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Students' Attitude towards Mathematics at the University of Évora, Portugal

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Mama

Patak sa luha
Sakripisyo,pag-antos
Sa imo dalit

Resumo

Atitude dos Alunos em Relação à Matemática na Universidade de Évora, Portugal

Este estudo é uma tentativa de determinar a atitude dos estudantes de primeiro ano, que tiveram como objecto de estudo a matemática no primeiro semestre no ano académico de 13/14 na universidade de Évora, Portugal. Um questionário foi feito, passou por verificações de fiabilidade e validade, e serviu para reunir dados sobre a atitude dos estudantes em relação a matemática tais como a motivação, interesses, compreensão e níveis de ansiedade. Os resultados desta pesquisa mostraram que os alunos de primeiro ano normalmente têm uma atitude positiva em relação à matemática antes de entrarem na universidade. Existe uma forte correlação ente a atitude, motivação e interesse, perceção da competência e nível de ansiedade. Esta avaliação é importante para a universidade e para o seu corpo administrativo pois levanta preocupações sobre o fator aprendizagem. Também ajuda a entender a predisposição dos estudantes para a matemática e ajuda a criar hipóteses de intervenção para ajudar aqueles que tem uma atitude mais negativa em relação ao objecto de estudo.

Palavras-chave: atitude em relação à matemática, análise fatorial, estudantes do primeiro ano na universidade, escala de Likert.

Abstract

Students' Attitude towards Mathematics at the University of Évora, Portugal

This study is an attempt to determine the attitude of freshmen students who were taking a math subject in the fall semester of the academic year 2013-2014 at the University of Évora, Portugal. A questionnaire was developed, which underwent validity and reliability analyses, and used to gather data about students' attitude towards math and their motivation, interest, perceived competence, and anxiety levels. The results of this research show that freshmen students generally have positive attitude towards mathematics prior to commencing university formation. There is a strong positive correlation between attitude and the motivation and interest, perceived competence and anxiety dimensions. This assessment is important to the university faculty and administration as it raises concern on the affective aspect of learning. It also helps them to understand the disposition of their students in math and create possible means of intervention to help those with a negative attitude towards the subject.

Keywords: attitude towards math, factor analysis, freshman students, Likert summated rating scale

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The Problem

Introduction

The initial training ground in preparation for the professional world is college or the university. The course program chosen prior to entering a higher institution is affected by certain belief systems that a person upholds. Most of the time, they choose the course which they believe would give a significant impact in their lives and pave a path for a brighter future. These course programs provide relevant skills and training needed to become successful in the chosen field, which are reflected on the subjects or curricular units included in its respective curriculum.

In most academic disciplines offered in the university, mathematics has always been a part of the curriculum. It is often a compulsory requirement in courses related to engineering, social science, commerce and hard science. The offering of the subject is perceived and historically understood to have an impact and utility to which it anchored to. For instance, statistics is taught to students taking a course in economics to forecast the possible rise and fall of an economy.

Mathematics is generally everywhere. It can be observed in the most basic organism to the very complex laws of the universe. The importance of learning mathematics during undergraduate training cannot be understated as it is necessary to understand the rudiments and complexity of the world around us.

Mathematics is almost as important as any major subject in any undergraduate program. Math provides the rudiments necessary in any profession such as computational and statistical skills that are useful in expanding one's potential and productivity in the workplace. It also provides the mental training which results to better analytical, critical and evaluative skills.

Learning of any subject matter is not entirely dependent on the cognitive ability, but also on the manner of how learning is perceived, character towards the subject, and sense of control. Mathematics is of no exception. The values and beliefs of an individual that forms his attitude and that were gathered in the course of his learning experiences affect his decisions and actions. The attitude of an individual plays a vital role in his learning. It serves as a basis by which he behaves and acts in a particular learning environment.

Attitudes are referred to as mental states used by individuals to structure the way they perceive their environment and guide the way they respond to it (Raagas, 2010). Since attitude is a psychological construct, it cannot be directly measured. It is by a person's words and actions that can imply the presence of attitudes (Henerson, Fitz-Gibbon, & Morris, 1991).

Over the years, the study of attitude motivated researchers to find in depth answers as to the gravity of its influence and impact towards learning, especially, in the area of mathematics. Studies show that the more a student develops or has a positive attitude towards math, the stronger the drive to study more in the subject (Akinsola & Olowojaiye, 2008; Ponte, Matos, Guimarães, & Canavarro, 1992).

As students enter college mathematics classes, they carry with them certain attitudes towards the subject. They also bring with them certain expectations of the qualities that a teacher should possess in order for them to gain profound learning and harness their full potential. In the course of their basic education, it is more likely that these students have experienced events which changed outlook on the subject. As such, affected the way they treat the subject.

In the university level, more attention should be given to the understanding and development of the attitude of students towards math. As the subject is generally viewed as difficult, adverse consequences arise from this view resulting to desistance, avoidance, fear, anxiousness and discomfort, or in brief negative feelings towards it. Students taking math in the university often feel obliged and forced rather than taking the subject as part of their training and understanding of the professional work they are to be involved in the future. This, in turn, does not allow them to see the significance of the subject as a means of understanding and associating the concrete things around them.

Given the importance of the acquisition and improvement of skills in mathematics to the different sectors of society, professors and university personnel should work together to develop a positive attitude towards math in students, most especially among those whose course programs are perceived to be as instruments that respond to the needs of their relevant societies.

However, it seems like this is not one of the priorities of most university math departments as they are more focused on the technical, applied and theoretical aspect of the subject. This suggests that the affective domain of learning is not given much importance by teachers.

Students entering the university would often choose course programs with less mathematics in the curriculum or none at all. Their view of mathematics and perception of their learning may have influenced their decision. Certain experiences in the past may have caused them to favor courses which do not deal much about the subject. For instance, their past failures in problem solving may have affected their views of mathematics as a subject.

The benefits of understanding the attitude of students towards math is broad enough that it can even address the minutest problem faced by the students and teachers alike. This allows both parties to take action and see which aspects in the teaching and learning process has to be addressed in order to achieve success. It is imperative that the attitude of students towards math be known as early as their freshmen year in college, so that adjustments can be made as they move forward in their university life, and to plan possible intervention for the incoming ones.

Attitude influences not only how a person perceives the world around him, but also how he interprets situations, circumstances and actions of others. Hence, a more positive attitude has to be developed among university students at an early stage to enable them to make the right choices and decisions in life and in learning.

In Portugal, there are no known studies on the attitude of students towards math focusing on the students in higher education. The current study is an attempt to make a contribution to the understanding of the attitude towards math among freshmen students in the University of Évora. Part of the study is the development of an instrument, and applying it to explore the nature of a select group of freshmen students based on their demographic profile.

Statement of the Problem

Prior to this study, there has not been any attempt to investigate the attitude of students in the University of Évora towards math. A preliminary search for references relating to the subject in the university library database revealed none. Thus, this research is probably the first attempt to study the attitude of the students towards math.

This study investigated the students' attitude towards mathematics of the newly admitted freshmen student in the University of Évora, Fall Semester of Academic Year 2013/2014. In particular, it sought answers to the following questions:

1. What are the underlying factors that affect the attitude of students toward math?
2. What is the profile of students in terms of their gender, age, time spent in studying math outside class, previous math rating, general weighted average upon entrance to the university, and academic discipline?
3. How are the attitude of students characterized considering: gender, age, time spent in studying math outside class, previous math rating, general weighted average upon entrance to the university and academic discipline?
4. What is the level of students' attitude in terms of possible attitude subscales?

Study Objectives

The aim of this study is to explore the nature of attitude of the freshmen students in the University of Évora towards mathematics. The specific objectives in this study are as follows:

1. To develop an instrument that measures the attitude of students towards mathematics.
2. To create a profile of the students involved in the study in terms of their gender, age, study time, previous math rating, high school general average and academic discipline.
3. To characterize the attitude of students towards math in terms of their perceived competence, motivation, interest, and anxiety.

Conceptual Framework

This research was anchored on the concept that attitude plays a significant role in learning. When a student is engaged in learning, he carries with him certain predispositions that influence how he behaves, acts, understands, and treats the subject. Attitude can go in two directions (i.e. positive/negative), depending on the magnitude, could affect achievement.

Attitude is a construct that is difficult to quantify, yet it can be observed based on an individual's acknowledgment and affirmation through words and actions. Being able to know the level of a student's attitude allows improvement on various educational decisions that pushes achievement, success, and development.

Attitude is an accumulation of one's experiences gained through time. The experiences gathered from the interaction between self and society develops beliefs and is translated to behaviors. Beliefs are an embodiment of what a person learned or came across from his experiences. It includes the truths or the things that he believes to be true or not. Behaviors represent the actions toward a certain entity or object. For example, if a student thinks that he has not been learning in a series of lessons, a display of frustration or untoward actions will be evident in the execution of activities or tasks.

Attitude is an important aspect of an individual as it influences the choices he makes. It is important that an individual develops a positive attitude. Doing so enables a person to have a better perspective, a degree of control, and the ability to adapt to situations that are not to his advantage.

For students to have a positive attitude towards learning, especially in math, is one of the goals that have to be achieved in the classroom. This also includes the students at the university. It is generally thought by university students that they can avoid mathematics classes. Although this is true in arts and most humanities courses, math is an essential subject in courses related to engineering, hard sciences and social sciences. In fact, this is a sign of students having an unfavorable attitude towards math.

Developing a positive attitude among the students opens opportunities for improvement in the teaching and learning process. Teachers will be able to adjust their strategies, methods, evaluation, presentation and delivery of the subject while students will be more receptive and motivated to learn. It also develops a better teacher-student relationship as the person in authority is able to deal the students accordingly.

In order to develop a positive attitude among students, it is important to know and understand their current state. It serves as a benchmark on the measures that can be done for those who have a negative attitude and reinforce those who already have a positive one.

The dependent variable in this study is the attitude of students towards math. Attitude cannot be directly measured yet knowing certain factors that constitutes or likely affect a student's attitude can be accounted for. The overall attitude of a student can be perceived based on four factors consisting of perceived competence, motivation, interest and anxiety.

The perceived competence of a student is his understanding of his capabilities in solving problems or find solutions to challenges given to him. To a certain extent, students are able to determine the degree of confidence on how strong or weak they can perform in tasks or activities in math. Their perceived competence influences the way he will treat the subject. If a student thinks that he is weak in the subject, most common tendencies are giving up or cease to continue further with the challenges facing him, as a result, showing a negative attitude. On the contrary, students who think they are strong in math will persist and strive to succeed, thus showing a positive attitude towards math.

Motivation is considered as an individual's intrinsic drive to pursue something that is valuable. In education, motivation directs a student's behavior towards a particular goal or increases his drive and effort to achieve the goal (Liu & Lin, 2010). A motivated student is determined to succeed in the subject regardless of the level of difficulty he faces. Students who are motivated tend to show desirable behaviors such as accomplishment of tasks without the regard for reward, persistence amidst failure, selection of deeper and more efficient performance among others (Middleton & Spanias, 1999).

A student's interest in the classroom depends on a variety of factors. In most cases, it depends on the dynamics of the teaching and learning process led by the teacher. It is important that students' interest be stimulated and maintained in every learning moment in the classroom. Once they are hooked within the lesson proper, students are able to understand the lesson and grasp the concept better. This triggers the curiosity of a student and as result the student is more engaged in the lesson.

Most people commonly perceive math as difficult and requires a lot of effort especially in problem solving (Pejouhy, 1990; McLeod, 1992). This partiality has caused adverse consequences on the younger generation. Some of them feel uneasy or uncomfortable when confronted with problems which require mathematical skills or just by hearing the word math. It is important that students are nurtured in a way that does not make them feel uncomfortable in math. Unnecessary stress can impede a student's productivity and can eventually lead to failure in the subject.

A student with a more positive attitude towards math is likely to become successful in this area and also in other subjects where math is embedded (e.g. Physics and Chemistry). High achievement is perhaps one of the benefits of having a positive attitude. The transfer and acquisition of knowledge becomes easier when a student has a positive disposition.

To better understand the attitude of students towards math, certain student characteristics were looked into. These characteristics were held as the independent variables of this study as these facts can no longer be changed and stand as it is. This includes gender, age, study time, previous math rating, high school general average, and academic discipline.

Figure 1 shows the schema showing the relationship between the dependent and independent variables.

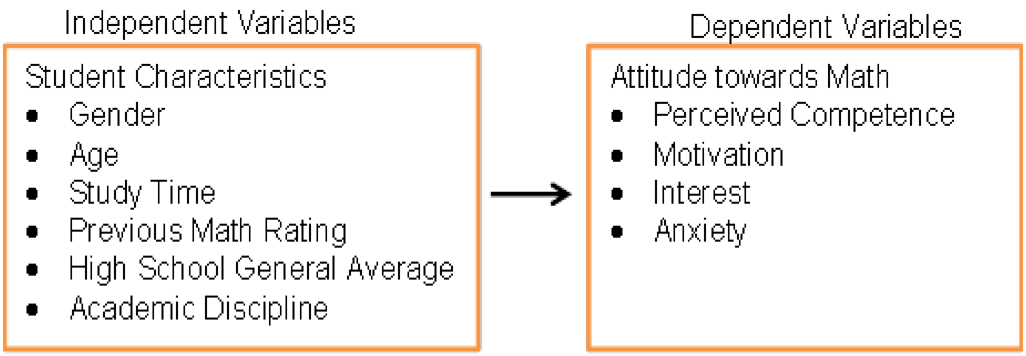

Figure 1 – The Schema of the Study

Relevance of the Study

The importance of this study stems from the fact that it will contribute to the lack of investigation with regards to the affective domain at play in the teaching and learning process of university mathematics. It is expected that this study clarifies the extent of truth on the beliefs regarding the attitude of students in the University of Évora. There is a great need for such studies especially in the intention of solving concrete problems such as low marks and class attendance encountered by professors and the feeling of discomfort experienced by students. This also serves as a benchmark for future researches revolving around the subject.

Specifically, the results of this study will also be beneficial to the following:

a. For University of Évora Math Professors, to get to know their students better, to build a better relationship with them and serve as anchors and conduits in the development of a more positive attitude towards math. Also, for them to become more responsible in their teaching function as it is one of the factors that significantly affect the improvement of the teaching and learning process. They may also utilize this to hone their teaching skills being able to plan and organize learning experiences that are reflective and sensitive to the complex attitude of students. They may also utilize the data to adjust their teaching practices, enabling them to become effective math professors and become more aware of the existing phenomena in the classroom.
b. For the University of Évora Math Department, to make curricular choices that are reflective and sensitive to the issues that relates to student attitude. This will help them improve the implementation of the curriculum that gears toward a more holistic professional development of students by also considering the affective domain of learning. It can also serve as Bases for planning and organizing intervention or reinforcement to support students who have negative attitude towards math.
c. For University of Évora Administrators, to design programs, trainings, seminars, and workshops for awareness of issues related to the affective domain and how to address them in the classroom level. This will also help them in the improvement of student services and reflective to the educational choices implemented in the university.
d. For Future Researchers, the result may serve as a reference for further studies in relation to the attitude of students at the university level. They may investigate further on the areas that are not discussed in this

study and provide a better understanding on how to better improve university practices that affect the attitude of students towards math.

Scope and Delimitation of the Study

The main purpose of this study was to determine the attitude of students towards math. It involved newly admitted freshmen students coming from degree programs which offer a math class for the fall (1st) semester of the Academic Year 2013/2014 at the University of Évora. Only those who attended classes from November 18 to December 20, 2013 were considered. In terms of taking math subjects, there are no compulsory pre-requirements that prohibit any student from taking a subject belonging to the other year level syllabus. As such, freshmen students who opted not to take the indicated math subject for the fall semester of AY 2013/2014 were not able to participate.

There is no existing rule in the university that prohibits students from deferring a math class. It is also a possibility that students may have taken a second course in the university and are considered to be freshmen students. Also, an existing program of the university considers admitting students whose ages are above 23. Hence, varying age can be a limitation to this study.

Tests on statistical significance were not used to analyze the data. The respondents of this study do not constitute a random sample as there was no reliable tally of the actual registered students in math classes. The evaluation methods employed in the university is one of the hindrances in establishing a random sample that will represent the entire population of freshmen students taking a math class in that particular semester. As students can somehow determine their success in a particular class based on the score they obtain in one of the tests administered to them, it is most likely that only those students with a possibility to pass the subject during regular class evaluations (as opposite to just taking a final exam) were present during the administration of the questionnaire. Thus, responses of students who do not have this chance were not collected.

An instrument that measures attitude of students towards math fashioned in the common language of the students was created as there were none available. It was subjected to item, reliability and factor analyses to ensure quality. Only four factors that explain the attitude of students toward math were identified. It is limited to perceived competence, motivation, interest and anxiety, differing from most researches on the topic.

Chapter I
Review of Related Literature

Introduction

Students' success (or failure) in mathematics may be influenced by a variety of factors, including their attitude towards the subject. Being able to know their attitude and perception opens potential opportunities to improve the teaching and learning process.

This chapter deals with the review of literature about the affective domain in mathematics education. It primarily focuses on students' attitude towards mathematics. Research developments of the relationship between attitudes towards mathematics have been also looked into.

The first part of the review begins with a brief introduction of the inclusion of mathematics in the curriculum. It is followed by a discussion of the affective domain and its importance in the field of mathematics education which then shifts focus to the term "attitude" and its usage in various studies in history. The next section provides details on the efforts in measuring attitude, including the methods used, the instrument development, and the dimensions covered in such instruments. It also highlights the results of several studies and the work done on some factors or variables which likely affects attitude towards mathematics. Researches on this area are provided, followed by a discussion of significant results.

Mathematics in School Curriculum

When students face difficulties in understanding a math lesson they end up frustrated and ask the question, "Why do we need to study math?" This question indicates that students have an interest in knowing and understanding the rationale of compulsory teaching and learning of school mathematics. Intrinsically, they feel the need to be enlightened on the matter. Students turn to their teachers to seek for answers, but most of the time, teachers themselves do not have a concrete explanation and end up giving half-hearted answers (Davis, 1995).

The inclusion of mathematics in the curriculum has not been very clear to most of the people in the academe and the general public. Teaching and learning mathematics is believed to have a certain value in industries such as in finance, commerce, science, technology and engineering, yet its purpose is not being tackled deeply before students take a formal math class. Thus, it is necessary that the compulsory teaching of mathematics in school is to be clarified.

Most of the undergraduate courses offered in the university contain at least one math course in its curriculum. These math courses are deemed to have significance in the execution of tasks involved in professional practice (e.g. Statistics and Probability for a Biochemistry program). The math skills learned by students in their previous education are further enhanced or honed as they go through a math class in the university.

In the article *Why Teach Mathematics* by Paul Ernest (2000), he presented three concerns that take bearing in the discussion of the aims of teaching mathematics. First, he argued that the nature of mathematics is too broad of a discipline that its diversity has to be adapted in the justification of teaching mathematics. It is undeniable that most students take mathematics because they believe that the skills they will further achieve and hone will help them in some way at work. In this sense, the selection of which math content to be included and the manner of how it should be taught has to be grounded in the respective fields for which it may seem fit. The rationale of the teaching and learning mathematics, the content and the didactics of teaching mathematics should altogether be addressed as these important aspects are inseparable.

It has been generally accounted that the teaching of mathematics began as the demand for service and tremendous changes happened in areas of capitalism, industrialization, science, and urbanization. Until now, evidence that learning mathematics is seen to be important in such areas can be found in textbooks used at any level of education, specifically on how example problems are presented. Further traces of this can be found in curriculum rationales which highly stresses on large scale calculations.

