NN	PG	GN	GG	Foreigner	Male	YES	40%	10%	10%	0%	20%	20%	30%	40%
28	GG	NN	GN	GG	NG	NG	GG	GG	NN	GN	Foreigner	Male	YES	40%	0%	20%	0%	20%	20%	40%	40%
29	GG	GN	GG	NN	NN	NN	GN	NN	GG	NN	Foreigner	Male	YES	30%	0%	20%	0%	50%	0%	70%	50%
30	GG	NN	GN	GG	GN	GN	NN	GG	NG	GG	Foreigner	Male	YES	40%	0%	30%	0%	20%	10%	50%	30%
31	NN	GG	GN	GG	GN	NG	NN	GG	PN	GG	Foreigner	Male	YES	40%	0%	20%	10%	20%	10%	50%	30%
32	GG	GG	GN	GG	GN	GN	GG	GG	GN	GG	Foreigner	Female	YES	60%	0%	40%	0%	0%	0%	40%	0%

Table G.2 - Demographic data of students' tested at Edinburgh Napier University (MSc-MEng) in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MSc MEng	4th Year 5th Year	12	UK	12 Male	10
					0 Female	0
			20	Foreigners	17 Male	7
					3 Female	1
Total	MSc 24 MEng 8	4th Year 5th Year	32	12 UK 12 Male – 0 Female 20 Foreigners 17 Male – 3 Female		18

Table G.3 - Demographic data of students' tested at Edinburgh Napier University (MSc-MEng) in percentage format

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	MSc MEng	4th Year 5th Year	37,5%	UK	37,5% Male	31,25%
					0% Female	0%
			62,5%	Foreigners	53,12% Male	21,87%
					9,38% Female	3,13%
Total	MSc 75% MEng 25%	4th Year 5th Year	100%	37,5% UK 37,5% Male – 0%Female 64,52% Foreigners 53,12% Male – 9,38% Female		56,25%

Table G.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at Edinburgh Napier University (MSc-MEng)

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	16	14	12	13	11	13	10	10	15	16
PG	0	0	0	0	1	0	2	2	2	0
PN	2	4	0	0	4	0	2	2	3	0
GN	4	3	8	10	5	9	6	3	5	3
NG	1	1	1	1	2	3	0	4	2	4
NN	9	10	11	8	9	7	12	11	5	9

Table G.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at Edinburgh Napier University (MSc-MEng)

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	50,00	43,75	37,5	40,62	34,37	40,62	31,25	31,25	46,87	50,00
PG	0,00	0,00	0,00	0,00	3,12	0,00	6,25	6,25	6,25	0,00
PN	6,25	12,5	0,00	0,00	12,5	0,00	6,25	6,25	9,37	0,00
GN	12,5	9,37	25,00	31,25	15,62	28,12	18,75	9,37	15,62	9,37
NG	3,12	3,12	3,12	3,12	6,25	9,37	0,00	12,5	6,25	12,5
NN	28,12	31,25	34,37	25,00	28,12	21,87	37,5	34,37	15,62	28,12

Table G.6 - Average percentage of students' answers in each of the six student answer categories at Edinburgh Napier University (MSc-MEng)

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	40,00%
GN	"Good Knowledge – No Understanding"	17,81%
PG	"Poor Knowledge – Good Understanding"	2,18%
PN	"Poor Knowledge – No Understanding"	5,31%
NG	"No Knowledge – Good Understanding"	5,64%
NN	"No Knowledge – No Understanding"	29,06%