However, Ernest (2000) reasoned that there has been too much emphasis being given to the usefulness of school mathematics in the present time. He claimed that it is not school mathematics which makes sense of reality, but the industries that utilizes and applies complex mathematics, thus creating systems that regulates the different areas of people’s lives. He stressed that it is not necessary to acquire more knowledge and skill of mathematics beyond that which are achieved at the basic education level as it does not ensure the economic success of modern industrialized society.

Pejouhy (1990), Davis (1995, 2001), and Ernest (2000) supported the idea that there are social and societal reasons for which math is being taught. Students will eventually become part of the society that aims to improve the different aspects of the lives of people. In this modern time, to be a model and good citizen requires an individual to possess certain mathematical skills in order to fully serve better. A sufficient amount of knowledge and reasoning skills is needed to become an informed and productive citizen.

The vast majority understands the importance of basic mathematical literacy. This means that being able to use math is as important as being able to understand why it is being used. It can be observed that the teaching of mathematics is based on the notion that certain historical and cultural motives that works in the social and societal realms.

In addition, the teaching and learning of mathematics is essential in the 21st century. Technological change must be integrated in the curriculum. There is a need to adjust the teaching of math in order to make room for the new essential skills that are necessary for success in a highly technological world (Pejouhy, 1990: 77). The learning of math should not be confined to the acquisition of knowledge, but should also concentrate on developing the human reasoning skills needed to take advantage of technology.

Affect in Mathematics Education

Due to its rigorous nature, math is perceived to be primarily a cognitive endeavor. At times, when teachers gather and discuss about their mathematics classes, they never seem to fail to mention how their students react on certain achievements or failures. Likewise, students seem to share among themselves their feelings and emotions when facing difficulty (or success) in a math problem, and produce comments with regards to liking (or disliking) math and their feelings on activities performed in or out of the classroom. The indication of affect having a significant role in learning mathematics is supported by a number of studies and analyses throughout history (Aiken, 1970; Reyes, 1984; McLeod, 1988, 1992, 1994; Pehkonen & Pietila, 2003; Leder & Grootenboer, 2005; Debellis & Goldin, 2006; Zan, Brown, Evans & Hannula, 2006; Grootenboer, Lomas, & Ingram, 2008;

Blanco, Guerrero & Carrasco, 2013)

As affect plays a significant role in mathematics learning and instruction, it has been a popular topic of interest in mathematics education research. For more than four decades, researchers have looked into various situations like how students value learning mathematics, how teachers perceive their ability in teaching math or how students and teachers feel in mathematical tasks. It is believed that affective variables have an effect in the learning outcomes or being predictive of future success (Hannula, 2004). As such, affective issues must be integrated in studies related to learning and instruction if its maximum impact on teachers and students is concerned (McLeod, 1992). Researchers on both affective and cognitive domains should be aware and reflective of each other’s works.

Affect is certainly at play in a student’s mathematical learning although researchers have varied opinions to its meaning and coverage. McLeod (1992) described the affective domain as a wide range of beliefs, feelings and moods that are generally regarded as going beyond the domain of cognition. For math education, he tagged emotional responses to mathematical tasks to extend the description of the affective domain. He also pointed out that these emotional responses are referred to as attitudes in the literature, yet most definitions do not seem to encapsulate it.

Affect includes changing states of emotional feelings during mathematical tasks (local affect) and more stable, longer-term constructs (global affect) that establishes its context (Debellis & Goldin, 2006). Damasio (1994), as cited by Debellis and Goldin (2006), stated that affect includes changing states of emotional feeling during mathematical activities of which they may be consciously or unconsciously aware of.

Reyes (1984) used the term to represent student’s feelings related to mathematics learning or about themselves as learners of mathematics. However, this definition does not intend to limit the affective domain to general feelings towards math such as like or dislike, nor rule out perceptions of the difficulty, usefulness, and appropriateness of math as a school subject.

Providing a more thorough definition of the affective domain is said to be difficult as there is no solid theoretical framework on the subject. The definition of affective domain has yet to be clarified and remains to be a major concern in mathematics education research. However, new developments have put the topic into a better perspective.

According to McLeod (1992), the affective domain is characterized by three subcategories which describe the wide range of affective responses to mathematics. These are beliefs, attitudes and emotions. These subcategories vary in stability and intensity. Beliefs and attitudes are generally stable while emotions may change rapidly, deeming it unstable.

Debellis and Goldin (2006) later added a fourth category to this partition (i.e. values/morals/ethics) and illustrating the interaction of these categories in a tetrahedral model (see Figure 2).

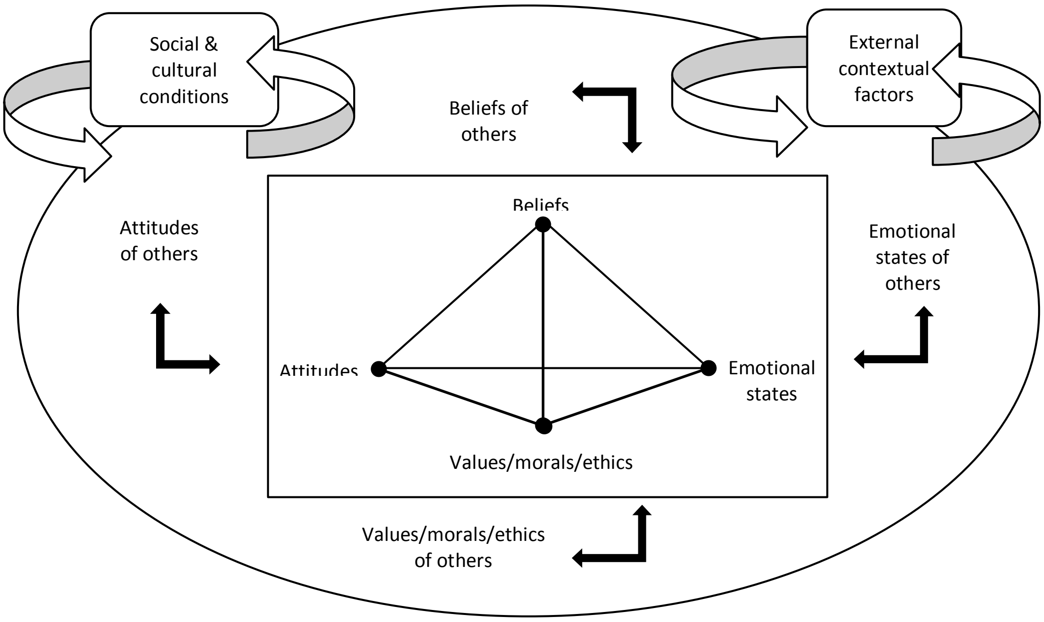

Figure 2 A tetrahedral model describing the subcategories of the affective domain (Debellis & Goldin, 2006)

The model shows how each subcategory dynamically interacts with each other and how outside or external factors influence an individual's affective responses by corresponding systems of the (mathematical/ educational) subcultures wherein the person is situated. Furthermore, Debellis and Goldin (2006) described each of the subcategories of the affective domain.

Emotions describe rapidly-changing states of feeling experienced consciously, occurring pre-consciously or unconsciously during mathematical activity. Emotional feelings range from mild to intense (less stable), and are local and contextually-embedded.

Attitudes describe orientations or predispositions toward certain sets of emotional feelings (positive or negative) in particular (mathematical) contexts. This differs from the more common view of attitudes as predispositions toward certain behavior. Attitudes are moderately stable, involving a balance of interacting affect and cognition.

Beliefs involve the attribution of some sort of external truth or validity to systems of propositions or other cognitive configurations. Beliefs are often highly stable, highly cognitive, and highly structured – with affect interwoven in them, contributing to their stabilization.

Values, including *ethics* and *morals*, refer to the deep, “personal truths” or commitments cherished by individuals. They help motivate long-term choices and shorter-term priorities. They may also be highly structured forming value systems.

Affect may empower or disempower a student in relation to learning mathematics. In this regard, researches have been conducted on the four core concepts of affect in mathematics education namely, beliefs, values, attitudes and emotions or feelings (Hannula, et al, 2004). Leder and Grootenboer’s editorial piece (2005) in the *Mathematics Education Research* Journal showed an illustration of how the four concepts can be conceptualized based on the levels of cognition, stability, affectivity, and intensity in a model (see Figure 3).

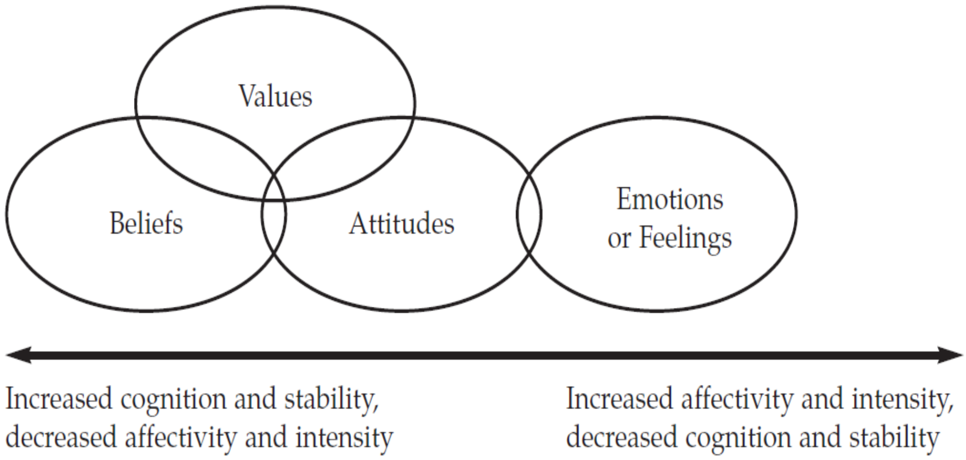

Figure 3 The affective domain (Leder & Grootenboer, 2005)

This model shows a simplified structure of the complex interactions between the affective subdomains. Beliefs, values and attitudes seem to have overlapping characteristics while attitude has an exclusive link with emotions or feelings. It is further illustrated that when beliefs and values have an increased cognition and stability, the affectivity and intensity is decreased. The stability of beliefs, values and attitudes can be linked to the notion of embedded truth in an individual which are not easily changed over time. Emotions or feelings has a stability of mild to very intense and may rapidly change states. On the other hand, attitudes are moderately stable predispositions towards ways of feeling, involving a balance of affect and cognition.

Research efforts have concentrated on how certain variables (exogenous; e.g. gender, economic background) affect, influence, or associate with the attitude subdomain, specifically on attitude towards mathematics. Previously, it concerned only with the individual cases of the students, leaving other factors such as the classroom environment which may have a strong impact on student outcomes (Haladyna, Shaughnessy & Shaughnessy, 1983). However, 21st century studies have expounded the scope and including variables (endogenous) directly related within the school context (e.g. teacher quality, classroom management, learning environment), yet still focusing on one subdomain rather than the analysis of all of the components of the affective domain (McLeod, 1992).

Attitude

The study of attitude is often attached with the question, “How are attitudes formed?” An individual’s significant human experiences allow him to develop certain beliefs which serve as his guiding post in life. These beliefs are formed through his interactions with the environment which can be an object, action, event or another human being.

In Fishbein & Ajzen's (1975) Theory of Reasoned Action, a person’s attitude is formed based on the beliefs that he hold. These beliefs are called salient beliefs, that is, the topmost five to nine beliefs held by a person at a given point in time and that are considered to be the most important. Each belief links an object to some attribute that which a person evaluates. The attitude of a person toward an object is a function of his evaluation of these attributes. Note that the positive or negative direction of attitude does not depend on the direction of the belief, but on his evaluation of the belief. Say for example, if a person infers that the usage of calculator among elementary pupils is good, but believes that younger students should not use it until they reach high school, that person may develop an overall attitude towards the idea that is neutral or negative. As such, a positive belief does not necessarily mean a positive attitude.

Attitude research in the context of math education is perhaps the most studied aspect of the affective domain and has the longest history, including the testing of the relationship among known variables. For decades, the study of attitude in the context of mathematics education has become popular in an attempt to establish a strong theoretical foundation. Various researchers are in consensus with regards to the lack of theoretical framework to characterize research on attitude towards math. Research on this construct has dealt more on the development of measuring tools rather than its theoretical definition (Zan & Di Martino, 2007).

The definition of attitude is loosely defined in the literature. Most empirical researches depend on the methodology and instruments used to measure the construct to define attitude (which is more implicit), rather on a single definition that encompasses the central idea of the term (Zan & Di Martino, 2007). Several authors have provided their own understanding of the term in order to clarify the ambiguity on its usage in research.

For Haladyna, Shaughnessy, and Shaughnessy (1983), attitude towards math is defined as a general emotional disposition toward the school subject of mathematics. However, they stressed that it should not be mixed up with other areas like the field of mathematics, problem solving ability or toward some specific math area.

Aiken (1970) defined attitude as a learned disposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another perspective.

According to Zan and Di Martino (2007), when a definition is explicitly given, such as the ones above, it may fall under one of the three following types:

1. A simple definition that describes attitudes as a positive or negative degree of affect associated with a certain subject.
2. A multidimensional definition recognizing three components in the attitude: emotional response, beliefs regarding the subject, behavior related to the subject; and
3. A bi-dimensional definition that is a pattern of beliefs and emotions associated with mathematics

Zan and Di Martino (2007), citing Kulm (1980), indicated that a universal definition of attitude towards math may seem impossible to obtain as it may not work across all possible situations in which it will be applied. In addition, it may also be deemed too general, rendering it to be less useful. Thus, studies which concentrate on attitude takes on an operational role, dependent on the researchers' posed problem. Also, researchers often rely on the means of attitude assessment in order to provide understanding of the construct.

Affective refers to student's feelings about math, aspects of the classroom or about themselves as learners of mathematics. Note that the definition does not intend to limit it to general feelings such as liking or disliking math, or to exclude perceptions of difficulty, usefulness and appropriateness of math as a school subject (Reyes, 1984).

In early attitude research, methods of assessing the construct were discussed by Aiken (1970). For a small scale research or with a small group of respondents, observation and interviews would be fairly good procedures for assessment. Attitude can be observed in a one on one basis, up to its fine detail, and changes over time can be tracked, yet it is advised that these procedures be performed with extreme caution. Two problems are posed by these procedures. First, it is time consuming; second, it may become influenced by the researcher's subjectivity.

Choosing the best measure should be pondered upon. The study of the affective domain is a very sensitive issue which raises concerns in terms of measurement. Finding the right tool should be a concern of the researcher. There are existing measures that can be chosen from the literature, but it is also suggested to develop an effective tool that conforms to the unique problem and parameters under consideration.

A method that is commonly used in assessing attitude is attitude scales. Two of the popular attitude scaling procedures is the Thurstone method of equal-appearing intervals by Louis Leon Thurstone in 1928 and Likert's summating rating as the most used by Rensis Likert in 1932.

The Thurstone technique involves a series of positive and negative statements, all of which varies in degree. These statements are previously judged and assigned with a specific scale value (the median or mean scale value of the items initially judged). A respondent's score on a scale consisting of a series of such statements is the sum of the scale values of the statements which he endorses (Fishbein & Ajzen, 1975; Gable & Wolf, 1993; Oppenheim, 1996).

The Likert summated rating scale is comprised of positive and negative statements where the respondent indicates the magnitude of his agreement (disagreement) depending on the chosen continuum. The respondent's score is the sum of the weights assigned to each statement. In both techniques, a high score would signify a positive attitude toward the particular topic of the scale.

Reyes (1984) cited reasons why there is a need to study affective variables in the context of mathematics learning. A student who feels very positive about math will likely have a higher level of achievement than a student with a negative attitude. Although this is a possibility, several researchers have differing results on the relationship of attitude towards math and student achievement. One important educational outcome is for students to have a positive attitude towards math. It is for this fact that knowing how students feel towards math shall educators be able to provide intervention for them to enjoy learning. Reyes added that a positive attitude plus a sufficient knowledge of mathematics will help the student to adapt to the ever-changing and advancing world.

McLeod's (1994) review on published researches on attitude of the Journal for Research on Mathematics Education pointed out several characteristics of how research was done at that time (1970-1994). It revealed that attitude was assessed through the use of questionnaires, yet researchers were more concerned of its reliability than validity. Studies were highly quantitative but the theoretical foundation was not much specified. There is evidence of the insufficiency of theoretical foundation and the major focus deals with psychometric approaches. Many instruments used to assess attitude were developed during that time. Attitude was analyzed on several dimensions, with Fennema-Sherman Mathematics Attitude Scale (Fennema & Sherman, 1976) as the most popular of all. Student characteristics were not given much emphasis in those studies.

The Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) was an attitude instrument with specific attitudinal dimensions. The initial purpose of the instrument was to determine the attitude of female student in relation to learning mathematics. It was later on used to determine gender-related differences on student's attitude.

Various researchers have worked on a theoretical framework in analyzing attitude towards math.

Hannula (2002) developed a framework for analyzing attitude based on the psychology of emotions. The attitude of the student is evaluated in four evaluative processes: (a) the emotions the student experiences during mathematics related activities, (b) the emotions that the student automatically associates with the concept mathematics, (c) evaluations of situations that the student expects to follow as a consequence of doing mathematics; and (d) the value of mathematics-related goals in the student's global structure.

His proposed framework in analyzing attitude is clearly linked to the other domains of learning. This shows that the study of affective variables cannot be separated from the cognitive and psychomotor domains. The important conclusion drawn from the application of this framework on a case study of a particular student named Rita appears to be of great use especially in observing attitude in a classroom level. The potential of this framework is strong enough to explore attitude in detail, track changes in a relatively short time, and the negative attitude towards math can be a successful defense strategy of a positive self-concept (Hannula, 2002).

In the theoretical framework suggested by McLeod (1988), research on affective issues, especially in relation to mathematical problem solving, should include the following factors; magnitude and direction of the emotion, duration of the emotion, level of awareness of the emotion and the level of control of the emotion. In studying affect, the intensity (magnitude) as well as the direction (positive or negative) of affective responses of students during mathematical tasks is taken into account. Responses can be shorter or longer depending on the stability and the length of the responses. To better understand the affective, especially as it is only translated into behavior, it is necessary to know the students' consciousness or unconsciousness to the reactions during mathematical experiences. If students become aware of their reactions, it could improve the manner by which they react to problems and become in charge of their emotions.

The study of attitude towards math is often taken into a bi-dimensional perspective, i.e. identifying attitude to be positive or negative. Attitude is assumed to be working in two directions; positive or negative. The usage of these two terms are said to be anchored on the definition of attitude.

The work of Zan and Di Martino (2007) explained the usage of the term positive and negative in identifying student's attitude. According to them, there are three dimensions to better understand the attitude of a student than just the positive or negative dichotomy. These three dimensions are like/dislike, the perception of being/not being able to succeed in mathematics, and vision of mathematics. The dimensions allow interpretation of attitude as not only heading to any particular direction, but also to understand the underlying precepts of self-concept and view of mathematics.

One goal of mathematics is to understand the nature of the world we live in and, in mathematics education, to appreciate the utility of math in this task. To be able to achieve this goal, a student must have the emotional state which allows him to be more perceptive and a better outlook. Thus, in general, it is best for students to develop a more positive attitude. Haladyna, Shaughnessy, and Shaughnessy (1983) listed three reasons why a positive attitude among students is valued: (a) a positive attitude is an important school outcome in and of itself, (b) attitude is often positively, although slightly, related to achievement, and (c) a positive attitude towards math may increase one’s tendency to choose math courses in advance studies and careers in mathematic or mathematics-related fields.

Many researches included attitude as one of the “factors” that possibly affect the achievement of a student in math. As to the clear meaning of attitude, there is still no general description or meaning that is universally used by math educators. Though, it is quite an interesting fact that somehow, the performance of students and their ability to master mathematics depends on how they view math as a subject. Although the attitude of the students also depends on the teaching method and the attitude of their teachers, as studies would define, without interest and personal effort in learning math, they can hardly perform well in the subject.

According to Aiken (1970), students in the college level generally have a more positive attitude towards academic work. Hence, it would be expected that only a few students possess a negative attitude towards math. In this regard, correlation between achievement and attitude would be somewhat smaller. To promote high attitude-achievement correlation, it is necessary for college students to be conscientious and reflective is answering attitude inventories.

The relationship of achievement and attitude towards math would be of less concern if the latter was not thought to affect performance in math. Citing Neale (1969), Aiken (1970) pointed out the reciprocal influence of achievement in math and attitude towards math. This means that achievement affects attitude and in turn, attitude affects achievement. Research suggests that neither attitude nor achievement is dependent on each other (McLeod, 1992). An example of this is the 2011 Trends in International Mathematics and Science Study, where East Asian countries such as Chinese Taipei, Japan and Korea have high mathematics performance yet have the smallest percentage of students having positive attitudes toward mathematics. The 2011 TIMSS report is consistent with previous TIMSS assessment (Mullis, Martin, Foy & Arora, 2012).

Haladyna, Shaughnessy and Shaughnessy (1983) introduced a model for the study towards mathematics where it includes internal and external school related factors which may contribute to attitude formation. However, their research focused only on the immediate variables related to the classroom environment (e.g. teaching practices, learning environment).

An analysis of 113 studies on the relationship between attitude towards mathematics and achievement in mathematics conducted by Ma and Kishor (1997) showed that the cause and effect relationship was statistically significant, but not strong enough to be useful for educational practice. For its reverse relationship, it revealed to be insignificant. This implies that both achievement in math and attitude in math do not depend on each other. Also, their analyses showed that gender has no effect on the relationship.

Working with a select group of college students, Blanco, Barona and Carrasco (2013) made use of a variety of tools to describe and analyze prospective teachers' attitudes, beliefs and emotions related to problem solving. They found out that the prospective teachers' understanding of the mathematical content in math problems is limited to traditional practices. It revealed that these prospective teachers have little confidence in their abilities when solving normal problems, viewing themselves as less capable or less skilled in math. Another study by Ignacio, Blanco-Nieto and Barona (2006), using a self-inventory, they studied the beliefs and attitudes in six thematic blocks; (a) student's profile, (b) beliefs about the nature of mathematics and its teaching and learning, (c) beliefs about oneself as a learner of mathematics, (d) beliefs about the role of the mathematics teacher, (e) beliefs corresponding to the social and family context, (f) attitudes and emotional reactions to mathematics and its learning. Results revealed that boys had a better self-concept than girls. They also found out that those with a high or satisfactory level of performance in mathematics to show positive behavior and high success. It also revealed that boys show more confidence than girls in solving problems.

One common opinion in the college level is that students would not have a positive attitude towards mathematics. Evans (2007) investigated the attitude, conception, and achievement of students in an undergraduate college statistics with results refuting the opinion. It showed that college students coming from different college units taking a statistics class already have a positive attitude towards the subject and no significant changes occurred. Furthermore, sociology students had a more positive attitude towards math than mathematics and psychology students.

Most of the studies conducted on attitude in relation to some factors (e.g. achievement, gender differences) are done at the elementary and secondary level and little attention is given to students at the college level. Other efforts in tracking and observing attitude change and in relation to achievement at college level can be seen in the works of Whannell and Allen (2012), Hodges and Kim (2013), Alves, Rodrigues and Rocha (2012), and Sundre, Barry, Gynnild and Ostgard (2012).

Instrument Development in the Affective Domain

The investigation of students' attitude toward math most often involves the development of an instrument or a tool that allows assessing it. As the concept of attitude is a construct, measuring it directly is nearly impossible. Examining or measuring it is not the same as examining a man's heart condition or measuring body temperature. Attitudes can be only inferred based on an individual's words and actions (Henerson, Morriz & Fitz-Gibbon, 1997).

Instrument development in the affective domain follows a rigorous process in order to ensure high quality. Gable and Wolf (1993), suggested steps to be followed in affective instrument development. This includes the conceptualization of the affective characteristic to be studied, belief statements or item formulation, scaling technique, response formats, initial draft, pilot study, validity and reliability analyses, and revision.

Conceptualizing the definition of attitude is the first important step in the instrument development. The conceptual definition of any affective characteristics is a crucial part in the process of instrument development as it serves as the theoretical base supporting the instrument. For example, in the study of Yara (2009), he differentiated the definition of attitude towards science and attitude in science. There is no one definition of attitude in mathematics education research. Various researchers have given their own interpretation of the term based on the previous studies that preceded theirs.

In this early stage of instrument development, the research must revisit the objectives initially set and clarify the issue being addressed, in this case attitude. Poor judgment and lack of thought may lead to untrustworthiness and loss of credibility and value of the study (Raagas, 2010).

Instruments developers usually look into different components or dimension that explain or may have an impact on the overall attitudes, in order to gain a better understanding or perspective of its relationship to mathematics. The dimensions or subscales (e.g. self-confidence, motivation) are dependent on the objectives and area of concern of the proposed study (e.g. Teacher Attitudes, Attitudes towards the School). Belief statements that will be used in the instrument abide on such dimensions.

In the 70's, Fennema and Sherman (1976) developed the Fennema-Sherman Mathematics Attitude Scales which was designed to gain more information concerning the learning of mathematics among females and information on variables related to the election of mathematics courses. The scales were (a) attitude towards success in mathematics, (b) mathematics as a male domain, (c) perception of parents' view on child's ability, (d) perception of teacher's attitudes, (e) confidence in learning mathematics, (f) mathematics anxiety, (g), effectance motivation in mathematics, and (h) mathematics usefulness. These scales were understood by the authors to intersect one another yet believed on the importance of separately measuring each variable.

Tapia (1996) developed the Attitude towards Mathematics Inventory for the purpose of measuring students' attitude towards mathematics in the high school level. Initially, six variables were considered - value, anxiety, motivation, confidence, and adults' perspectives – which later changed to sense of security, value, motivation and enjoyment, after rigorous statistical analyses. In a later collaboration, Tapia and Marsh (2000) investigated on students of middle school level; three factors were left from the original six. It consisted of self-confidence, enjoyment and value.

A study in Singapore by Wong and Chen (2012) provided different variables that explain attitude towards mathematics. Their analysis on the nature of an Attitude toward Learning Mathematics questionnaire revealed to have six underlying dimensions: checking solutions, confidence, enjoyment, the use of Information Technology in mathematics learning, multiple solutions, and usefulness of mathematics.

In an attempt to measure attitude towards mathematics among Portuguese students, da Silva (2013) adapted the attitude instruments developed by Brito (1998) and Goméz-Chacón (2003). The Questionário de Atitudes Face à Matemática consisted of five variables namely interesse (interest), competência percebida (perceived competence), ansiedade (anxiety), valor percebido (perceived value), and emoções ou sentimentos (feelings and emotions).

A measurement procedure that allows an individual to locate a certain concept in a bipolar evaluative dimension (Fishbein & Ajzen, 1975) is required in measuring attitude. The Expectancy-Value Model proposed by Fishbein (1975) deals with the relationship between the beliefs about a target object and attitude toward that object. This model suggests that the scaling technique to be used in measuring attitude should be able to connect an individual's belief on a target object to some attribute (Gable & Wolf, 1993). This is because a person's attitude is a function of his beliefs at a given time, with those beliefs as primary determinants of his attitude (Fishbein & Ajzen, 1975).

Currently, the most popular technique in measuring attitude is the Likert Summated Rating (Likert, 1932). The developer attempts to develop statements that respondents can easily judge. Raters rate their inclination or agreement to the statements based on a continuum that is usually in a positive and negative direction. This technique have been commonly used in most researches as they are relatively easy to construct, can be highly reliable and have been successfully adapted to measure many types of affective characteristics (Nunnally, 1978; cited by Gable & Wolf, 1993).

The attitude instrument using the Likert technique contains two parts; the belief statements and the Likert response format. A substantial amount of statements or items are initially formulated in this technique. The developer has the freedom to choose which items fit the operational definitions or the variables considered to affect attitude. A careful selection of the items is essential for the internal or content validity. It is appropriate that items be subjected to a judgmental review by experts to see the extent of its relevance to the conceptual definition of attitude used in the study. Additionally, careful and sensitive review has to take place in order to ascertain that the items to be in a positive or negative nature.

The response format for the Likert technique is known as the Likert response format. The selection of the format depends on the information that is intended to be gathered. It must be consistent with the items phrasing and instructions asked. Common response formats are used for rating agreement, frequency, importance, quality and likelihood. The continuum (e.g. agree/disagree, approve/disapprove) of responses must depict clear intervals and the options can be assumed to be equal.

The number of options in the response format varies in recent studies. Practicality is valued by some researchers. They consider the ability (e.g. age, cognitive level) of the respondents in answering the questions. The most common scale used, however, is the 5 point scale. On the other hand, other researchers examined the possibility of having more response options than the basic 5 point scale. While McKelvie (1978; cit. by Gable & Wolf, 1993) found that 5 point and 6 point scales were most reliable, Munshi (2014) found out that a 7 point scale has lower measurement error and a higher precision than the 5 point scale. Another consideration is the even scales. As odd scaled formats include a neutral or no response option, this consideration is to eliminate such and force respondents to locate their opinion in the continuum.

Serious problems can be encountered in the latter analysis and interpretation in the event of misuse of the Likert technique. Brown (2011) listed ten myths that misinformed researchers befall into. Carifio and Perla (2007) discussed the top ten myths and urban legends about Likert scales and Likert-type items but provided counter arguments and antidotes. It is important that researchers know how to distinguish between Likert-type items and Likert scales.

Clason and Dormody (1994, cit. by Boone & Boone, 2012) described Likert-type items to be single questions that have features of the original Likert response alternatives, yet there is no attempt to combine responses from several items into a composite scale. These are unique and can stand alone. On the other hand, Likert scales are composed of multiple Likert items which are summed or averaged from the response of several items to measure a particular trait or variable (Dukes, 2005). The decision in using Likert-type items or Likert scale should be clarified in the beginning as it is the basis for the statistical analyses to be employed later on.

The usage of Likert scales can be seen on the works of Tapia (1996), Tapia and Marsh (2000), da Silva (2013), Kalder and Lesik (2011), Pomar, Neto, Silva and Candeias (2011) and Likert type items by Lim-Teo, Ahuja and Lee (1999).

Another important factor to be considered in the initial construction of the instrument is content validity. This stage should not be rushed as it will most likely affect the construct validity and internal consistency of the test upon obtaining the initial data. Content validity focuses on the content of the test (instrument). It deals with the extent of generality for which the sample items are representative of a specific domain. In simple terms, it addresses the question: *Do the items cover enough of the domain to be measured?* To demonstrate content validity, the items selected for the instrument must be aligned with the theoretical construct (i.e. attitude) and the dimensions definitions. It is expected that the developer must have conducted a thorough literature review on the most prominent theoretical and practical papers to guide the item selection (Desselle, 2005).

One approach that can be done is a review by experts of the area concerned. The purpose of the review is to establish the instrument's credibility, accuracy, relevance and breadth of knowledge regarding the theoretical construct for which the instrument is based upon (Burton & Mazerolle, 2011). The instrument developer has to rely on the professional expertise of experts of the affective characteristic under consideration. In the case of the Likert Summated Rating Technique, the statements must clearly illustrate a positive or negative nature. Following the Expectancy-Value Model, the respondents of the instrument must be able to locate themselves in the response continuum.

The next step to be accomplished is the preparation of the draft of the instrument and the gathering of preliminary data. This involves the process of formatting, layout, and development of directions that tells how the respondents should complete the form. This serves as the final review of the instrument which deals with the clarity of the instructions, readability, ease of responding, and grammar issues. Feedback which usually comes from a select number of colleagues and students could help with the refinement of the face validity of the questionnaire. Having such feedbacks could be a valuable contribution to the success of the study.

The completion of this initial phase signals that the final instrument can already be utilized for the final pilot testing. In gathering the final pilot data, the investigator must choose a representative number of respondents. This step requires that the sample is enough for the consequent statistical analyses to be done. Ideally, the number of respondents is around 6 to 10 times the number of items on the instrument. For example, if an instrument has 35 items, the number of respondents must be around 210 to 350 people. The data gathered will confirm the empirical basis of the validity, reliability and scoring scheme of the instrument (Gable & Wolf, 1993). It is also possible to use a fewer number of respondents for the pilot testing. The analysis of the pilot data will reveal later on whether the sample size is sufficient or not. The investigator must also remember that the characteristics of the respondents in the pilot study must be similar to the target population where the instrument will be used (van Teijlingen & Hundley, 2001). According to Gable and Wolf (1993):

> The real issue is not the number of people but the variability and representativeness of the response patterns compared to those of the large population from which you have sampled. If the sample respondents do not produce response patterns similar to those of the population, the factor structure of the pilot data will not be stable across future groups of respondents.

Data gathered after the final pilot testing are subjected to statistical analyses including factor analysis, item analysis and reliability analysis. The purpose of this is to establish a strong confidence on the quality of the affective instrument created, based on the results of the different analysis methods employed. In this phase, the instrument undergoes further validity and reliability analyses in order to find evidences on whether the instrument measures what it said it would measure and the scores produced are consistent. The process of validating an instrument is to ensure that error in the measurement process is reduced (Kimberlin & Winterstein, 2008).

The quality of the instrument of any assessment purpose is ensured by conducting validity and reliability analyses. It is important that the tool used in any assessment has the trust and integrity needed to establish faith and confidence on the results. In measurement, validity refers to the degree to which a test measures what it intends to measure (Raagas, 2010; Oppenheim, 1996). Content and construct validity are the two important types of validity commonly addressed in elementary instrument development.

Construct validity refers to the validation of a test in terms of the concepts it expects to measure. This procedure is involved whenever a test is to be interpreted as a measure of some attribute or construct (Cronbach, Meehl, 1955). The investigator attempts to determine whether responses to the items related to the proposed content categories shows evidence of a construct (concept) (Gable & Wolf, 1993), for which one can be sure of its representation (Henerson, Morris, Fitz-Gibbon, 1987), and serves as evidential basis for score interpretation under the concept in question (Messick, 1990). Administering the instrument to a representative sample of related respondents is executed in order to gather evidence of construct validity. A statistical technique used by elementary researchers to establish construct validity is factor analysis.

It is recommended that an item analysis is executed prior to conducting factor analysis, although these two procedures can be done interchangeably.

Factor analysis examines the correlations at item level, identify the group of items sharing sufficient variation to validate the existence of a factor (construct), and facilitate data reduction. Exploratory factor analysis (EFA) is one of the two major classes (the other Confirmatory factor analysis) of factor analysis. As suggested by the name, it is experimental and subjective in nature, and the researcher has no expectations as to the nature of the variables (Williams, Brown, & Onsman, 2010). The following are the suggested steps by Williams, Onsman and Brown (2010) that neophyte researches can follow in conducting factor analysis.

Step 1. Adequacy of Sample Size

Prior to conducting factor analysis, the researcher must ensure that the sample size is sufficient enough to conduct this test. Several rules of thumb for a sample size sufficient for factor analysis are cited by the authors. The consultation of Gable and Wolf (1993) on the works of Nunnally (1978), Cattell (1978), Everitt (1975), and Arrindell and van der Ende (1985) suggests the use of the N:p ratio (where *N* is the number of observations or cases and *p* is the number of variables or content categories) in determining the sample size to be used in the pilot study so that factor analysis can be executed.

However, the Kaiser-Meyer Olkin (KMO) Measure of Sampling Adequacy (Kaiser & Rice, 1974) advises the researcher of the adequacy of the sample size when cases to variable ratio are less than 1:5 which should supported by the Bartlett's Test of Sphericity. The KMO index ranges from 0 to 1 with <0.50 as an index deemed to be acceptable (Kaiser, 1974). Further classification of the KMO indexes are as follow: 0.90 as marvelous, in the 0.80's as meritorious, in the 0.70's as middling, in the 0.60's as mediocre, in the 0.50's as miserable, and below 0.50 as unacceptable. Additionally, the Bartlett's Test of Sphericity should be significant at a p-value <0.05 (Hair, Black, Babin & Anderson, 2010). These two tests would suggest the suitability of the factor analysis.

Step 2. Factor Extraction Method

The most common method in factor extraction is the Principal Components Analysis (PCA). This is the default method used by many statistical programs (e.g. Statistical Package for Social Science (SPSS)) and hence, the most commonly used in EFA. The central idea of PCA is described by Jolliffe (2002).

> … to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. This is achieved by transforming to a new set of variables,

> the principal components (PCs), which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables.

Abdi and Williams (2010) identified the aims of PCA.

a. To extract the most important information from the data table,
b. To compress the size of the data set by keeping only this important information,
c. To simplify the description of the data set, and
d. To analyze the structure of the observations and the variables

Step 3. Criteria for Factor Extraction

There are two most commonly followed practices in choosing the number of factors to be extracted. The first criterion, called Kaiser's criterion and Scree test.

The Guttman-Kaiser criterion, commonly known as Kaiser's criterion, was developed by Guttman (1954) and popularized by Kaiser (1958, 1960, 1961), is a classical technique of determining the significant number of factors to take based on the components with eigenvalues greater than or equal to 1.0 (Yeomans & Golder, 1982). The main point of this test is to extract factors whose eigenvalue is greater than the average. It serves as indicator for the variance explained by a factor (Wilson & Cooper, 2008).

Initially, the amount of variance contributed by each item to the total variance of the factors accounted for in the solution is 1. The eigenvalues produced in the initial extraction explain the amount of variance covered by the factors in the test. The variance of the factor is obtained by dividing the eigenvalue to the number of items. By adding the eigenvalues greater than 1, we can obtain the total amount of variance accounted for by the factors prior to rotation.

The Scree test (Cattell, 1966) is a procedure of identifying the optimum number of factors that can be extracted prior to the common variance structure being dominated by the amount of unique variance. It is obtained by plotting the eigenvalues (y axis) against the number of factors (x axis) in their order of extraction, resulting to a curve that is used to evaluate the cutoff point. As the curve decreases, the point where it begins to straighten out indicates the maximum number of factors to extract (Hair, Black, Babin & Anderson, 2010; Ledesma & Valero-Mora, 2007). Another useful way of identifying the number of factors to be extracted is the percentage of variance criterion. This approach allows the investigator to derive factors of practical significance by ensuring that they exceed a minimum specified amount of variance. The minimum value to consider varies in the field for which the factor analysis is being used. In particular, a factor solution which accounts for at least 60 percent of the total variance is most commonly applied in the social sciences and is considered satisfactory, although sometimes lesser.

In relation to the content categories during the content validity phase, instrument developers may opt to test these methods in order to determine which yields a more meaningful solution.

Step 4. Rotation Method

Aside from the number of factors, another consideration is the analysis of the items which relates to the factors extracted. The correlation between the original items and the factors, called factor loadings, are the key to understanding the nature of the factor. With the aim of clustering the items to the extracted factors, rotation helps achieve this by maximizing the high item loadings and minimizing low item loadings, thereby producing a more interpretable and simplified solution (Williams, Onsman & Brown, 2010). Two common rotation procedures are orthogonal rotation and oblique rotation.

The orthogonal factor rotation is the simplest case of rotation. The orthogonal varimax rotation, recommended by Gable and Wolf (1993) and also commonly used rotational method, is when the axes (keeping them independent or not related) are kept at 90 degrees while attempting to locate clusters of items nearer to an axis. This approach maximizes the sum of variances of required loadings of the factors leading the factor loadings to tend as close to -1 or +1 (indicating a positive or negative association) or 0 (indicating a lack of association) (Hair, Black, Babin & Anderson, 2010). The oblique rotation allows axes to collapse so that the derived factors are independent, but correlated to some extent. Researchers are to be careful in using this method especially when working with small samples or a low N:p ratio.