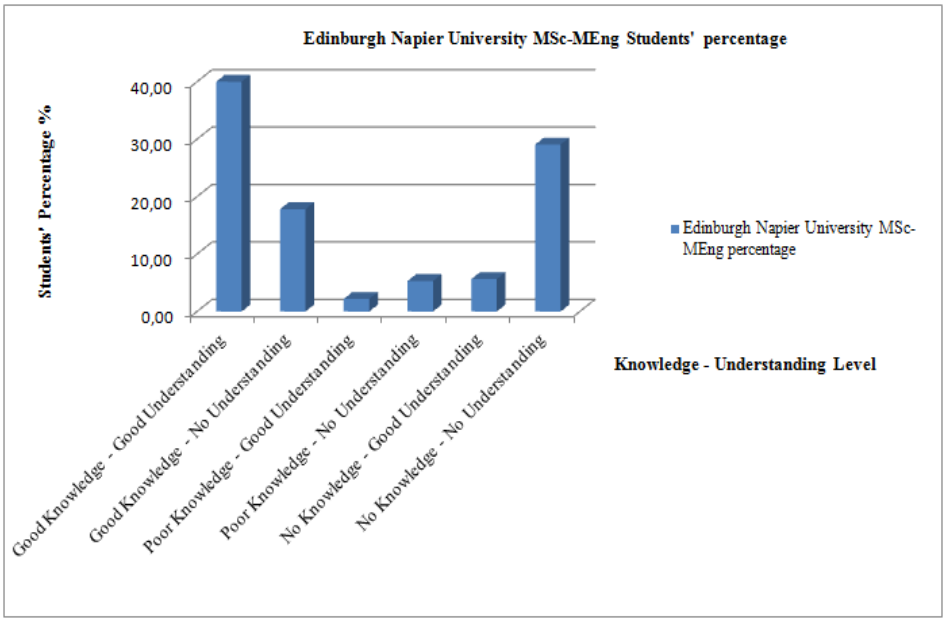


Figure G.1 - Average percentage of students' answers in each of the six student answer categories at Edinburgh Napier University (MSc-MEng)

Table G.7 – Average percentage value of students' answers in each of the four research data analysis categories at Edinburgh Napier University (MSc-MEng)

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	40,00%
"No Knowledge – No Understanding"	29,06%
"Lack of Knowledge"	35,00%
"Lack of Understanding"	51,88%

Table G.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at Edinburgh Napier University (MSc-MEng)

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	16	14	12	13	11	13	10	10	15	16
No Knowledge – No Understanding	9	10	11	8	9	7	12	11	5	9
Lack of Knowledge	10	11	12	9	11	10	12	15	7	13
Lack of Understanding	15	17	19	18	18	16	20	16	13	12

Table G.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Edinburgh Napier University (MSc-MEng)

	Student answers - Percentage totals									
Student Answers	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	50,00	43,75	37,50	40,62	34,37	40,62	31,25	31,25	46,87	50,00
No Knowledge – No Understanding	28,12	31,25	34,37	25,00	28,12	21,87	37,5	34,37	15,62	28,12
Lack of Knowledge	31,25	34,37	37,50	28,12	34,37	31,25	37,50	46,88	21,87	40,62
Lack of Understanding	46,88	53,12	59,38	56,25	56,25	50,00	62,50	50,00	40,62	37,50

APPENDIX H RESULTS FROM EDINBURGH NAPIER UNIVERSITY (BSc-BEng)

Table H.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Edinburgh Napier University (BSc-BEng)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
1	GG	GN	GG	GN	PN	GG	PG	NG	PN	NN	UK	Male	YES	30%	10%	20%	20%	10%	10%	50%	20%
2	GG	GN	GG	GN	NG	GG	PN	NN	PN	NN	UK	Male	YES	30%	0%	20%	20%	20%	10%	60%	30%
3	NN	PN	GG	GG	GN	NN	GN	NN	PN	GG	UK	Male	YES	30%	0%	20%	20%	30%	0%	70%	30%
4	PN	NN	GG	NG	GG	GG	GN	NN	PN	GG	UK	Male	YES	40%	0%	10%	20%	20%	10%	50%	30%
5	PN	NN	GG	GN	GG	GG	GN	NN	PN	GG	UK	Male	YES	40%	0%	20%	20%	20%	0%	60%	20%
6	PN	NN	GG	GG	NN	GG	GN	NN	GN	GG	UK	Male	YES	40%	0%	20%	10%	30%	0%	60%	30%
7	GG	NG	GN	NN	GG	GG	PN	NN	NN	GG	UK	Male	YES	40%	0%	10%	10%	30%	10%	50%	40%
8	GG	GG	GN	GG	GN	NN	PN	NN	NN	GG	UK	Male	YES	40%	0%	20%	10%	30%	0%	60%	30%
9	GN	NN	NN	NN	GG	GG	NN	NN	NN	GG	UK	Male	YES	30%	0%	10%	0%	60%	0%	70%	60%
10	NN	GG	NN	NN	GG	GG	NN	NN	NN	GG	UK	Male	YES	40%	0%	0%	0%	60%	0%	60%	60%
11	NN	NN	GN	GG	NN	GG	NN	NN	NN	GG	UK	Male	YES	30%	0%	10%	0%	60%	0%	70%	60%
12	GG	GG	NN	NG	NN	GG	NN	NN	NN	GG	Foreigner	Male	NO	40%	0%	0%	0%	50%	10%	50%	60%
13	GG	GG	GN	GG	GN	NN	NN	NN	NG	NN	Foreigner	Male	NO	30%	0%	20%	0%	40%	10%	60%	50%
14	GG	GG	GG	GN	GG	NN	GG	PN	GG	GG	Foreigner	Male	NO	70%	0%	10%	10%	10%	0%	30%	10%
15	NN	GG	GG	NN	PN	GG	GG	PN	GG	GG	Foreigner	Male	NO	60%	0%	0%	20%	20%	0%	40%	20%
16	PN	NN	GN	GG	GG	GN	GG	GG	GG	NN	Foreigner	Male	NO	50%	0%	20%	10%	20%	0%	50%	20%
17	GG	NG	GN	GG	NN	GN	GG	GG	GG	NG	Foreigner	Male	NO	50%	0%	20%	0%	10%	20%	30%	30%
18	GN	NN	NN	GN	NN	GN	NG	PG	GN	GN	Foreigner	Male	NO	0%	10%	50%	0%	30%	10%	80%	40%
19	NN	PN	NN	GN	NN	GN	NN	PN	GN	GN	Foreigner	Female	NO	0%	0%	40%	20%	40%	0%	100%	40%
20	NN	NN	GN	NN	NN	GN	NN	PN	GN	GN	Foreigner	Female	NO	0%	0%	40%	10%	50%	0%	100%	50%
21	GG	NN	NN	GG	GG	GN	NN	GG	GG	NN	Foreigner	Female	NO	50%	0%	10%	0%	40%	0%	50%	40%
22	NN	NN	GN	NN	NN	GN	NN	PG	GN	GN	Foreigner	Female	NO	0%	10%	40%	0%	50%	0%	90%	50%
23	PN	NN	NN	GN	NN	GN	NG	GG	GG	NN	Foreigner	Female	NO	20%	0%	20%	10%	40%	10%	70%	50%
24	NN	NN	NN	NN	NN	NG	NG	GG	GG	NN	Foreigner	Female	NO	20%	0%	0%	0%	60%	20%	60%	80%
25	GG	GG	GN	GG	PN	NN	NN	NN	NG	GG	Foreigner	Male	YES	40%	0%	10%	10%	30%	10%	50%	40%
26	GG	GN	NN	NN	GG	GN	GG	GG	GG	NN	Foreigner	Male	YES	50%	0%	20%	0%	30%	0%	50%	30%

Table H.1 - Students' answers for each question of the questionnaire, demographic data and student's average success percentage in all students answer categories at Edinburgh Napier University (BSc-BEng) (cont.)

Students	Questions										Nationality	Gender	Working while studying	Success percentage (GG)	Success percentage (PG)	Success percentage (GN)	Success percentage (PN)	Success percentage (NN)	Success percentage (NG)	Success percentage Lack of Understanding (GN + PN + NN)	Success percentage Lack of Knowledge (NG + NN)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10											
27	NN	GG	NN	GG	PN	NN	GG	GN	GG	NN	Foreigner	Male	YES	40%	0%	10%	10%	40%	0%	60%	40%
28	NN	GG	GG	NN	PN	GG	NN	GN	GG	NN	Foreigner	Male	YES	40%	0%	10%	10%	40%	0%	60%	40%
29	GN	NN	NN	GG	GG	GN	GG	GG	GG	NG	Foreigner	Male	YES	50%	0%	20%	0%	20%	10%	40%	30%
30	GG	PG	GG	NN	NN	GN	GG	GG	GG	NG	Foreigner	Female	YES	50%	10%	10%	0%	20%	10%	30%	30%
31	NN	GG	NN	GG	PN	NN	NN	GN	GN	NN	Foreigner	Female	YES	20%	0%	20%	10%	50%	0%	80%	50%

Table H.2 - Demographic data of students' tested at Edinburgh Napier University (BSc-BEng) in numerical format

	Numerical demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	BSc BEng	4th Year	11	UK	Male	11
					Female	0
			20	Foreigners	Male	5
					Female	2
Total	BSc 25 BEng 6	4th Year	31	11 UK 11 Male – 0 Female 20 Foreigners 12 Male – 8 Female		18

Table H.3 - Demographic data of students' tested at Edinburgh Napier University (BSc-BEng) in percentage format