Regardless of which rotation method to use, both orthogonal and oblique rotation yield similar results. There have been no specific rules in choosing which rotation technique to be used. The choice of which rotation to use still depends on the researcher and the given research problem.

Following the choice of rotation technique is the careful judgment of the factor loadings yielded by the rotation methods. The rotated solution produced by the rotation methods provides the best representation of the factor by the items for which it has more significance. It is important that the researcher is careful in examining which items has the best fit for the factors based on each factor loadings. Factor loadings which range from $\pm$0.30 (Cohen, Manion & Morrison, 2007) or $\pm$0.40 are deemed to be acceptable for interpretation of structure, but those with values greater than $\pm$0.50 are considered to necessary for practical significance (Hair, Black, Babin & Anderson, 2010). Items which have the highest loadings in the factor solution signify that they are representative of the underlying concept surrounding it. In case of uncertainty or difficulty with the location of the items given that it is significant in one or more factors, called cross-loading, it is best to consider other rotation methods to eliminate it. Looking at the item-to-item correlations and the content categories initially set during the content validity phase may also help. Otherwise, the item becomes a candidate for deletion, unless theoretically justified.

The amount of variance by the factor solution is no longer the same after rotation although the total amount of variance accounted for remains the same. This is because the items which determines or share variability within factors are now distributed. The items are now clustered to the factors for which they share similarity. The variance accounted for by the factors will be reflected in the alpha internal-consistency reliabilities (Gable & Wolf, 1993).

Step 5. Interpretation and Labeling

Following the conceptual and empirical decisions made after the previous steps is the interpretation and labeling of the factors. The researcher has to go back to the items ascribed to the factor and give it a name or a theme. In relation to affective instrument development, the central them of the items must adequately describe the factor. Say for example, if the items all relate to perceive difficulty in problem solving, then it is fair to name the factor as perceive competence in problem solving. It is important that there must be at least 3 items with high factor loadings to have a proper factor interpretation (Gable & Wolf, 1993). Labeling of the factors depend on the theoretical framework followed by the research, which makes it a subjective and intuitive process. Thus, the factor analysis is completed.

Attitude measurement using a Likert scale should meet the requirements of unidimensionality, that is, all items must be strongly associated together and represent one single concept. As such, factor analysis is a helpful tool to facilitate the determining of the dimensionality of a test (Hair, Black, Babin & Anderson, 2010; Oppenheim, 1996; Cohen, Manion & Morrison, 2007).

In measurement, and in instrument development, the reliability of the tool is an important criterion to look into. Note that a test must be valid and reliable. Reliability is the degree of consistency that a test or measurement tool in assessing a particular variable. In simple terms, any kind of measurement tool should be able to gather same data on multiple administrations. For attitude or the affective domain instruments, responses should not be too varied across time periods so that a measurement taken at any point in time is reliable. In other words, reliability addresses the question, “Is the instrument accurate enough to be used in assessing affective characteristics?”

The factor analysis technique also produces other indicators which help determine the validity and reliability of the test. As a data reduction technique, it also helps the item analysis of the instrument (i.e. choosing the items which relate most to the construct being tested). Correlations are also computed to see how items are related and useful in measuring the construct intended to be measured, and to see whether they relate to each other. Say for example, if the construct considered is attitude towards math, it should include in items such as, “I dislike math”, or “I’m not interested in taking math.” These statements clearly illustrate or intuitively related to the construct but its usefulness and relevance still have to be verified.

To demonstrate the reliability of the test, the internal consistency and the correlations of the items should be tested. Especially for attitude measurement using the Likert scale, the items in the summated scale should be consistent. The main point of internal consistency is to show that individual items or indicators of the scale should all measure the same construct, having high correlations with each other. Part of the results of factor analysis is the inter-item and item-to-scale correlations. Having those correlation values allow the researcher to decide which items to retain or discard. It is suggested that the item-to-scale correlations should be above 0.50 and inter item correlations be above 0.30 (Hair, Black, Babin & Anderson, 2010).

Internal consistency is determined by the use of a reliability coefficient called Cronbach's alpha. Cronbach's alpha is a function of the average intercorrelations of the items and the number of items in the scale (Kimberlin & Winterstein, 2008). Another method to examine internal consistency is the split-half technique. This procedure randomly splits the scale on the instrument into two equivalent set of items which represent the two samples from the content domain (Gable & Wolf, 1993).

Cohen, Manion and Morrison (2007) presented a range of values for the split-half and alpha coefficients from which the researcher could interpret internal consistency and judge the reliability of the instrument (i.e. <0.90 is very highly reliable, 0.80-0.90 is highly reliable, 0.70-0.79 is reliable, 0.60-0.69 is marginally or minimally reliable, and <0.60 is unacceptably low reliability). According to Hair, Black, Babin and Anderson (2010), the alpha coefficient must exceed the value of 0.70, although a lower value of 0.60 may be accepted in exploratory research. Added to this is the condition that once the number of items exceeds 10, a higher alpha coefficient must be used.

After conducting the relevant validity, item, and reliability analyses, the final instrument may now be produced. In the event that substantial amount of changes is done, Gable and Wolf (1993) suggested that it may be best to conduct a final pilot study, adding more data and repeat the process of conceptualization down to the statistical analyses. Time and resources have been invested much in the initial development alone that an unaccomplished instrument with hasty decisions could not be afforded. However, if only admissible errors and the entire process were satisfactorily achieved, the final pilot study may be avoided.

Chapter III
Research Methodology

Introduction

The purpose of this study was to determine the attitude of freshmen students towards mathematics at the University of Évora. The associations of other individual characteristics, potentially related to attitude, were also investigated. The variables considered were age, gender, average study time, previous math rating, grade upon entrance to university, and course program of choice. This chapter discusses the methods used to complete the research: study design, participants of the study, data collection methods and the statistical techniques used to analyze the data.

Research Design and Participants

The study has taken a descriptive research, cross-sectional design, using survey methodology. It mainly focused on the description and analysis of the attitude towards math of newly admitted freshmen students of the University of Évora. The process included the development of a valid and reliable questionnaire, gathering, analyzing, classifying, and tabulating data and making sufficient and accurate interpretations. The impact of underlying dimensions on the attitude of students towards math was also accounted for.

The study made use of purposive sampling due to unavoidable constraints (Cohen, Manion, & Morrison, 2007). It has taken into consideration the time limit for completion of the investigation, the existing bureaucracies in the university, cooperation of the professors to participate in the administration of the instrument (de Moor & Henderikx, 2013) and the erratic class attendance of the students.

Specific characteristics were determined in choosing the respondents. The students must be newly admitted freshmen students taking a 2013/2015 edition course program and at the same time registered in a math class during the fall semester of 2013. The sample was taken from students attending a math class within the period of November 18 to December 20 of 2013. This was to allow students to consolidate their attitude based on their experience from their high school and first encounter of mathematics in the university, since classes at the University have begun in mid-September of the academic year 2013/14. A total of 278 undergraduate freshmen students participated in the study.

The University of Évora is composed of four major schools namely, School of Arts, School of Science and Technology, School of Social Sciences, and St. John of God School of Nursing. Within the sample of 278 students, 7 were enrolled in the St. John of God School of Nursing, 140 in the School of Science and Technology and 131 in the School of Social Sciences. There were no participants from the School of Arts since none has met the criteria. For data analyses purposes, the 7 Nursing School students will be grouped with those from the Science and Technology School.

Data Gathering Procedure

Math professors were contacted to participate in the study, in order to administer the questionnaire to their students for about 10 minutes after their lesson proper in their respective class. The syllabus for the first semester of school year 2013/2104 of the different course programs were examined to determine which ones has a math class. Instructors in these classes were contacted and sought collaboration in order to gather data. Only one, out of all professors that were contacted, declined participation. The study was conducted for which the administration of the survey depended on the most convenient time within the class schedule of the professors and the students. Confidentiality of the students' responses was guaranteed. Math classes may include students who are repeaters or those who took the subject at a later time, yet only those who are 2013 entrants were considered. It was then followed by the formulation of an instrument which was refined further through a preliminary survey. The refined instrument was then used for the final survey conducted to the freshmen students.

Pilot Study

It was discussed that time for administration will be limited since students may be unenthusiastic in answering a long survey. Thus, a pilot study had to be conducted in order to refine the questionnaire. To ensure that responses will not be far from the intended population, a Mathematics professor, teaching a group of second year students from the Social Sciences School, was contacted to collaborate in the pilot study. The questionnaire was administered to 45 second year students taking a mathematics class during the first semester of the school year 2013/2014, specifically on October 15, 2013.

Data from the pilot study were analyzed employing techniques of factor analysis, item and reliability analysis (Gable & Wolf, 1993; Raagas, 2010). The questionnaire underwent a revision process to obtain an instrument to be used for the final survey.

The final instrument (see Appendix C) included 27 questions divided into two parts. Part 1: Perfil individual consisted of Questions 1 to 7, questions were demographic, providing a basic description of the respondents: age, gender, number of hours spent in studying mathematics per week, final mathematics rating obtained prior to entering the university, general average upon entering the university, year of entry to the university and program enrolled in.

Part 2: Atitudes relativamente à matemática consisted of items 8 to 27 (numbered 1 to 20) which asked for students' attitude towards math. For each item, the students had to rate their agreement with the statements along a 6-point Likert scale, indicating (A) concordo totalmente, (B) concord medianamente, (C) concordo ligeiramente, (D) discordo ligeiramente, (E) discordo medianamente and (F) discordo totalmente. The neutral or no opinion options were not included so that students will be obliged to make a choice.

Research Instrument

Development Procedure

An instrument was developed to measure students' attitudes toward mathematics in this study. It involved the investigation of the psychometric properties of the instrument and the identification of the underlying dimensions of students' attitudes toward mathematics.

The initial questionnaire was formulated, consisting of 2 demographic (age, sex), pre-university performance in math, choice of course program at the university, and 40 possible items to measure attitude, based on various attitude questionnaires in the Portuguese and English languages. The items were constructed using a 6-point Likert scale where students rate their agreement by indicating (A) concordo totalmente, (B) concord medianamente, (C) concordo ligeiramente, (D) discordo ligeiramente, (E) discordo medianamente and (F) discordo totalmente. The neutral or no response options were not included to preclude possible measurement of some meaningful opinions. Twenty of the items were negatively stated.

Language was a factor in the development of the questionnaire. The statements lifted from the various sources were translated into Portuguese and was adjusted to make the content applicable to university student. It was presented to some students to critique the readability and clarity of the questions. Changes were made after some the review.

Attitude towards mathematics was the theoretical construct considered in the development of this instrument. The variables considered to have an impact on the attitude towards mathematics were autoconfiança (self-confidence), motivação (motivation), interesse (interest), ansiedade/desconforto (anxiety) (Tapia, 1996; Liu & Lin, 2010; Kalder & Lesiki, 2011; Sundre, Barry, Gynnild, & Ostgard, 2012; Wong & Chen, 2012; Condeças, 2012; Da Silva, 2013).

Data Analysis

After the pilot study, the Cronbach Alpha coefficient was calculated to determine the internal consistency of the items. This was to identify whether the items measure the characteristic attitude. It was followed by the calculation of the item-total correlation to facilitate the item reduction process with the aim of obtaining only half of the initial number of items.

The final instrument was analyzed further in order to determine the factors that have an impact to attitude. Data was subjected to exploratory factor analysis using principal components method of varimax and oblique rotation (Gable & Wolf, 1993). Item-to-item correlations were calculated to identify the exact locations of unclear items. Reliability of the factors was also established by computing the Cronbach Alpha coefficient, Split-Half reliability and Spearman-Brown reliability.

The final survey responses to demographic questions were described using simple descriptive statistics. It includes frequency distributions and percentages for categorical data (e.g. gender) and measures of central tendency and standard deviation for continuous variables (e.g. number of hours spent in studying math per week).

Descriptive statistics were also used to characterize the attitude of students towards math. General attitude scores and subscales were compared in each of the independent variables. Possible correlations were also identified between their attitude, average study time, previous math rating, and grade upon entrance to university. Missing responses on the final survey were imputed based on the default command of SPSS. All data analyses were processed using the IBM SPSS Statistics v.20 package.

Chapter IV
Presentation and Interpretation of Data

Introduction

As stated in Chapter I, the primary purpose of this study was to probe for the attitude of students towards mathematics at the University of Évora, Portugal. This chapter is organized based on the accomplishment of the three objectives initially set. It reports the results of the pilot testing leading to the development of an instrument that will measure students' attitude towards math, the profile of the students in terms of age, gender, number of hours spent in studying mathematics per week, final mathematics rating obtained prior to entering the university, general average upon entering the university, year of entry to the university and program enrolled in, and finally the characterization of students' attitude towards math.

A total of 278 questionnaires were administered to newly admitted freshmen students taking a 2013/2015 edition course program and at the same time registered in a math class of the fall semester. These students were the ones who attended classes within the November 18 to December 20 timeframe.

4.1 Instrument Development

4.1.1 Information Gathering and Item Formulation

There has been no existing reference of a study in the University of Évora, conducted any researcher or by the Department of Mathematics, in relation to the attitude of its students toward mathematics. This also accounts that there is no instrument available that can be used to measure the attitude of students towards math. Thus, the lack of tool allowed the investigation and evaluation of the issue and further stressed the need to develop a questionnaire that addresses it.

Correspondingly, it was necessary to develop a questionnaire to achieve the objective of this study which is to assess the attitude of university freshmen students towards math. With the development of the instrument, teachers with or without a pedagogy background may complement their teaching with the knowledge and understanding of the attitude of student on the discipline and are able to plan mediations to develop a more positive attitude among the students.

The development of the instrument underwent several phases. Primarily, a comprehensive literature survey on attitude towards math was performed in order to formulate the items to include in the questionnaire. The items were contextualized based on the intended respondents of the study – University Freshmen Students. In addition, the literature review revealed underlying dimensions, which were initially considered; namely confiança e desconforto (confidence and anxiety), valor percebido (perceived value), prazer (enjoyment) and motivação (motivation) that explain attitude towards math.

In each of the dimensions, 10 items were formulated for which 5 were positively worded and the rest were in negative form, with the exception of confidence and anxiety. Based on the findings of Tapia and Marsh (2004), item for confidence and anxiety were combined forming one single factor. A total of 40 items (20 positive and 20 negative) were included in the preliminary questionnaire to be used in the pilot study (See Table 4-1).

Several important aspects were taken into consideration during the construction process of the instrument. Since the items were taken from various sources originally in the English language a translation was done in accordance to the common language used in the university. With the help of some native Portuguese speakers, the readability, understandability and appropriateness of the item construction were ensured. The preliminary version of the questionnaire revealed to have flaws on the clarity and relevance of the items. Changes were made and are reflected on the final instrument to be used for the pilot study (see Table 4-2) Item arrangement is considered to be an important factor in designing a questionnaire (Almeida & Freire, 2008; cit. by da Silva, 2013). It is important that the sequencing of the questions does not permit an order bias so as to avoid prior questions to influence subsequent questions (Raagas, 2010).

Following the popular attitude instruments of Fennema and Sherman (1976) and Tapia and Marsh (1996, 2000 & 2004), the Likert Scale was used as a means of determining the extent of the agreement or disagreement on each of the items. For the purpose of study, a 6-point Likert scale was chosen represented by 1 (Strongly Disagree) to 6 (Strongly Agree). It is expected that the student who shows desirable attitudes to a certain idea, expressing agreement on the items representing it, has a more positive attitude towards it. On the contrary, the student who shows a more negative attitude expresses agreement on the items that expresses negative or unfavorable trait to the idea. The 6-point Likert scale prevents central or neutral response tendencies.

Table 4-1 Dimensions of the Attitude Instrument and Its Respective Items

Dimensions	Item No. and Stem
Confiança e Desconforto	1 Eu sou capaz de resolver problemas de matemática, sem muita dificuldade. 2 Ter que aprender temas difíceis em matemática não me preocupa. 3 Eu sou bom em resolver problemas de matemática. 4 Eu entendo o que é explicado em aulas de matemática. 5 Eu sou bom em usar a matemática para resolver problemas da vida real. <u>6</u> Isso me deixa nervoso para sequer pensar em ter que fazer um problema de matemática. <u>7</u> Não importa o quanto eu estudo, a matemática é sempre difícil para mim. <u>8</u> Eu desisto facilmente quando os problemas de matemática são difíceis. <u>9</u> Estou sempre sob uma pressão terrível em uma aula de matemática. <u>10</u> Eu fico completamente em branco e não se lembra de nada quando estou prestes a fazer um problema de matemática.
Valor Percebido	11 Acredito que estudam matemática me ajuda com a resolução de problemas em outras áreas. 12 Eu sou capaz de entender a ligação da matemática na vida cotidiana (por exemplo, relatórios e anúncios sobre preços, venda, porcentagens, etc). 13 A matemática ajuda a desenvolver a mente e ensina uma pessoa a pensar. 14 A sólida formação matemática poderia me ajudar na minha vida professional. 15 Cursos de matemática do ensino médio seria muito útil, não importa o que eu decidir estudar na faculdade. <u>16</u> Tomei matemática apenas para preencher minha agenda. <u>17</u> Estudar matemática é um completo desperdício de tempo. <u>18</u> Eu não entendo a utilidade de matemática. <u>19</u> Eu não vejo nenhuma conexão entre matemática e meu dia-a-dia. <u>20</u> Eu acho que a matemática é útil apenas para testes.

Table 4-1 (cont.)

Dimensions	Item No. and Stem
Prazer	21 Eu costumo ter gostei de estudar matemática na escolar. 22 Eu gosto de ir para além do trabalho atribuído e tentando resolver novos problemas em matemática. 23 Estou disposto a tomar mais do que a quantidade necessária de matemática. 24 Eu recebo uma grande satisfação de resolver problemas de matemática. 25 Eu sou mais feliz nas aulas de matemática do que qualquer outra classe. 26 Eu não gosto de resolver problemas de matemática. 27 Eu preferiria escrever um ensaio do que para fazer um trabalho em matemática. 28 Acho matemática maçante e chato, porque não deixa espaço para a opinião pessoal. 29 Não há nada de criativo sobre a matemática, é só memorizar fórmulas e coisas. 30 Eu nunca gostei de matemática, e é o meu assunto mais temido.
Motivação	31 Eu quero desenvolver minhas habilidades matemáticas. 32 Se alguma coisa sobre matemática me intriga, eu me pego pensando sobre isso depois. 33 Estou à vontade para expressar minhas próprias idéias sobre como buscar soluções para um problema difícil em matemática. 34 Eu gostaria de ter mais projetos e trabalhos de casa que vão me ajudar a aprender mais. *35* Eu gostaria de ter alguns materiais difíceis que me fazem aprender mais. *36* Ter que gastar um monte de tempo em um problema de matemática me frustra. *37* Eu não entendo muito entusiasmo para a matemática. *38* O desafio de matemática não me agrada. *39* Nos dias que eu tenho de matemática, eu não tenho vontade de ir para a escolar. *40* Eu não tenho nenhuma intenção de tomar outras disciplinas de matemática do que o prescrito.

Underlined Items were negatively stated

Hence, the values from 1 to 6 were assigned to positively worded items and 6 to 1 for negatively worded items. An interpretation scale was formulated so that high value summated scores mean positive attitude toward math.

The final instrument used for the pilot study then included 6 additional questions for the student's profile. It included questions on gender, age, number of hours per week dedicated to studying math outside class, the rating obtained from their final math class prior to the university, general weighted average in high school and their course program (see Appendix B).

Table 4-2 Changes on the Items of the Attitude Instrument

Preliminary Version	**Final Version for Pilot Study**
Item No. and Stem	**Item No. and Stem**
Confiança e Desconforto	
1 Eu sou capaz de resolver problemas de matemática, sem muita dificuldade.	8 Eu sou capaz de resolver problemas de matemática, sem dificuldade.
4 Eu entendo o que é explicado em aulas de matemática.	5 Eu entendo o que é explicado nas aulas de matemática.
5 Eu sou bom em usar a matemática para resolver problemas da vida real.	15 Eu sou bom a usar matemática para resolver problemas da vida real.
6 Isso me deixa nervoso para sequer pensar em ter que fazer um problema de matemática.	9 Fico nervoso quando penso em fazer um problema de matemática.
7 Não importa o quanto eu estudo, a matemática é sempre difícil para mim.	26 Não importa o quanto estude, a matemática é sempre difícil para mim.
9 Estou sempre sob uma pressão terrível em uma aula de matemática.	31 Estou sempre sobre uma pressão terrível nas aulas de matemática.
10 Eu fico completamente em branco e não se lembra de nada quando estou prestes a fazer um problema de matemática.	24 Eu fico completamente em branco e não me lembro de nada quando estou prestes a fazer um problema de matemática.
Valor Percebido	
11 Acredito que estudam matemática me ajuda com a resolução de problemas em outras áreas.	7 Acredito que estudar matemática me ajuda com a resolução de problemas noutras áreas.
12 Eu sou capaz de entender a ligação da matemática na vida cotidiana (por exemplo, relatórios e anúncios sobre preços, venda, porcentagens, etc).	6 Eu sou capaz de entender a ligação da matemática com vida cotidiana (por exemplo, relatórios e anúncios sobre preços, venda, percentagens, etc).
14 A sólida formação matemática poderia me ajudar na minha vida professional.	3 Uma sólida formação matemática poderia ajudar-me na minha vida profissional.
15 Cursos de matemática do ensino médio seria muito útil, não importa o que eu decidir estudar na faculdade.	29 A disciplina da matemática é muito útil, independentemente do que eu venha estudar no ensino superior.
16 Tomei matemática apenas para preencher minha agenda.	14 Inscrevi-me numa disciplina de matemática apenas por passatempo.
21 Eu costumo ter gostei de estudar matemática na escolar.	36 Eu costumo gostar da disciplina de matemática na escola.

Table 4-2 (cont.)

Preliminary Version	Final Version for Pilot Study
Item No. and Stem	**Item No. and Stem**
Prazer	
22 Eu gosto de ir para além do trabalho atribuído e tentando resolver novos problemas em matemática.	11 Eu gosto de ir para além do trabalho atribuído, tentando resolver novos problemas de matemática.
23 Estou disposto a tomar mais do que a quantidade necessária de matemática.	12 Estou disposto a aprender mais matemática do que o necessário.
24 Eu recebo uma grande satisfação de resolver problemas de matemática.	22 Eu fico muito satisfeito quando resolvo problemas de matemática.
25 Eu sou mais feliz nas aulas de matemática do que qualquer outra classe.	33 Eu gosto mais das aulas de matemática do que quaisquer outras aulas.
27 Eu preferiria escrever um ensaio do que para fazer um trabalho em matemática.	<u>13</u> Eu preferiria fazer uma composição a fazer um trabalho de matemática.
28 Acho matemática maçante e chato, porque não deixa espaço para a opinião pessoal.	<u>35</u> Acho matemática aborrecida porque não deixa espaço para a opinião pessoal.
Motivação	
32 Se alguma coisa sobre matemática me intriga, eu me pego pensando sobre isso depois.	34 Se não consigo resolver um problema de matemática, continuo a pensar nisso até o conseguir resolver.
33 Estou à vontade para expressar minhas próprias idéias sobre como buscar soluções para um problema difícil em matemática.	17 Estou à vontade para expressar as minhas próprias ideias sobre como procurar resoluções para um problema difícil de matemática.
34 Eu gostaria de ter mais projetos e trabalhos de casa que vão me ajudar a aprender mais.	16 Eu gostaria de ter mais projetos e trabalhos de casa que me ajudassem a aprender mais.
35 Eu gostaria de ter alguns materiais difíceis que me fazem aprender mais.	20 Eu gostaria de ter desafios que me fizessem aprender mais.
36 Ter que gastar um monte de tempo em um problema de matemática me frustra.	<u>19</u> Gastar muito tempo na resolução de um problema de matemática frustra-me.
37 Eu não entendo muito entusiasmo para a matemática.	<u>23</u> Não fico muito entusiasmado com matemática.
38 O desafio de matemática não me agrada.	<u>30</u> Os desafios da matemática não me agradam.
39 Nos dias que eu tenho de matemática, eu não tenho vontade de ir para a escolar.	<u>28</u> Nos dias que tenho matemática, não tenho vontade de ir à escola.
40 Eu não tenho nenhuma intenção de tomar outras disciplinas de matemática do que o prescrito.	<u>37</u> Eu não tenciono inscrever-me noutras disciplinas de matemática que não sejam obrigatórias.

Underlined items are negative stated

4.1.2 Item and Factor Analyses

The pilot study was conducted on October 15, 2013 and participated by 45 second year students. The administration of the questionnaire was held at the last 10 minutes of their class time. The students were informed of the confidentiality and anonymity of their responses.

Data was processed using the IBM SPSS Statistics v.20. The analysis of the final instrument used for the pilot study followed the process employed by Tapia and Marsh (2000) and suggested by Gable and Wolf (1993). This involved the analysis of the construction of the questionnaire, pilot study, appropriateness to the target population (university freshmen students), quality of the instrument (reliability and correlation analysis), and item and factor analyses. The purpose of the analysis was to ascertain the quality of the instrument. It is important that the instrument be reliable and valid so that may be used by future researchers who intend to study the subject.

To facilitate data analysis, responses to positive items were scored 6 for concordo totalmente, 5 for concordo medianamente, 4 for concordo ligeiramente, 3 for discordo ligeiramente, 2 for discordo medianamente and 1 for discordo totalmente. All negative items were reversely scored (i.e. 6→1, 5→2, 4→3, 3→4, 2→5, 1→6) prior to the analysis so that high scores would reflect positive attitudes.

The Cronbach Alpha coefficient was calculated to estimate the consistency of the scores or the reliability of the instrument. It reported an alpha of 0.94 on the 40 items, indicating a high degree of internal consistency for group analyses. The mean and standard deviation of the total score were 187.29 and 29.938. Of the 40 items, 28 had item-to-total correlation above 0.46, with the highest being 0.82, suggesting significant contribution to the total scale.

Although an alpha of 0.94 indicates a high degree of internal consistency, an item deletion process was performed to further limit the number of items in the IAFM to 20. Items that were less effective were discarded (Henerson, Morris, Fitz-Gibbon, 1991). A total of 12 items with correlations below 0.46 were discarded and excluded for the IAFM (see

Appendix A).

Among the 28 items with item-to-total correlation above 0.46, 20 of those items were retained. The alpha value increased to 0.95 after deleting half of the items. The split-half reliability was 0.94 and the Spearman-Brown reliability was 0.95. The revised instrument had a mean of 91.96 and a standard deviation of 21.57 All 20 items had an item-to-total correlation above 0.53, with the highest being 0.86. This suggested a significant contribution of all the items in the questionnaire, also suggesting homogeneity of the items (see Table 4-3).

Table 4-3 Correlation Analysis of the Item to Scale of the Pilot Study Data

Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
2	.825	.951
4	.702	.953
5	.722	.953
10	.682	.953
12	.532	.955
13	.638	.954
17	.721	.953
23	.818	.951
24	.757	.952
25	.718	.953
26	.781	.952
28	.711	.953
30	.729	.952
31	.662	.953
33	.787	.952
34	.565	.955
35	.741	.952
36	.737	.952
37	.535	.956
40	.861	.951

The questionnaire was subjected to an exploratory factor analysis using principal components method of extraction and varimax and oblique rotations to analyze the dimensionality of the scale, considering only the remaining 20 items considered for the IAFM. The appropriateness of this procedure was concurred by the results of the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (0.855) and Bartlett’s Test of Sphericity ($p<0.001$), given that there were only n = 45 respondents in the pilot study.

The KMO value is considered to be meritorious since the value is greater than 0.80 (Hair, Black, Babin & Anderson, 1998).

The Kaiser criterion, retaining of factors with eigenvalues greater than 1, and Cattell's scree test were used to determine the number of factors to be extracted (Gorsuch, 1974, cit. by Tapia & Marsh, 2000; Gable & Wolf, 1993). Both tests suggested a 4-factor solution and has accounted for 75.71% of the total variance (see Table 4-4).

Table 4-4 Total Variance Explained

Components	**Initial Eigenvalues**		
	Total	% of Variance	Cumulative %
1	11.203	56.016	56.016
2	1.500	7.500	63.516
3	1.389	6.943	70.459
4	1.052	5.260	75.719

The 4-factor model suggested a structure to measure students' attitude towards math. Items that load 0.40 or greater in each of the factors were identified as they are the ones that best describe the factor. Items that were deemed ambiguous in their location were subjected to further analysis. The items were assigned based on the items with the highest loadings in each factor with which they have highly significant correlations. One of the factors was collapsed since it contains only two items, forming a 3-factor model. After the factor analysis, a careful evaluation of the stems was performed in order to properly judge the items to its related factor (Gable & Wolf 1993). The highest factor loadings of each item based on the rotation results and the item-item correlation decisions for the ambiguous items are shown on Tale 4-5.

During the construction process, content validity was established by relating the items to the categories under consideration; confiança e desconforto (confidence and anxiety), valor percebida (perceived value), prazer (enjoyment) and motivação (motivation). Each of the factors was characterized based on the content of each item and the structure that was initially set. Evidence of construct validity can be seen between the initial categories and the derived factors yet it was necessary to rename the new factors as the items have been mixed.

Table 4-5 Three-Factor Model of the IATM

Items	Factors		
	I	II	III
40	**.745**		
36	**.858**		
12	.844**		
37	.592**		
35	.659*		
33	.552*		
28	.709*		
24	.583*		
23	.567*		
5	.626*		
13		**.790**	
31		**.808**	
30		.632*	
26		.613*	
02		.743*	
10			**.774**
34			**.815**
25			.455*
17			.448*
4			.774*

* Grouped according to Item-Item Correlation
** Merged Items

Further reliability analysis was also performed to estimate internal consistency and reliability of scores on the subscales. The following are the identification and brief interpretation of the factors:

A. Factor I – Motivação e Interesse

Table 4-6 shows the items included in this factor, which described the intrinsic drive of a student to learn math and the interest in pursuing additional experiences. Factor I contains 10 items with a mean of 45.422 (SD = 11.378) and a Cronbach α of 0.925. Split-half reliability and Spearman-Brown reliability coefficients were 0.912 and 0.919, respectively. Items in this factor came from among those generated for motivação e prazer.

Table 4-6 Factor and Correlation Analyses Results of Factor I – Motivação e Interesse

Item Number	Stem	h^2	Item-Factor
<u>40</u>	Eu não gosto de resolver problemas de matemática	.886	.891**
36	Eu costumo gostar da disciplina de matemática na escola.	.886	.880**
<u>35</u>	Acho a matemática aborrecida porque não deixa espaço para a opinião pessoal.	.789	.853**
33	De todas as aulas, as que mais gosto são as de matemática	.690	.816**
<u>28</u>	Nos dias que tenho matemática, não tenho vontade de ir à universidade.	.744	.809**
<u>24</u>	Eu fico completamente em branco e não me lembro de nada quando estou prestes a resolver um problema de matemática	.715	.766**
<u>23</u>	Não fico muito entusiasmado com matemática	.799	.849**
5	Eu entendo o que é explicado nas aulas de matemática.	.831	.745**
12	Estou disposto a aprender mais matemática do que o necessário	.787	.634**
<u>37</u>	Eu não tenciono inscrever-me noutras disciplinas de matemática que não sejam obrigatórias	.534	.644**

Underlined items are negative stated. ** Significant at p< 0.01

B. Factor II – Desconforto

Table 4-7 show the items included in this factor, which described how students feel stress, avoidance and uneasiness in mathematics. Factor II contains 5 items with a mean of 24.422 (SD = 6.503) and Cronbach α of 0.902. Split-half reliability and Spearman-Brown reliability coefficients were 0.808 and 0.846, respectively. Items in this factor came from among those generated for confiança e desconforto.

Table 4-7 Factor and Correlation Analyses Results of Factor II – Desconforto

Item Number	Stem	h^2	Item-Factor
<u>13</u>	Eu preferiria fazer uma composição a fazer um trabalho de matemática	.722	.828**
<u>31</u>	Estou sempre sobre uma pressão terrível nas aulas de matemática.	.749	.864**
<u>30</u>	Os desafios da matemática não me agradam.	.737	.815**
<u>26</u>	Não importa o quanto estude, a matemática é sempre difícil para mim.	.757	. .842 **
<u>2</u>	Eu nunca gostei de matemática e é o meu assunto mais temido.	.891	.903**

Underlined items are negative stated. ** Significant at p< 0.01

C. Factor III - Competência Percebida

Table 4-8 shows the items included in this factor, which described students' self-concept of their ability to do the mathematics. Factor III contains 5 items with a mean of 22.11 (SD = 5.73) and a Cronbach α of 0.880. Split-half reliability and Spearman-Brown reliability coefficients were 0.811 and 0.838, respectively. Items in this factor came from the categories confiança, interesse e motivação of the original list.

Table 4-8 Factor and Correlation Analyses Results of Factor III – Competência Percebida

Item Number	Stem	h^2	Item-Factor
<u>10</u>	Eu desisto facilmente quando os problemas de matemática são difíceis	.748	.833**
34	Se não consigo resolver um problema de matemática, continuo a pensar nele até o conseguir resolver	.726	.796**
<u>25</u>	Não há nada de criativo sobre a matemática, é só memorizar fórmulas e coisas	.654	.802**
17	Estou à vontade para expressar as minhas ideias sobre como procurar soluções para um problema difícil de matemática	.786	.851**
4	Eu sou bom a resolver problemas de matemática.	.713	.842**

Underlined items are negative stated. ** Significant at p< 0.01

Students scored highly on these factors would be perceived as having high confidence in being successful in math tasks and activities, deep interest and high enthusiasm in learning more math, and feeling less stress or difficulty in mathematics, resulting to a positive attitude towards the subject. Reliability scores in each of the subscales and the overall attitude scale revealed a good internal consistency, signifying homogeneity of the items. The final instrument used in the final study can be seen in Appendix C.

4.2 Profile of the Respondents

There were n=278 freshmen students who completed the survey questionnaire. The first part of the questionnaire collected information about their age, gender, number of hours spent in studying mathematics per week, final mathematics rating obtained prior to entering the university, general average upon entering the university, year of entry to the university and program enrolled in.

Question 1 asked students to indicate their gender. Among the respondents, there were 155 (55.8%) females and 123 (44.2%) were males. Table 4-9 shows the distribution of respondents by gender.

Table 4-9. Respondents by Gender

Gender	Count	Percentage
Female	155	55.8
Male	123	44.2
Total	278	100.0

The second question asked students to provide their age. Responses were then grouped into 2 age categories for ease of analysis and interpretation (see Table 4-10). A total of 218 (78.42%) fell into the first age category (ages 17-19), and 56 (20.14%) students were in the final category (ages 20 and above). There were 4 students who chose not to disclose their age.

Majority of the students who participated were 18 years old. The age of the students ranged from 17 to 41 years. According to the 2011 OECD report, the age range of the new entrants into the tertiary education may be of certain reason that include differences in the typical graduation ages from upper secondary education, young people grabbing opportunities to enter the labor market prior to tertiary education and intake capacity of institutions (see the scope and delimitation of the study for other reasons).

Table 4-10. Respondents by Age

Age Group	Count	Percentage	Statistics	
17 – 19	218	78.42	Mean	18.91
20 +	56	20.14	Median	18
Missing Responses	4	1.4	Mode	18
			SD	2.16
			Range	24
			Minimum	17
Total	278	100.0	Maximum	41

The third question asked an estimate of the students' amount of time spent in studying math outside class time. This included doing homework and other mathematical activities during the term. The time spent for studying was measured in hours per week and categorized into four groups. In relation to the use of ECTS in Portugal, students taking a math class typically have 6 ECTS credits which is approximately 156 hours student workload (1 ECTS = 26 hours). The number of hours expected of students to dedicate in studying math outside class is calculated based on the difference of the hours spent for introduction of module, learning activities, learning assessment and other educational activities, from the expected student workload.

Table 4-11 shows the distribution where a total of 133 (47.8%) of the students spent less than 3 hours per week (low), 75 (27.0%) of the students spent between 3 to 5 hours (average), 58 (20.9%) of the students spent between 5 to 10 hours (high), and 5 (1.8%) of them went to an extreme of more than 10 hours. Apparently, 7 students did not want to reveal how much time they spend in studying math outside class.

Typically, the students spend 3.29 hours (SD = 3.47) in studying math besides that which is done in the university, with most of them spending 2 hours. It also revealed that there were those who do not spend time studying math outside the regular mathematics instruction. A response of 48 hours is particularly doubtful as the respondent may have included the actual contact hours.

Table 4-11 Respondents by Time Spent in Studying Math Outside Class

Study Time	**Count**	**Percentage**	**Statistics**	
Low	133	47.8	Mean	3.39
Average	75	27.0	Median	3.0
High	58	20.9	Mode	2.0
Extreme	5	1.8	SD	3.47
Missing Responses	7	2.5	Range	48.0
			Minimum	0
Total	278	100	Maximum	48.0

The fourth and fifth questions asked for the grade obtained by the students from their final math class prior to university and the general average of their grades as they entered the university, respectively. The grades of the students were classified based on the Capitulo III, Secçao I, Artigo 16-17° of the Decreto Lei no. 42/2005 de 22 de Fevereiro. To better understand the background of the students at the time of the study and their attitude towards math, it was necessary to determine how they fair in their final math class.

There were 268 respondents who indicated the grade they obtained in their final math class prior to university while 10 (3.6%) others did not provide the information (see Table 4-12). The average math grade of the student is 12.67 (SD = 2.83) for which half of the respondents did not exceed the Suficiente classification ($\tilde{x}$= 13.0) and most of them obtained a final grade of 12. The grades of the students ranged from 2 to 20.

Based on the grade classifications, 6 (2.2%) students obtained a final grade from 18 to 20, 32 (11.5%) had a grade from 16 to 17, 67 (24.1%) had a grade from 14 to 15, and 152 (54.7%) had a grade from 10 to 13. There were also those who did not do well in their final math class as 11 (4.0%) of them got a final math grade below 10.

Table 4-12 Respondents by Final Math Grade

Classification	Count	Percentage	Statistics	
Excelente	6	2.2	Mean	12.67
Muito Bom	32	11.1	Median	13.0
Bom	67	24.1	Mode	12.0
Suficiente	152	54.7	SD	2.83
Insuficiente	11	4.0	Range	18.0
Missing Responses	10	3.6	Minimum	2.0
Total	278	100	Maximum	20.0

Table 4-13 shows the general average obtained by the students during their final year in high school. The final rating of the students varied from 11 to 19.30 with an average of 13.55 (SD = 1.26). Half of the general average scores did not exceed the sufficient classification ($\tilde{x}$ = 13.0) and most of them gained a 13.