	Percentage demographic data					
	Course	Year	Number of students	Nationality	Gender	Working While studying
	BSc BEng	4th Year	35,48%	UK	35,48% Male	35,48%
					0% Female	0%
			64,52%	Foreigners	38,71% Male	16,13%
					25,81% Female	6,45%
Total	BSc 80,65 % BEng 19,35 %	4th Year	100%	35,48% UK 35,48% Male – 0% Female 64,52% Foreigners 38,71% Male – 25,81% Female		58,06%

Table H.4 - Number of students' answers in each of the six student answer categories, for each question of the questionnaire, at Edinburgh Napier University (BSc-BEng)

	Student answers - Numerical totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	12	10	10	12	10	12	8	8	12	13
PG	0	1	0	0	0	0	1	2	0	0
PN	5	2	0	0	6	0	3	4	5	0
GN	3	3	9	7	3	11	4	3	6	4
NG	0	2	0	2	1	1	3	1	2	3
NN	11	13	12	10	11	7	12	13	6	11

Table H.5 - Percentage of students' answers in each of the six student answer categories, for each question of the questionnaire, at Edinburgh Napier University (BSc-BEng)

	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
GG	38,7	32,25	32,25	38,7	32,25	38,7	25,8	25,8	38,7	41,93
PG	0,00	3,22	0,00	0,00	0,00	0,00	3,22	6,45	0,00	0,00
PN	16,12	6,45	0,00	0,00	19,35	0,00	9,67	12,9	16,12	0,00
GN	9,67	9,67	29,03	22,58	9,67	35,48	12,9	9,67	19,35	12,9
NG	0,00	6,45	0,00	6,45	3,22	3,22	9,67	3,22	6,45	9,67
NN	35,48	41,93	38,7	32,25	35,48	22,58	38,7	41,93	19,35	35,48

Table H.6 - Average percentage of students' answers in each of the six student answer categories at Edinburgh Napier University (BSc-BEng)

	Student answers – Average in percentage totals	
	Student answers	Average value in percentage
GG	"Good Knowledge – Good Understanding"	34,52%
GN	"Good Knowledge – No Understanding"	17,10%
PG	"Poor Knowledge – Good Understanding"	1,29%
PN	"Poor Knowledge – No Understanding"	8,06%
NG	"No Knowledge – Good Understanding"	4,84%
NN	"No Knowledge – No Understanding"	34,19%

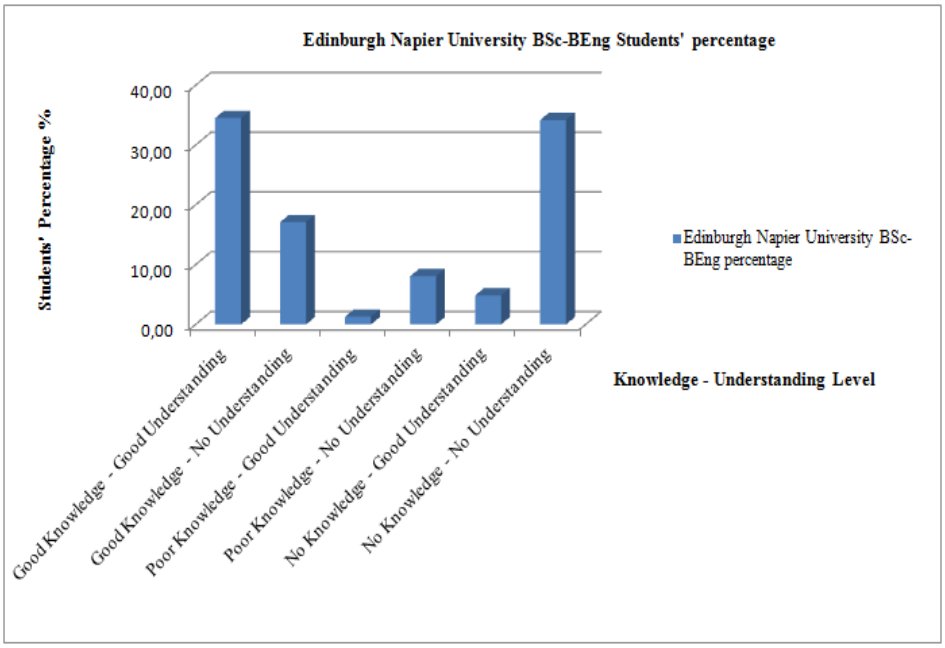


Figure H.1 - Average percentage of students' answers in each of the six student answer categories at Edinburgh Napier University (BSc-BEng)