Their general average used to enter in the university were also classified based on Decreto Lei no. 42/2005 de 22 de Fevereiro for ease of analysis and interpretation. Amongst them, only one student (0.4%) fell into the Excelente classification. A frequency of 12 (4.3%) students were classified in Muito Bom, 79 (28.4%) were classified in Bom, a majority of 172 (61.9%) students were classified in Suficiente and 14 (5.0%) of the students did not indicate their general average. As there is a sole student with an Excelente classification, it will be remained as it is while all else will be considered for further interpretation.

Table 4-13 Respondents by General Average

Classification	Count	Percentage	Statistics	
Excelente	1	0.4	Mean	13.55
Muito Bom	12	4.7	Median	13.50
Bom	79	28.4	Mode	13.00
Suficiente	172	61.9	SD	1.26157
Missing Responses	14	5.0	Range	8.30
			Minimum	11.00
Total	278	100	Maximum	19.30

The final question asked students on which program they were enrolled in. On Table 4-14, the distribution of the respondents by course programs is presented. The responses in this question were used to group the students into groups of academic disciplines that are closely related to each other. A broad level of analysis was chosen due to the exploratory nature of this study. Another reason was the underrepresentation of several programs due to the inconsistent attendance of students or few students registered in the program.

Table 4-14 Respondents by Course Program

Program	Count	Percentage
Agronomia	14	5.0
Ciência e Tecnologia Animal	28	10.1
Matemática Aplicada	2	.7
Ciências da Educação	16	5.8
Bioquímica	22	7.9
Biotecnologia	19	6.8
Engenharia Civil	2	.7
Economia	20	7.2
Geografia	3	1.1
Geologia	1	.4
Biologia Humana	9	3.2
Engenharia Informática	25	9.0
Gestão	61	21.9
Engenharia Mecatrónica	10	3.6
Enfermagem	7	2.5
Psicologia	23	8.3
Engenharia das Energias Renováveis	5	1.8
Sociologia	10	3.6
Turismo	1	.4
Total	278	100.0

Programs were grouped as follows: Engineering included Engenharia Civil, Engenharia das Energias Renováveis, Engenharia Informática and

Engenharia Mecatrónica; Commerce included Economia, Gestão and Turismo; Social Science included Ciências da Educação, Psicologia and Sociologia; Hard Science included Biologia Humana, Bioquímica, Biotecnologia, Enfermagem, Geografia, Geologia and Matemática Aplicada; and Agricultural Science included Agronomia and Ciência e Tecnologia Animal.

Once grouped, 42 (15.1%) students were enrolled in Agricultural Science related courses as well as in Engineering, 82 (29.5%) students in Commerce, 63 (22.7%) in Hard Science, and 49 (17.6%) in Social Science. Table 4-15 shows the distribution of the respondents by academic discipline.

Table 4-15 Respondents by Academic Discipline

Program	Count	Percentage
Agricultural Science	42	15.1
Commerce	82	29.5
Engineering	42	15.1
Hard Science	63	22.7
Social Science	49	17.6
Total	278	100.0

4.3 Students' Attitude towards Mathematics

The second part of the questionnaire was a self-inventory of students' attitude towards math. The students were asked to rate their agreement on 20 statements based on 6-point Likert scale, indicating (A) concordo totalmente, (B) concordo medianamente, (C) concordo ligeiramente, (D) discordo ligeiramente, (E) discordo medianamente and (F) discordo totalmente. Summative scores were calculated in order to infer the attitude levels.

For the purpose of this Master's study, students' attitudes were categorized into six levels for ease of attitude identification: strongly negative, moderately negative, slightly negative, slightly positive, moderately positive and strongly positive. These categories were assigned by identifying the possible range of each respondent's score and divided by six. A range of 100 was identified with the lowest possible score of 20 (rating 1 on each of 20 statements) and the highest possible score of 120 (rating 6 on each of 20 statements). Each category cumulatively increased by 17 points (see Table 4-16).

The attitude subscales were categorized into two levels, high and low. These categories were assigned by identifying the possible range of the items belonging to each subscale. A range of 25 was identified with the lowest possible score of 5 and the highest possible score of 30 for perceived competence and anxiety while a range of 50 was identified for motivation and anxiety with the lowest possible score of 10 and the highest possible score of 60. Each category for perceived competence and anxiety is cumulatively increased by 13 points and 25 points for motivation and interest. Scores that are categorized as high in perceived competence and motivation and interest meant that the students have a favorable reflection on themselves which contributes to the likelihood of having a positive attitude towards math. Note that for anxiety, a high score would mean that students have less anxiety which allows them to be more comfortable of the subject thus contributing to a positive attitude towards math.

Table 4-16 Scoring Procedure for the Attitude and Subscales

Score Range	Attitude	Score Range	Subscale
[20,37)	Strongly Negative	[10,35][a]	High Level
[37,54)	Moderately Negative	(35,60][a]	Low Level
[54,71)	Slightly Negative		
[71,88)	Slightly Positive	[5,18][b, c]	High Level
[88,105)	Moderately Positive	(18,30][b, c]	Low Level
[105,120]	Strongly Positive		

[a] Motivation and Interest
[b] Perceived Competence
[c] Reversed for Anxiety

4.3.1 Overall Attitude Results

Table 4-17 shows the general attitude scores of the students. Among the respondents, 30 (10.8%) have a strong positive attitude, 94 (33.8%) have a moderately positive attitude and 79 (28.4%) have a slightly positive attitude towards math. This suggests that, initially, majority of the students (72.03%) began with a positive attitude towards math as they enter the university.

On the other hand, 26.97% students began with a negative attitude towards math for which 51 (18.3%) revealed to have a slightly negative attitude, 22 (7.9%) with a moderately negative attitude and 2 (0.7%) with a strongly negative attitude.

On average, students have a slightly positive towards mathematics

($\tilde{x}$=82.36, SD = 19.20). The students scored between 32 to 117 points suggesting that they have varied attitude towards mathematics, from strongly negative to strongly positive.

Table 4-18 Overall Results of the Attitude Self-Inventory

Classification	Count	Percentage	Statistics	
Strongly Negative	2	0.7	Mean	82.36
Moderately Negative	22	7.9	Median	84.00
Slightly Negative	51	18.3	Mode	102.00
Slightly Positive	79	28.4	SD	19.20
Moderately Positive	94	33.8	Range	85.00
Strongly Positive	30	10.8	Minimum	32.00
Total	278	100.0	Maximum	117.00
			Skewness	-.395

Shown in table 4-18 is the overall statistics on the subscales that explains a students' attitude towards math. On the average, students have a high level of perceived competence given the mean score of 20.43 (SD=4.33). It can be seen that majority of the students tend to have a high level of perceived competence given the 25th percentile score of 17.75. This means that students believe on their ability to successfully accomplish mathematical tasks given to them. Students in general have a high level of motivation and interest in math given the mean score of 39.63 (SD=10.32).

The 25th percentile score of 32 suggests that majority of the students tend to have a high level of motivation and interest. This means that students are more inclined to pursue more learning experiences in math. Data shows that there are more students with high motivation and interest (n=189, 67.98) than students with low motivation and interest (n=89, 32.02%). Also, there are more students with high perceived competence (n=186, 66.90%) than students with low perceived competence (n=92, 33.10%).

The mean anxiety score of 22.30 (SD=5.92) indicates that student generally are less anxious or feel discomfort in math classes or related activities. It shows that at least 75% of the students have less anxiety in math classes given the 25th percentile score of 19. This also suggests that students feel less stress and are comfortable in performing math activities or other related tasks in class. Data shows that a lot of students are have low anxiety level (n=210, 75.53%) than those with a high anxiety level (n=68, 24.4%).

Table 4-18 Overall Results of the Attitude Subscales

Statistics		Subscales		
		MI	ANX	PC
Mean		39.63	22.30	20.43
Median		40.50	23.00	20.50
Mode		38.00	30.00	23.00
SD		10.32	5.92	4.33
Skewness		-.331	-.761	-.277
Range		48.00	25.00	22.00
Minimum		11.00	5.00	7.00
Maximum		59.00	30.00	29.00
Count	High	189	68	186
	Low	89	210	92
Percentiles	25^{th}	32.00	19.00	17.75
	75^{th}	48.00	27.00	24.00

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

Moreover, the odds ratio was calculated to determine the association between attitude and the subscales and the likelihood of having a negative or positive attitude with a high or level of perceived competence, motivation and interest or low and high level of anxiety.

As shown on Table 4-19, 72 out of the 75 students with a negative have a low motivation and interest, while 186 out of the 203 students with a positive attitude have a high motivation and interest level. It shows that there is association between the attitude of a student towards math and the motivation and interest level. Students with a negative attitude towards math will likely have a low motivation and interest and students with a positive attitude towards math will likely have a high motivation and interest level. The value of 0.044 compares ratio of students with a negative and positive attitude in the high level category of motivation and interest. This implies that students with a negative attitude are less likely to have a high level of motivation and interest as compared to those with a positive attitude. The value of 11.464 for the cohort low motivation and interest implies that students with a negative attitude towards math are more likely to have a low level of motivation and interest than those with a positive attitude. The calculated odds ratio shows that students with a negative attitude towards math have only a 0.004 times the odds of having a high motivation and interest level than those with a positive attitude.

There is a greater frequency of students with a negative attitude having a high anxiety level than those with a positive attitude. Similarly, a high number of students with a positive attitude have a low anxiety level than those with a negative attitude. Data shows that students with a negative attitude are about 28 times more likely to have a high anxiety level than students with a positive attitude. Given the cohort value of 0.179 for low anxiety level, conversely, shows that students with a positive attitude are more likely to be on that level. The association exists between these variables as those with a negative attitude are more likely to have a high level of anxiety than those with a positive one. It further shows that the odds of students with a negative attitude of having a high anxiety level are 156.59 times the odds than those with a positive attitude.

Among those who have a negative attitude towards math, the ratio of having a high level and low level of perceived competence is 0.2295; while among those with a positive attitude towards math are 5.548. Students with a negative attitude are 0.220 times likely to have a high level of perceived competence and 5.326 times likely to have a low level of perceived competence than those with a positive one. The odds ratio value can be similarly understood as students with a positive attitude towards math tend to have a high level of perceived competence than those with a negative attitude.

Table 4-19 Contingency Table and Odds Ratio of Attitude and the Subscales

			MI		**ANX**		**PC**		Total
		Scores	High	Low	High	Low	High	Low	
Attitude level	Negative	Count	3	72	62	13	14	61	75
		% within Attitude Level	4.0	96.0	82.7	17.3	18.7	81.3	100.0
	Positive	Count	186	17	6	197	172	31	203
		% within Attitude Level	91.6	8.4	3.0	97.0	84.7	15.3	100.0
	Total	Count	189	89	68	210	186	92	278
		% within Attitude Level	68.0	32.0	24.5	75.5	66.9	33.1	100.0
Odds Ratio for Attitude Level (Negative/Positive)			.004		156.59		.041		
For cohort = High			.044		27.97		.220		
For cohort = Low			11.46		.18		5.33		

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

Presented on Table 4-20 are the correlations (Pearson r) between the attitude subscales and the overall attitude score which supports the existence of the association previously mentioned. It shows that the subscales and the overall attitude are strongly correlated. Based on the correlation values, there exists a strong positive relationship between the overall attitude of the students and the subscales. This means that when a student's perceived competence and motivation and interest are high and anxiety level is low, the attitude of students tend to be more positive.

Table 4-20 Correlations between the Attitude Subscales and the Overall Attitude Scores

	Overall Attitude	**Perceived Competence**	**Motivation and Interest**	**Anxiety**
Overall Attitude	1			
Perceived Competence	.848	1		
Motivation and Interest	.973	.759	1	
Anxiety	.927	.697	.860	1

4.3.2 Attitude Results According to Gender

Table 4-21 shows the results of the attitude self-inventory according to gender. The attitude scores between females range from 37 to 117 indicating that the students attitude towards math vary from being moderately negative to strongly positive. It also shows that none of them have a strongly negative attitude. On the other hand, male students' attitude scores range from 32 and 117. This suggests male students have an attitude that spans from being strongly negative to strongly positive.

Female respondents' attitude score averaged 81.20 (SD = 19.73) with a median of 82, while male respondents attitude score averaged 83.82 (SD = 18.49) with a median of 87. These results are above the middle point of the scale which means that both genders generally have positive attitudes towards math. However, male students tend to exhibit a positive attitude towards math than girls.

Among the 155 female respondents, none of them have a strongly negative attitude towards math. It is revealed that 14 (9.0%) have a moderately negative attitude and 36 (23.2%) have a slightly negative attitude.

Data on 123 male respondents revealed that 2 (1.6%) to have strongly negative attitude, 8 (6.5%) with a moderately negative attitude and 15 (12.2%) with a slightly negative attitude. The frequency of female students having generally negative attitude towards math is greater than that of males.

Among the female respondents, 16 (10.3%) have a strong positive attitude, 51 (32.9%) have a moderately positive attitude, and 38 (24.5%) have a slightly positive attitude. As for the male respondents, 14 (11.4%) have a strong positive attitude, 43 (35.0%) with a positive attitude and 41 (33.3%) with a slightly positive attitude.

The ratio of male students having a positive and negative attitude towards math is 3.92 while it is 2.1 for the female students. However, the calculated odds ratio shows that female students have a 1.867 times the odds of having a negative attitude towards math than male students. The cohort value of 1.587 suggests that female students tend to have a negative attitude as compared to male students. The cohort value of 0.85, conversely, means that male students tend to have a positive attitude than female students. There is no clear association between gender and attitude.

Table 4-21 Results of the Attitude Self-Inventory by Gender

Classification	Female		Male					
	Count	%	Count	%	Total	Statistics	Female	Male
Strongly Negative	0	0.0	2	1.6	2	Mean	81.20	83.82
Moderately Negative	14	9.0	8	6.5	22	Median	82.00	87.00
Slightly Negative	36	23.2	15	12.2	51	SD	19.73	18.49
Slightly Positive	38	24.5	41	33.3	79	Range	80.00	85.00
Positive	51	32.9	43	35.0	94	Minimum	37.00	32.00
Strongly Positive	16	10.3	14	11.4	30	Maximum	117.00	117.00
Total	155	100	123	100	278	Skewness	-0.226	-0.633
Odds Ratio for Gender (F/M)		1.867						
For Cohort = Negative		1.587						
For Cohort = Positive		.85						

Shown on Table 4-22 are the attitude subscale results grouped according to gender. On the average, male students have a high level of motivation and interest given the mean score of 40.18 (SD=10.11), low anxiety level given the mean of 22.98 (SD=5.46), and high perceived competence given the mean of 20.67 (SD=4.17). Likewise on the average, female students have a high level of motivation ($\tilde{x}$=39.20, SD=10.49), low level of anxiety ($\tilde{x}$=21.77, SD=6.22) and high level of perceived competence ($\tilde{x}$=20.24, SD=4.47). It can be seen that on both genders majority have a high level of motivation and interest, low level of anxiety and high level of perceived competence.

Table 4-22 Results of the Attitude Subscales According to Gender

Statistics		Male			Female		
		MI	ANX	PC	MI	ANX	PC
Mean		40.18	22.98	20.67	39.20	21.77	20.24
Median		41.00	24.00	21.00	39.00	23.00	20.00
SD		10.11	5.46	4.17	10.49	6.22	4.47
Skewness		-.520	-1.041	-.343	-.193	-.568	-.222
Range		48.00	25.00	20.00	43.00	25.00	22.00
Minimum		11.00	5.00	9.00	16.00	5.00	7.00
Maximum		59.00	30.00	29.00	59.00	30.00	29.00
Percentiles	25^{th}	34.00	21.00	18.00	30.00	17.00	17.00
	75^{th}	47.00	27.00	23.00	48.00	27.00	24.00

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

As can be seen on Table 4-23, the ratio of female students with high and low levels of motivation and interest is 1.767 and 2.727 for male students. The value 0.873 compares the ratio of female and male students with a high motivation and interest level. This shows that male students are more likely to have a high motivation and interest level as compared to female students. The value 1.347 for the cohort low motivation and interest shows that female students are more likely to have it than male students. It also shows that female students have 0.648 times the odds of having a high motivation and interest than male students.

On both genders, the ratio of having a high and low anxiety levels is 0.422 for female students and 0.217 for male students. This means that both genders tend to have a low anxiety level. But, data shows that female students are more likely to have a high anxiety level (cohort=1.659) and less likely to have a low anxiety level (cohort=0.856) than male students. It also shows that the odds of female students to have a high anxiety level are 1.937 times the odds of male students. This means that male students are likely to have a low anxiety level than female students.

The perceived competence level is high on both genders. Yet in this case, male students are more likely to have a high perceived competence level and female students are more likely to have a low perceived competence level. The odds of having a high perceived competence level for female students are 0.732 times the odds for male students.

Table 4-23 Contingency Table and Odds Ratio of Gender and the Subscales

			MI		ANX		PC		Total
		Scores	High	Low	High	Low	High	Low	
Gender	Female	Count	99	56	46	109	99	56	155
		% within Gender	63.9	36.1	29.7	70.3	63.9	36.1	100.0
	Male	Count	90	33	22	101	87	36	123
		% within Gender	73.2	26.8	17.9	82.1	70.7	29.3	100.0
	Total	Count	189	89	68	210	186	92	278
		% within Gender	68.0	32.0	24.5	75.5	66.9	33.1	100.0
		Odds Ratio for Gender (Female/Male)	.648		1.937		.732		
		For cohort = High	.873		1.659		.903		
		For cohort = Low	1.347		.856		1.234		

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

4.3.3 Attitude Results According to Age Groups

Table 4-24 shows the results of the attitude self-inventory considering age groups. Only 274 responses were analyzed as there were four missing responses. The attitude scores of both age groups vary from being strongly negative to strongly positive. Attitude scores of age group A averaged an 83.09 (SD=19.09) while group B averaged a 79.09 (SD=19.68), indicating a slightly positive attitude towards math in both groups. Half of the students in age group A scored above 86 while in group B scored above 76.5. It can be seen that the distribution of scores in group B is almost normal.

Table 4-24 Descriptive Results of the Attitude Self-Inventory by Age Group

Statistics	Age Group	
	Group A (17 – 19)	Group B (20+)
Mean	83.09	79.09
Median	86.00	76.50
SD	19.09	19.68
Minimum	32.00	36
Maximum	117.00	117
Range	85.00	81
Skewness	-.497	0.005

Figure 4 shows that among the students age 17 to 19 (n=218), only 1 (0.45%) student has a strongly negative attitude towards math, 19 (8.71%) with a moderately negative attitude and 33 (15.13%) with a slightly negative attitude. There 64 (29.35%) with a slightly positive attitude, 78 (35.77%) with a moderately positive attitude and 23 (10.55%) with a strongly positive. It can be seen that majority in this age group have positive attitude towards math.

In the above 20 age group (n=56), there is only 1 (1.78%) student with a strongly negative attitude, 3 (5.35%) with a moderately negative attitude and 17 (30.35%) with slightly negative attitude. There were 15 (26.78%) with a slightly positive attitude, 14 (25%) with a moderately positive attitude and 6 (10.71%) with a strongly positive attitude. There is a lesser frequency of students ages 17 to 19 with a negative than with a positive attitude. Only a small difference exists in the frequency of students above 20 years old with a negative and a positive attitude.

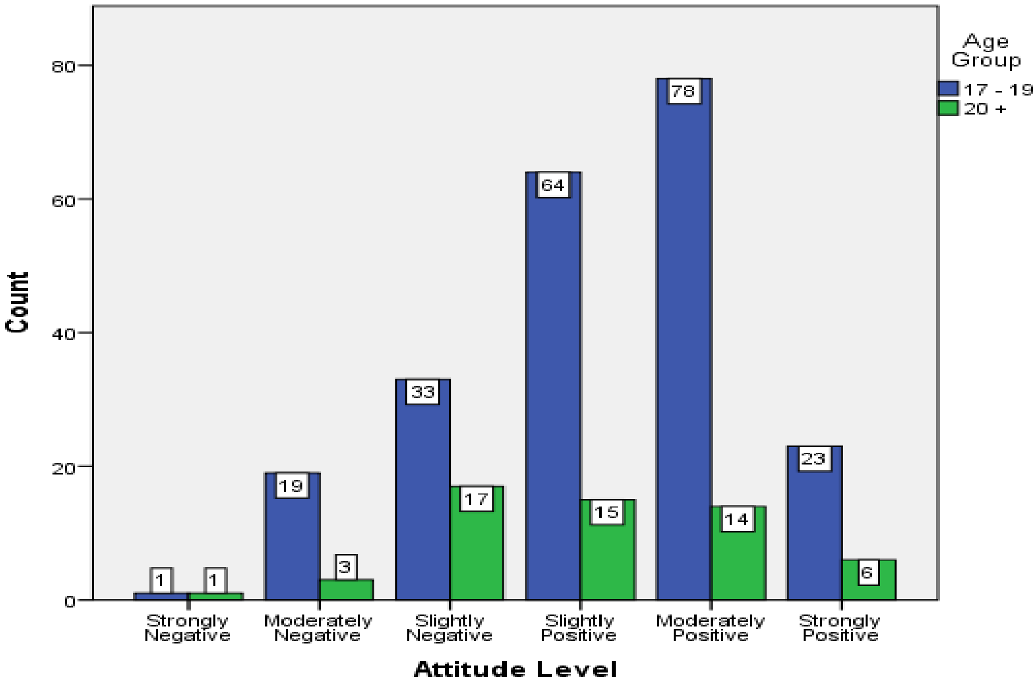

Figure 4 Distribution of Attitude Results According to Age Group

The ratio of students aged 17 to 19 having a positive and negative attitude towards math is 3.11 while it is 1.67 for the students aged 20 and above. However, the calculated odds ratio between age groups show that students aged 17 to 19 have a 0.535 times the odds of having a negative attitude towards math than student aged 20 and above. The cohort value of 0.648 suggests that students aged 17 to 19 tend to have a negative attitude as compared to students aged 20 and above (see Table 4-25).

Table 4-25 Contingency Table and Odds Ratio of Age Group and Attitude

			Attitude		Total
			Negative	Positive	
Age Group	17 - 19	Count	53	165	218
		% within Age Group	24.3	75.	100.0
	20 +	Count	21	35	56
		% within Age Group	37.5	62.5	100.0
	Total	Count	74	200	274
		% within Age Group	27.0	73.0	100.0
Odds Ratio for Age Group (17 - 19 / 20 +)			.535		
For cohort Attitude = Negative			.648		
For cohort Attitude = Positive			1.211		

On the average, both age groups have a high motivation and interest level given the mean scores of 39.73 (SD=10.39) and 38.75 (SD=10.55), respectively. Majority of the students in both age groups have a high level of motivation and interest although students of the age group 17 to 19 tend to be more motivated and interested in mathematical learning than the other group (see Table 4-26).

In terms of anxiety level, both age groups are categorized as low with means of 22.65 (SD=5.82) and 20.94 (SD=6.29), respectively. There is a greater majority of students of ages 17 to 19 (n=170) with a low level of anxiety than those 20 and above (n=36). Also, the younger students tend to have a lower anxiety level as compared to those with ages 20 and above.

The perceived competence level of both age groups is high, given the means of 20.69 (SD=4.25) and 19.60 (SD=4.56) respectively. Less than 25% of the respondents in both age groups have a low perceived competence level.

Table 4-26 Results of the Attitude Subscales According to Age Group

Statistics		**17-19**			**20+**		
		MI	**ANX**	**PC**	**MI**	**ANX**	**PC**
Mean		39.73	22.65	20.69	38.75	20.94	19.60
Median		41.00	24.00	21.00	37.00	22.00	19.00
SD		10.39	5.82	4.25	10.55	6.29	4.56
Skewness		-.412	-.850	-0.280	.044	-.422	-.296
Range		48.00	25.00	19.00	42.00	23.00	21.00
Minimum		11.00	5.00	10.00	17.00	7.00	7.00
Maximum		59.00	30.00	29.00	59.00	30.00	28.00
Percentiles	25^{th}	33.00	19.00	18.00	30.50	17.25	16.25
	75^{th}	48.00	27.00	24.00	47.00	26.08	22.75
Count	High	151	48	150	35	20	33
	Low	67	170	68	21	36	23

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

Looking at the correlations between age, attitude and the subscales, age, the overall attitude, perceived competence and anxiety are weakly correlated. Based on the correlation values, there exists a weak negative relationship between age, overall attitude of the student, perceived competence and anxiety. This means that when a student becomes older, the attitude, perceived competence level and anxiety level may not totally decrease. It further shows that age has a weak positive correlation with motivation and interest. This may not necessarily mean that when a student becomes older, the motivation and interest goes high.

Table 4-27 Correlation Results between Age, Overall Attitude and Subscales

		Age	Overall Attitude	Perceived Competence	Motivation and Interest	Anxiety
Age	Pearson Correlation	1	-.032	-.073	.014	-.075
	N	274	274	274	274	274

4.3.4 Attitude Results According to Study Time

Students' attitude scores were also analyzed based on the number of hours they spent studying outside their normal classes. In this case, students with an extreme classification of study time were merged with those in the high category as there are only 5 respondents. This totals to three groups with the high classification categorized as spending more than 5 hours dedicated to studying math outside school. Only 271 responses were analyzed as there were 7 respondents who did not provide any information.

The distribution of students' attitude considering study time can be seen in Figure 5. Among those with a low study time (n=133), 2 (1.50%) have a strongly negative attitude, 15 (11.27%) have a moderately negative attitude and 23 (17.29%) have a slightly negative attitude towards math. On the positive direction, 48 (36.09%) have a slightly positive attitude, 38 (28.57%) have a moderately positive attitude and 7 (5.26%) have a strongly positive attitude towards math.

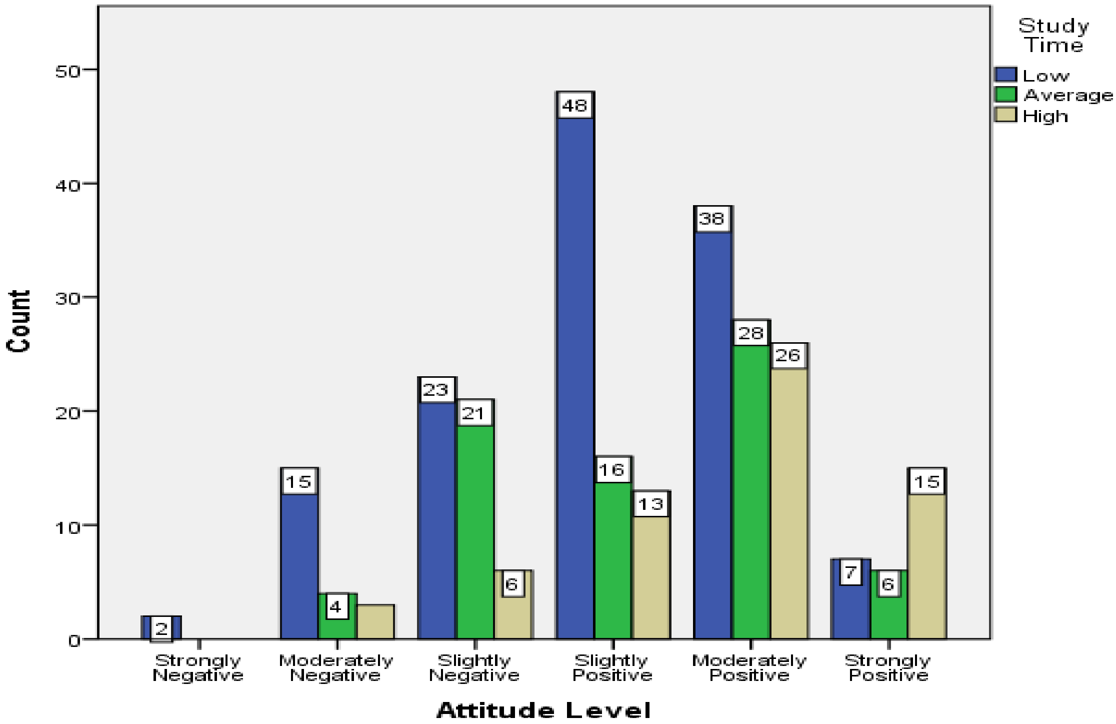

Figure 5 Distribution of Attitude Results According to Study Time

No student in the average study time category has a strongly negative attitude towards math. Also in this category, 4 (5.33%) have a negative attitude and 21 (28%) have a slightly negative attitude. Many students in this category tend to have a positive attitude towards math, having 16 (21.33%) with a slightly positive attitude, 28 (37.33%) with a moderately positive attitude and 6 (8%) with a strongly positive attitude.

Same as in the average study time category, no student has a strongly negative attitude towards math in the high study time category though there were 3 (4.76%) with a moderately negative attitude and 6 (9.52%) with a slightly negative attitude. Most of the students in this category tend to have a positive attitude towards math, having 13 (20.63%) with a slightly positive attitude, 26 (41.26%) with a moderately positive attitude and 15 (23.80%) with a strongly positive attitude.

On Table 4-28 students with low study time (less than 3 hours per week) has an attitude score average of 77.58 (SD = 18.82) and more than half of the score are above 80. This means that students in this category generally have a slightly positive attitude towards math with half of them tending to have a positive attitude towards math. Their scores span from 32 to 117 indicating a spread of attitude from strongly negative to strongly positive.

Those with an average study time (between 3 to 5 hours per week) averaged an attitude score of 82.20 (SD = 18.07). This also means that students in this category generally have a slightly positive attitude towards math. The median of 85 suggests that half of the students with an average study time tend to have a positive attitude. Scores in this category span from 41 to 116 indicating a spread from moderately negative to strongly positive attitude, having no one with a strongly negative attitude.

Students with a high study time outside class (between 5 to 10 hours per week) averaged an attitude score of 91.53 (SD = 17.99). It means that students in this category generally have a positive attitude towards math. The median score of 97 indicates that more than half of them tend to have a positive attitude although their attitude scores ranges from 46 to 117, attitude spanning from being moderately negative to strongly positive.

Table 4-28 Descriptive Results of the Attitude Self-Inventory by Study Time

Statistics	**Low**	**Average**	**High**
Mean	77.58	82.20	91.53
Median	80.00	85.00	97.00
SD	18.82	18.07	17.99
Minimum	32.00	41.00	46.00
Maximum	117.00	116.00	117.00
Range	85.00	75.00	71.00
Skewness	-.388	-.214	-.867

Results of the attitude self-inventory as grouped according to study time suggests that the more a student dedicates time in studying math outside class, a more positive attitude is possessed. This is also consistent with the subscale results (see Table 4-29).

Majority of students in all of the categories revealed to have high levels of motivation and interest, perceived competence, and a low level of anxiety. In general, as the study time increases, the motivation and interest and perceived competence level goes high and the anxiety level goes low.

Table 4-29 Results of the Attitude Subscales According to Study Time

Statistics		Low			Average			High		
		MI	ANX	PC	MI	ANX	PC	MI	ANX	PC
Mean		37.20	21.47	19.23	39.14	22.07	20.99	44.69	24.80	22.05
Median		38.00	22.00	19.00	41.00	23.00	21.00	47.00	26.10	23.00
SD		9.94	6.26	4.16	9.86	5.33	4.14	9.79	5.20	4.23
Skewness		-.302	-.741	-.278	-.284	-.431	-.125	-.755	-1.151	-.655
Range		47.00	25.00	22.00	43.00	22.00	18.00	40.00	20.00	19.00
Minimum		11.00	5.00	7.00	16.00	8.00	11.00	19.00	10.00	10.00
Maximum		58.00	30.00	29.00	59.00	30.00	29.00	59.00	30.00	29.00
Percentiles	25^{th}	30.00	18.00	17.00	32.00	18.00	18.00	38.00	22.00	19.00
	75^{th}	44.00	26.00	22.50	47.00	27.00	24.00	52.00	29.00	25.00
Count	High	84	35	77	48	24	53	52	8	50
	Low	49	98	56	27	51	22	11	55	13

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

The correlation values between study time, overall attitude and subscales show that they are positively correlated with fair strength, given the values greater than 0.219. This shows that as the study time of a student increases, the attitude of tend to go high with high levels of motivation and interest and perceived competence and low anxiety level (see Table 4-30).

Table 4-30 Correlation Results between Study Time, Overall Attitude and Subscales

		Study Time	Overall Attitude	Perceived Competence	Motivation and Interest	Anxiety
Study Time	Pearson Correlation	1	.284	.276	.288	.219
	N	271	271	271	271	271

4.3.5 Attitude Results According to Achievement

As achievement has been popularly investigated in relation to attitude towards math (Ma & Kishor, 1997; Nicolaidou & Philippou, 2003), students' prior performance in high school was considered in this research. Achievement factors to consider in analyzing the attitude of freshmen students towards math are the note they obtained in their final math subject in high school and the general average of their final year in high school.

The final math grade of the students was classified based on the Decreto Lei no. 42/2005 de 22 de Fevereiro. On Table 4-31, the attitude scores range from 32 to 117 showing a span of strongly negative attitude to strongly positive attitude regardless of the note classification.

Students who were classified Insuficiente (0-9 note) averaged an attitude score of 61.73 (SD = 26.16). This means that they generally have a slightly negative attitude and is supported by the median of 48, indicating that half of them tend to have a moderately negative attitude towards math.

Students with an approved note have different results. Those classified Suficiente (10-13 note) averaged an attitude score of 80.15 (SD = 17.59) which means that they generally have a slightly positive attitude. The median of 81.50 supports the indication that these students tend to have a moderately positive attitude.

Attitude scores of students whose final grade were classified as Bom (14-15 note) averaged an 89.04 (SD = 16.76), those with Muito Bom (16-17 note) averaged an 88.44 (SD = 18.95) and those with Excelente (18-20) averaged a 94.17 (SD = 23.04). This means that the students with these classifications generally have a moderately positive attitude towards math. The median of 90 for Bom, 94.50 for Muito Bom and 100.50 for Excelente means that students in these classifications tend to have a strongly positive attitude towards math.

The distribution of students' attitude considering their previous math rating can be seen on Figure 6. The line graph shows that students who obtained a previous math rating of above 10 tend to have a positive attitude towards math. As expected, those who obtained an insuficiente classification tend to have a negative attitude towards math. Previous math rating and attitude are fairly correlated. Based on the correlation value 0.366, there exists a fairly positive relationship between the variables, showing that as previous math rating goes higher, so as the attitude level.

Table 4-31 Descriptive Results of the Attitude Self-Inventory by Previous Math Rating

Statistics	Insuficiente	Suficiente	Bom	Muito Bom	Excelente
Mean	61.73	80.15	89.04	88.44	94.17
Median	48.00	81.50	90.00	94.50	100.50
SD	26.16	17.59	16.76	18.95	23.04
Minimum	32.00	36.00	47.00	39.00	53.00
Maximum	108.00	117.00	116.00	117.00	115.00
Range	76.00	81.00	69.00	78.00	62.00
Skewness	.639	-.292	-.471	-.641	-1.352
Correlation (Pearson r) = .366					

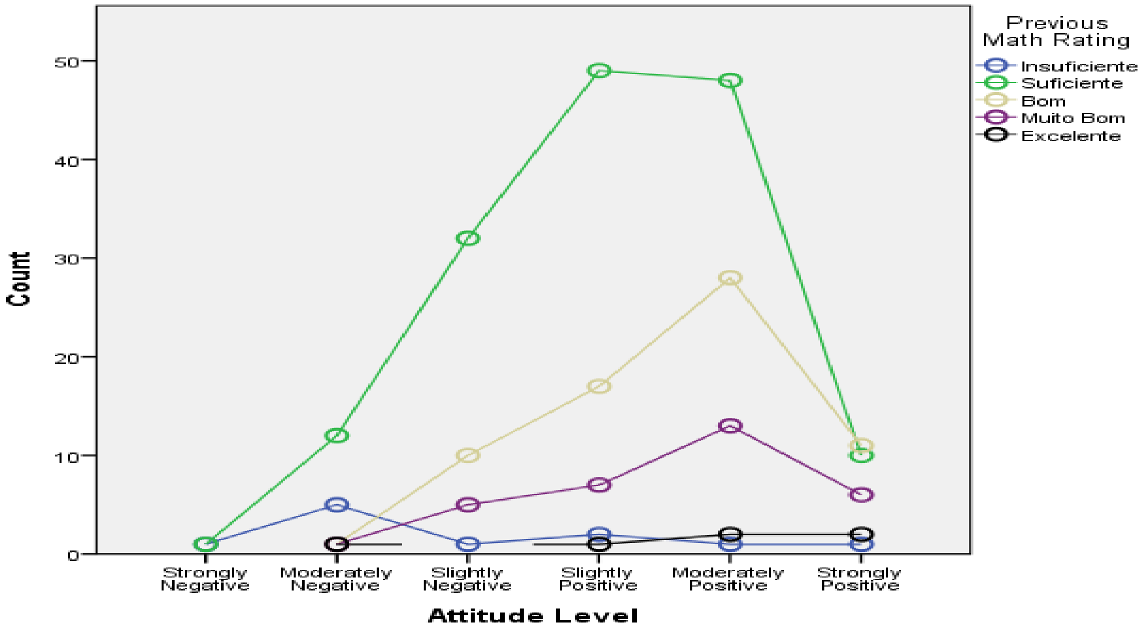

Figure 6 Distribution of Attitude Results According to Previous Math Rating

Subscale results on tables 4-32 to 4-34 show that students who obtained a previous math rating of below 10 generally have a low motivation and interest level ($\tilde{x}$=28.09, SD=13.73), high anxiety level ($\tilde{x}$=16.07, SD=8.40), and low level of perceived competence ($\tilde{x}$=17.36, SD=5.39). Also, majority in this group have a low level of motivation and interest, high anxiety level and low level perceived competence.

Noticeably in all subscales, students with a passing grade in their previous math rating generally have a high level of motivation and interest with mean scores greater than 38, high level of perceived competence with mean scores greater than 20 and low level of anxiety with mean scores greater than 21. This shows that as the previous math rating goes higher, students tend to have high levels motivation and interest and perceived competence and low level of anxiety. Majority of the students in all grade classification have a high level of motivation and interest and perceived competence and low anxiety level.

Looking at the correlations between previous math rating and the subscales shows that they are fairly correlated. Based on the correlation values, there exists a fairly positive relationship between previous math rating and the subscales. This means that when their grade goes high, the subscales also fairly increases.