Table H.7 – Average percentage value of students' answers in each of the four research data analysis categories at Edinburgh Napier University (BSc-BEng)

Student answers – Average in percentage totals	
Student answers	Average value in percentage
"Good Knowledge – Good Understanding"	34,52%
"No Knowledge – No Understanding"	34,19%
"Lack of Knowledge"	36,45%
"Lack of Understanding"	59,35%

Table H.8 – Number of students that answered in each of the four research data analysis category for each question of the questionnaire at Edinburgh Napier University (BSc-BEng)

Student Answers	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	12	10	10	12	10	12	8	8	12	13
No Knowledge – No Understanding	11	13	12	10	11	7	12	13	6	11
Lack of Knowledge	11	15	12	12	12	8	15	14	8	14
Lack of Understanding	19	18	21	17	20	18	19	20	17	15

Table H.9 – Percentage of students that answered in each of the four research data analysis category for each question of the questionnaire at Edinburgh Napier University (BSc-BEng)

Student Answers	Student answers - Percentage totals									
	Questions									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Good Knowledge – Good Understanding	38,70	32,25	32,25	38,70	32,25	38,70	25,80	25,80	38,70	41,93
No Knowledge – No Understanding	35,48	41,93	38,70	32,25	35,48	22,58	38,70	41,93	19,35	35,48
Lack of Knowledge	35,48	48,39	38,70	38,70	38,70	25,80	48,39	45,16	25,80	45,16
Lack of Understanding	61,29	58,06	67,74	54,84	64,52	58,06	61,29	64,52	54,84	48,39

APPENDIX I A COMPARISON OF THE GAPS IN KNOWLEDGE AND UNDERSTANDING OF STRUCTURAL CONCEPTS ACROSS UNIVERSITIES

Table I.1 – Average percentage of students' that answered in each research data analysis category for all universities tested

	Average percentage value of each research data analysis category			
University	"Good Knowledge – Good Understanding"	"No Knowledge – No Understanding"	"Lack of Knowledge"	"Lack of Understanding"
Edinburgh Napier (MSc/MEng)	40,00%	29,06%	35,00%	51,88%
Edinburgh Napier (BSc/BEng)	34,52%	34,19%	36,45%	59,35%
Heriot-Watt (MSc/MEng)	37,25%	32,00%	36,25%	56,5%
Aristotle (MEng)	43,43%	26,00%	30,57%	49,14%
NTUA (MEng)	48,16%	23,16%	25,79%	47,10%
T.E.I. of Serres (BEng)	39,06%	30,63%	34,38%	55,00%
T.E.I. of Piraeus (BEng)	32,07%	36,55%	39,32%	62,98%

Table I.2 – Further analysis of the percentage of students' that answered in category 'Good Knowledge – Good Understanding' for all universities tested

University	Percentage values in category "Good Knowledge – Good Understanding"			
	Average percentage	Student answers		
		0 and up to 4 out of 10 Questions	5 out of 10 Questions	6 and up to 10 out of 10 Questions
Edinburgh Napier (MSc/MEng)	40,00%	68,77%	18,75%	12,50%
Edinburgh Napier (BSc/BEng)	34,52%	74,20%	19,36%	6,46%
Heriot-Watt (MSc/MEng)	37,25%	70,00%	17,50%	12,50%
Aristotle (MEng)	43,43%	51,42%	25,71%	22,85%
NTUA (MEng)	48,16%	47,37%	18,42%	34,20%
T.E.I. of Serres (BEng)	39,06%	70,31%	20,31%	9,38%
T.E.I. of Piraeus (BEng)	32,07%	88,51%	9,20%	2,30%

Table I.3 - Further analysis of the percentage of students' that answered in category 'No Knowledge – No Understanding' for all universities tested

University	Percentage values in category "No Knowledge – No Understanding"		
	Average percentage	Student answers	
		3 to 10 out of 10 Questions	
Edinburgh Napier (MSc/MEng)	29,06%	53,13%	
Edinburgh Napier (BSc/BEng)	34,19%	67,73%	
Heriot-Watt (MSc/MEng)	32,00%	70,00%	
Aristotle (MEng)	26,00%	45,71%	
NTUA (MEng)	23,16%	36,84%	
T.E.I. of Serres (BEng)	30,63%	59,36%	
T.E.I. of Piraeus (BEng)	36,55%	82,77%	

Table I.4 - Further analysis of the percentage of students' that answered in category 'Lack of Knowledge' for all universities tested

	Percentage values in category "Lack of Knowledge"	
University	Average percentage	Student answers
		3 to 10 out of 10 Questions
Edinburgh Napier (MSc/MEng)	35,00%	78,13%
Edinburgh Napier (BSc/BEng)	36,45%	83,89%
Heriot-Watt (MSc/MEng)	36,25%	75,00%
Aristotle (MEng)	30,57%	57,15%
NTUA (MEng)	25,79%	50,00%
T.E.I. of Serres (BEng)	34,38%	78,12%
T.E.I. of Piraeus (BEng)	39,32%	70,11%

Table I.5 - Further analysis of the percentage of students' that answered in category 'Lack of Understanding' for all universities tested

	Percentage values in category "Lack of Understanding"	
University	Average percentage	Student answers
		3 to 10 out of 10 Questions
Edinburgh Napier (MSc/MEng)	51,88%	96,89%
Edinburgh Napier (BSc/BEng)	59,35%	100,00%
Heriot-Watt (MSc/MEng)	56,50%	97,50%
Aristotle (MEng)	49,14%	94,28%
NTUA (MEng)	47,10%	94,73%
T.E.I. of Serres (BEng)	55,00%	95,29%
T.E.I. of Piraeus (BEng)	62,98%	100%

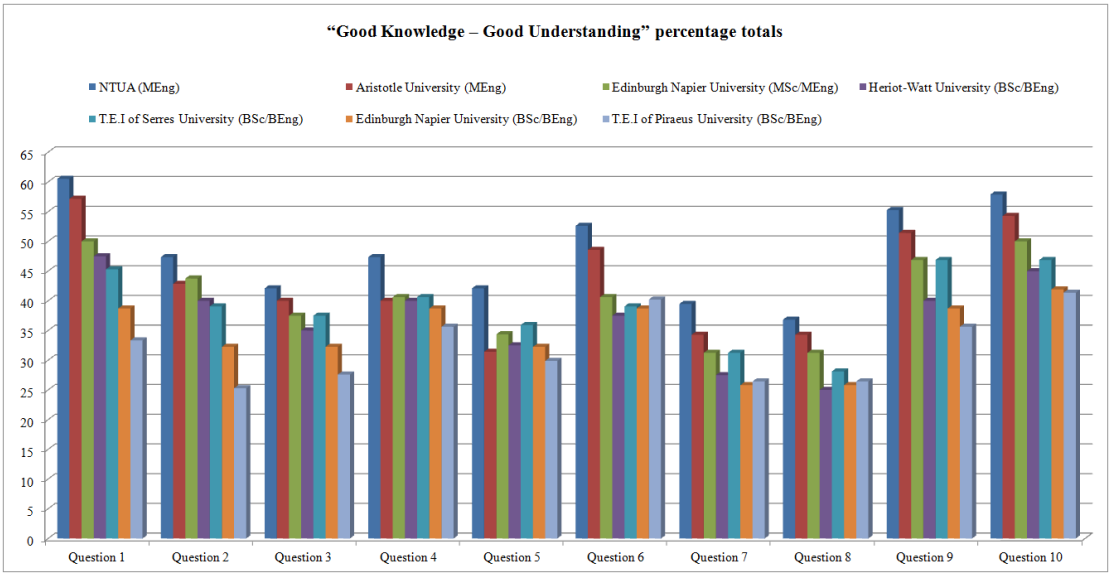


Figure I.1 - University comparison based on the percentage values of students' answers in the category 'Good Knowledge – Good Understanding' for each question

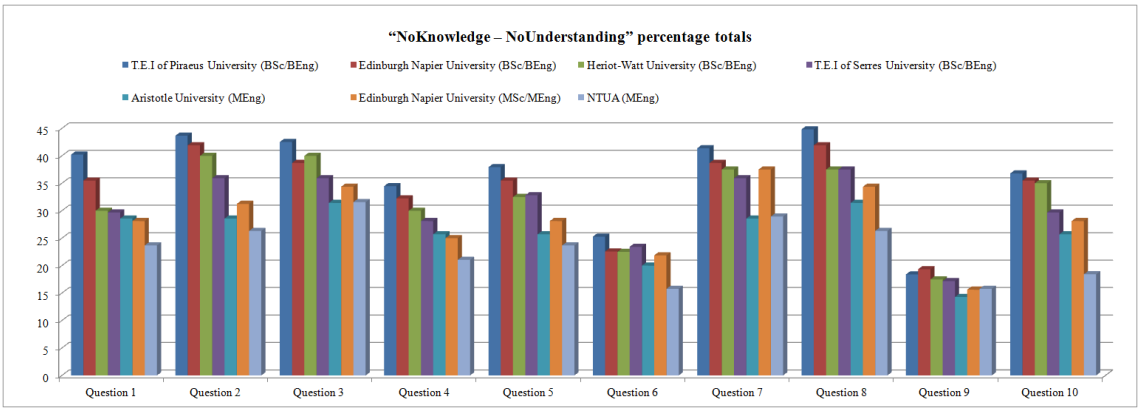


Figure I.2 - University comparison based on the percentage values of students' answers in the category 'No Knowledge – No Understanding' for each question

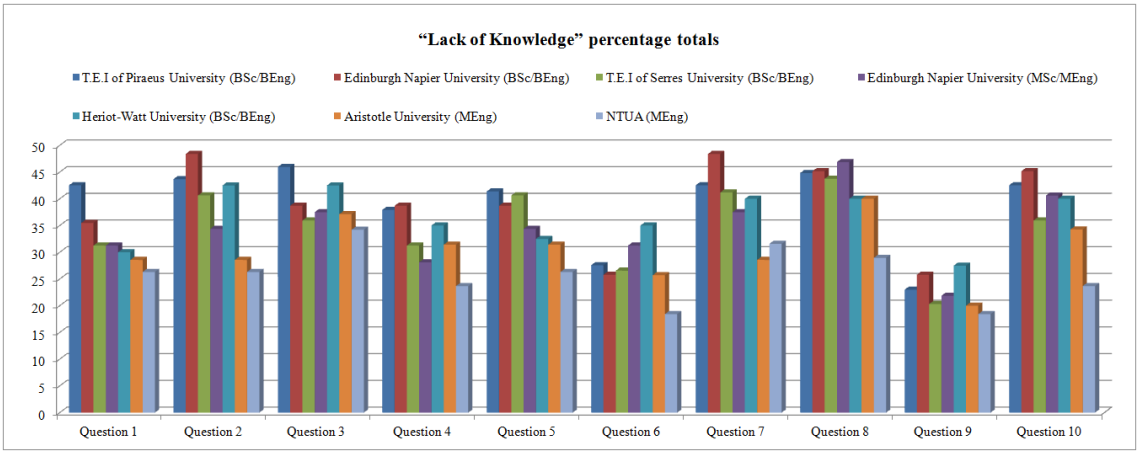


Figure I.3 - University comparison based on the percentage values of students' answers in the category 'Lack of Knowledge' for each question

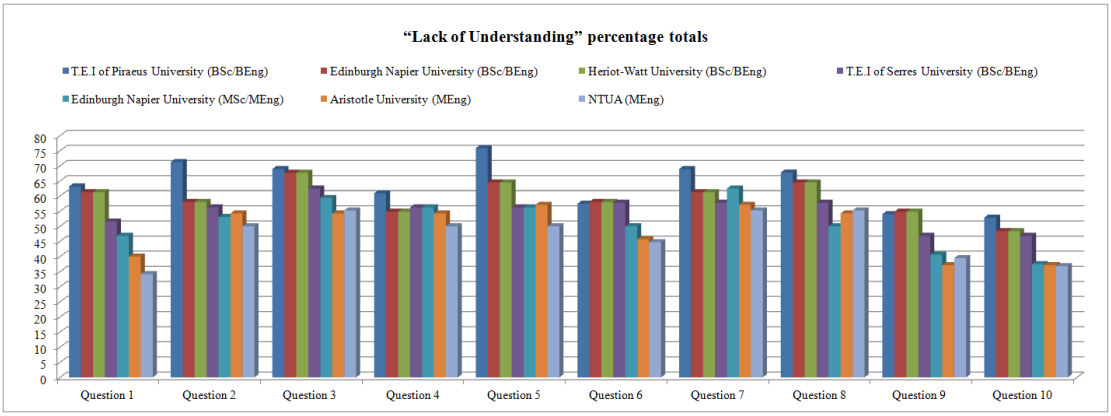


Figure I.4 - University comparison based on the percentage values of students' answers in the category 'Lack of Understanding' for each question