Table 4-32 Results of the Motivation and Interest Subscale According to Previous Math Rating

Statistic		Insuficiente	Suficiente	Bom	Muito Bom	Excelente
Mean		28.09	38.42	43.29	42.66	46.67
Median		23.00	38.00	43.00	46.00	50.00
SD		13.73	9.48	8.97	9.97	12.60
Skewness		.457	-.213	-.337	-.326	-1.382
Range		41.00	41.00	35.00	36.00	33.00
Minimum		11.00	17.00	24.00	23.00	24.00
Maximum		52.00	58.00	59.00	59.00	57.00
Percentiles	25^{th}	16.00	31.25	38.00	34.00	38.25
	75^{th}	41.00	45.00	50.00	49.00	56.25
Count	High	4	98	55	22	5
	Low	7	54	12	10	1
Correlation (Pearson r) = .367						

Table 4-33 Results of the Anxiety Subscale According to Previous Math Rating

Statistic		Insuficiente	Suficiente	Bom	Muito Bom	Excelente
Mean		16.27	21.65	24.12	24.53	25.00
Median		15.00	23.00	25.00	26.50	28.00
SD		8.40	5.55	5.08	5.68	7.43
Skewness		.315	-.731	-.894	-1.478	-1.738
Range		24.00	23.00	20.00	25.00	19.00
Minimum		5.00	7.00	10.00	5.00	11.00
Maximum		29.00	30.00	30.00	30.00	30.00
Percentiles	25^{th}	11.00	19.00	21.00	21.00	20.00
	75^{th}	24.00	26.00	28.00	29.00	30.00
Count	High	7	37	11	5	1
	Low	4	115	56	27	5
Correlation (Pearson r) = .356						

Table 4-34 Results of the Perceived Competence Subscale According to Previous Math Rating

Statistic		Insuficiente	Suficiente	Bom	Muito Bom	Excelente
Mean		17.36	20.07	21.63	21.50	22.50
Median		17.00	20.00	23.00	22.00	22.50
SD		5.39	.08	4.20	4.40	4.09
Skewness		.458	-.109	-.451	-.593	.119
Range		17.00	20.00	17.00	17.00	10.00
Minimum		10.00	9.00	12.00	11.00	18.00
Maximum		27.00	29.00	29.00	28.00	28.00
Percentiles	25^{th}	13.00	17.00	19.00	18.25	18.00
	75^{th}	20.00	23.00	25.00	25.00	26.50
Count	High	5	97	52	24	4
	Low	6	55	15	8	2
Correlation (Pearson r) = .257						

The general average of the students obtained in their final year in high school was also classified based on Decreto Lei no. 42/2005 de 22 de Fevereiro. None of the students obtained an Insuficiente classification and only 1 student obtained and Excelente classification (see Table 4-35).

Students whose general average were classified as Suficiente averaged an attitude score of 83.19 (SD = 19.48) which mean they generally have a slightly positive attitude. The median score of 87 indicates that students tend to have a moderately positive attitude toward math. Attitude scores in this classification range from 32 to 117 demonstrating an attitude span from strongly negative to strongly positive.

Attitude scores of those whose general average were classified as Bom and Muito Bom averaged 81.13 (SD = 18.19) and 80.75 (SD = 22.93). This means that they generally have a slightly positive attitude towards math. The attitude scores ranging from 38 to 117 in both classifications demonstrate an attitude span from moderately negative to strongly positive.

Table 4-35 Descriptive Results of the Attitude Self-Inventory by General Average

Statistics	Suficiente	Bom	Muito Bom	Excelente
Mean	83.19	81.13	80.75	
Median	87.00	83.00	82.00	
SD	19.49	18.19	22.93	
Minimum	32.00	38.00	41.00	Constant
Maximum	117.00	117.00	109.00	
Range	85.00	79.00	68.00	
Skewness	-.454	-.272	-.484	

The distribution of students' attitude considering general average can be seen in figure 7. Among those in the Bom and Muito Bom classification, no student has a strongly negative attitude while there were 2 (1.16%) in the Suficiente classification.

Among the students with a general average classified as Suficiente, 14 (8.13%) have a moderately negative attitude, 29 (16.86%) have a slightly negative attitude, 44 (25.58%) with a slightly positive attitude, 62 (36.04%) with a moderately positive attitude and 21 (12.20%) with a strongly positive attitude. In the Bom classification, 5 (6.32%) have a moderately negative attitude, 18 (22.78%) have a slightly negative attitude, 25 (31.64%) have a slightly positive attitude and a moderately positive attitude, and 6 (7.59%) have a strongly positive attitude. It shows that, in general, students belonging to the Suficiente and Bom classifications tend to have a positive attitude.

Only few students have a general average that can be classified as Muito Bom. An even frequency of 2 has a moderately negative attitude, slightly negative and strongly positive attitude in the Muito Bom classification. Also, an even frequency of 3 has a slightly positive and moderately positive attitude.

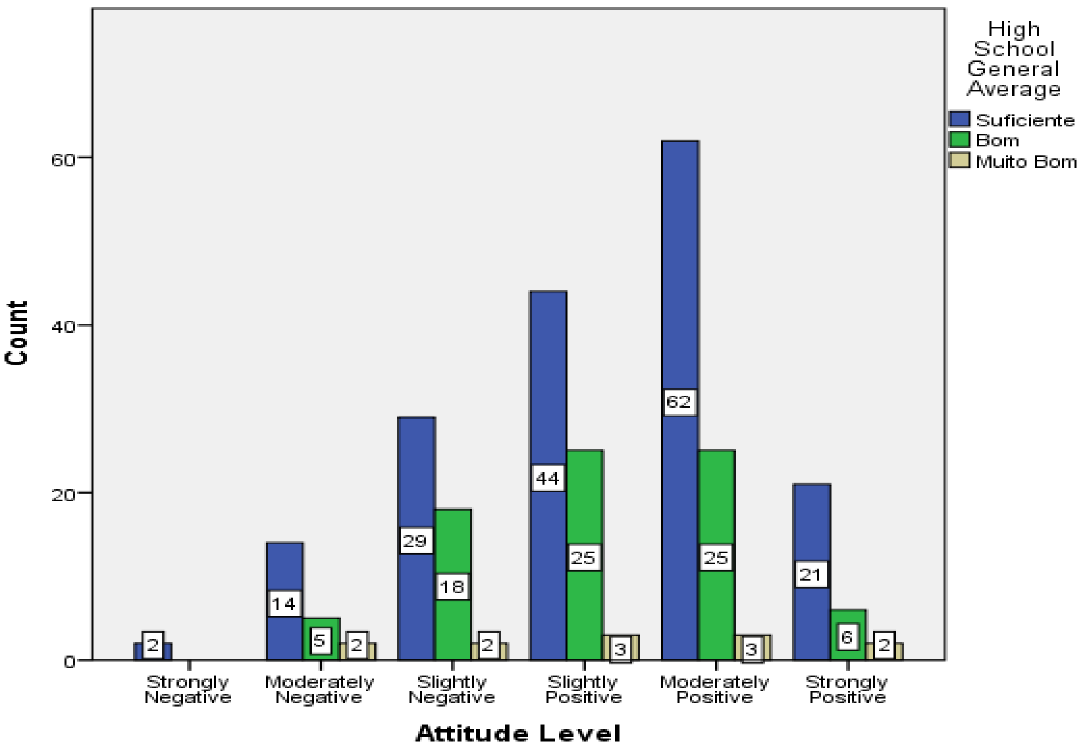

Figure 7 Distribution of Attitude Results According to High School General Average

On table 4-36, it shows that students obtaining a grade above 10 generally have a high motivation and interest level although it favors those with a suficiente classification, given the mean scores above 38. Majority of the students with a passing mark have a high level of motivation and interest. Students who obtained a mark between 10 and 13 tend to have a high level of motivation and interest than the students who obtained a mark between 14 and 16. Likewise, the perceived competence level of the students is generally high with mean scores greater than 19. Majority of them also have a high level of perceived competence.

The anxiety level of the students in the suficiente, bom, and muito bom classifications are generally low with mean scores above 21. Majority of the students in these classifications have low level of anxiety.

Table 4-36 Results of the Attitude Subscales According to General Average

Statistics		Suficiente			Bom			Muito Bom		
		MI	ANX	PC	MI	ANX	PC	MI	ANX	PC
Mean		40.05	22.60	20.54	38.70	21.81	20.62	39.5	21.92	19.33
Median		41.50	24.00	20.00	39.00	23.00	21.00	41.50	21.50	21.50
SD		10.6	5.89	4.38	9.61	6.00	4.12	12.57	6.07	5.33
Skewness		-.380	-.812	-.280	-.182	-.827	-.165	-.535	-.508	-.546
Range		48.00	25.00	22.00	42.00	25.00	18.00	39.00	20.00	115.00
Minimum		11.00	5.00	7.00	16.00	5.00	11.00	16.00	10.00	11.00
Maximum		59.00	30.00	29.00	58.00	30.00	29.00	55.00	30.00	26.00
Percentiles	25^{th}	33.25	19.00	18.00	32.00	18.00	18.00	27.25	19.00	13.25
	75^{th}	48.00	27.00	24.00	46.00	27.00	23.00	50.25	27.50	23.00
Count	High	120	40	115	51	21	55	8	2	8
	Low	52	132	57	28	58	24	4	10	4

Legend: MI – Motivation and Interest, ANX – Anxiety, PC – Perceived Competence

The correlation values show very weak relationships between general average, overall attitude, and the subscales. This means that attitude towards math and the subscales are not dependent on the general average of the students (see Table 4-37).

Table 4-37 Correlation Results between General Average, Overall Attitude and Subscales

		General Average	Overall Attitude	Perceived Competence	Motivation and Interest	Anxiety
General Average	Pearson Correlation	1	-.005	-.011	-.006	0.002
	N	264	264	264	264	264

4.3.6 Attitude Results According to Academic Discipline

The distribution of students' attitude considering academic discipline is shown in Figure 8. There are no students with a strongly negative attitude towards math that come from courses related to Agricultural Science, Commerce and Hard Science. There is but only 1 student in Engineering (2.38%) and Social Science (2.04%) that has a strongly negative attitude.

Among the students who are taking Agriculture Science related courses, 3 (7.14%) have a moderately negative attitude, 16 (38.09%) have a slightly negative attitude, 14 (33.33%) with a slightly positive attitude, 7 (16.66%) with a moderately positive attitude and 2 (4.76%) with a strongly positive attitude towards math.

There are more students in the positive direction among those who are taking Commerce related courses. There were 24 (29.26%) with a slightly positive attitude, 33 (40.24%) with a moderately positive attitude and 17 (20.73%) with a strongly positive attitude. Only 7 (8.53%) have a slightly negative attitude.

From those coming from Engineering related courses, there is 1 student (2.38%) with a moderately negative attitude and 6 (14.28%) with slightly negative attitude. Towards the positive direction, 15 (35.71%) of them have a slightly positive attitude, 16 (38.09%) have a moderately positive attitude and 3 (7.14%) with a strongly positive attitude.

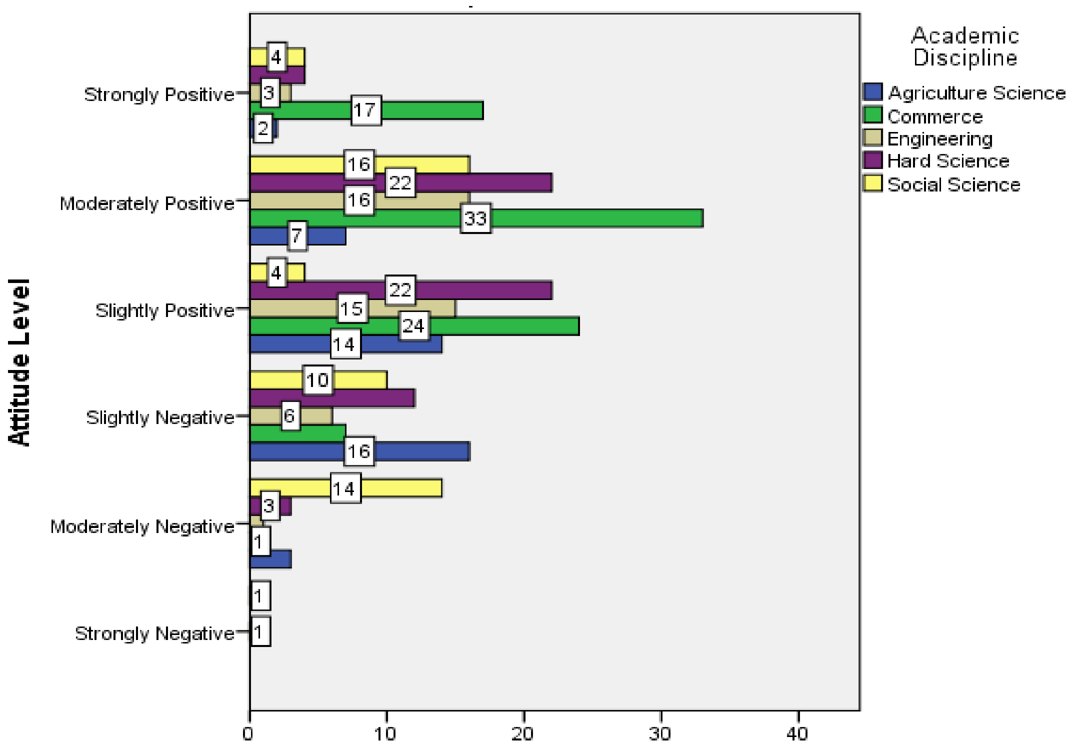

Figure 8 Distribution of Attitude Results According to Academic Discipline

There were 3 (4.7%) students from Hard Science related courses with a moderately negative attitude and 12 (19.04%) with a slightly negative attitude. Those with a slightly positive and a moderately positive attitude had the same frequency of 22 (34.92%). There were 4 (6.34%) who have a strongly positive attitude.

In the Social Science related courses, there were 14 (28.57%) with a moderately negative attitude and 10 (20.40%) with a slightly negative attitude. Among them, 4 (8.16%) have a slightly positive attitude, 16 (32.65%) with a moderately positive attitude and 4 (8.16%) with a strongly positive attitude.

Those coming from the Agricultural Science field averaged an attitude score of 61.72 (SD = 26.15). This means that students who are registered in courses related to agricultural science have a slightly negative attitude towards math. The median of 48 indicate that they tend to have a moderately negative attitude. Attitude scores of students in this academic discipline range from 32 to 108, which means that their attitude spans from being strongly negative to strongly positive (see Table 4-38).

Students whose courses are commerce related averaged an attitude score of 80.14 (SD = 17.58). They generally have a slightly positive attitude with half of them tending to have a positive attitude ($\tilde{x}$ = 81.5). The attitude scores range from 36 to 117 which indicate that their attitude span from being strongly negative to strongly positive.

The attitude score of students from Engineering related courses averaged an 89.04 (SD= 16.76) which means that they generally have a moderately positive attitude towards math. The median score of 90 indicates that students tend to have a strongly positive attitude towards math. As scores range from 47 to 116, this means that their attitude span from being moderately negative to strongly positive.

Those in the Hard Science related courses averaged an attitude score of 88.43 (SD = 18.94). This indicates that they normally have a moderately positive attitude towards math. Half of the students scored above 94.5 which means they tend to have a moderately positive attitude. Attitude scores range from 39 to 117 indicating an attitude span from moderately negative to strongly positive.

Students in Social Science related courses averaged an attitude score of 94.16 (SD = 23.04). This means that they generally have a moderately positive attitude. The median of 100.5 indicates that half of the students tend to have strongly positive attitude. Attitude scores range from 53 to 115 illustrating a span of attitude from being moderately negative to strongly positive.

Among all the academic disciplines, the students coming from social science courses tend to have a more positive attitude toward math than the others while students coming from agricultural science courses tend to have a negative attitude.

Table 4-38 Descriptive Results of the Attitude Self-Inventory by Academic Discipline

Statistics	**Agricultural Science**	**Commerce**	**Engineering**	**Hard Science**	**Social Science**
Mean	61.73	80.15	89.04	88.44	94.17
Median	48.00	81.50	90.00	94.50	100.50
SD	26.16	17.59	16.76	18.95	23.04
Minimum	32.00	36.00	47.00	39.00	53.00
Maximum	108.00	117.00	116.00	117.00	115.00
Range	76.00	81.00	69.00	78.00	62.00
Skewness	.639	-.292	-.471	-.641	-1.352

Table 4-39 shows the results of the attitude subscales by academic discipline. On the motivation subscale, students generally have a high motivation and interest level given the mean scores that are greater than 35, except for agricultural science. It can be seen that among all academic disciplines, majority of students coming from the agricultural science have low motivation and interest level while the rest have a high motivation and interest level.

Noticeably, students from commerce related courses tend to have a high motivation and interest level than the rest. In terms of the anxiety level, students in all academic disciplines generally have a low level of anxiety given the mean scores that are greater than 18.86. Majority of the students coming from courses related to agricultural science, commerce, engineering and hard science have low anxiety level. Students with a high anxiety level and low anxiety level in the social science group differ only of about 2% in their respective frequency. Students who tend to have a low anxiety level are those coming from commerce, engineering and hard science related courses.

Students in the different academic disciplines generally have a high level of perceived competence. Also, the majority in all the academic disciplines have a high level of perceived competence. Students who tend to have a high perceived competence level are those coming from engineering related courses.

Table 4-39 Results of the Motivation and Interest Subscale According to Academic Discipline

Statistic		**Agriculture Science**	**Commerce**	**Engineering**	**Hard Science**	**Social Science**
Mean		34.48	44.98	41.05	38.74	35.04
Median		33.50	45.00	41.50	39.00	36.00
SD		8.34	8.33	8.71	9.25	12.88
Skewness		0.226	-.476	-.207	-.2s59	-.031
Range		34.00	40.00	38.00	42.00	46.00
Minimum		17.00	19.00	19.00	17.00	11.00
Maximum		51.00	59.00	57.00	59.00	57.00
Percentiles	25^{th}	27.00	39.00	35.50	33.00	23.00
	75^{th}	41.25	51.25	49.00	45.00	47.50

Table 4-40 Results of the Motivation and Interest Subscale According to Academic Discipline

Statistic		**Agriculture Science**	**Commerce**	**Engineering**	**Hard Science**	**Social Science**
Mean		20.53	24.83	23.10	22.33	18.86
Median		20.50	26.00	23.00	23.00	18.00
SD		5.37	4.77	5.30	4.96	7.55
Skewness		-.282	-1.060	-.889	-.937	-.102
Range		22.00	20.00	22.00	23.00	25.00
Minimum		8.00	10.00	8.00	7.00	5.00
Maximum		30.00	30.00	30.00	30.00	30.00
Percentiles	25^{th}	16.75	21.75	20.75	20.00	12.50
	75^{th}	25.00	29.00	27.25	26.00	26.00

Table 4-41 Results of the Motivation and Interest Subscale According to Academic Discipline

Statistic		**Agriculture Science**	**Commerce**	**Engineering**	**Hard Science**	**Social Science**
Mean		19.43	21.35	21.02	20.51	19.12
Median		19.00	22.00	22.00	20.00	19.00
SD		4.06	3.94	4.44	3.77	5.33
Skewness		-.026	-.128	-.664	-.167	-.058
Range		18.00	16.00	20.00	15.00	22.00
Minimum		10.00	13.00	9.00	12.00	7.00
Maximum		28.00	29.00	29.00	27.00	29.00
Percentiles	25^{th}	16.00	18.00	18.00	18.00	15.00
	75^{th}	23.00	24.00	24.25	24.00	23.00

Chapter V
Summary and Discussion of Results

This chapter concludes the thesis by highlighting the major points of the research process, summarizing the findings according to the four research questions, and a discussion of their implications.

The Research Process

The study reported here was an investigation of the attitudes of freshmen college students towards mathematics. This research primarily used a survey methodology, employing an attitude self-inventory in an attempt to explore their initial attitude at the early stage of university education. Data from the *Inventário de Atitudes Face à Matemática* (IAFM) were used to build the profile of the respondents, verify the dimensions related to attitudes as gathered in the literature, and determine the magnitude and direction of their attitudes. The research relied solely on a researcher-made instrument, whose validity and reliability have been verified.

Summary and Discussion of Findings

A. *Instrument Development and Underlying Dimensions of Attitude*

The first research question was: *What are the underlying factors that affect the attitude of students towards math?* To assess students' attitude towards math, it was necessary to construct an instrument as there was none that is readily available for the specific group of students considered in this study (i.e. first year college students).

The scores on the revised IAFM indicate a high degree of reliability. The revised instrument has 20 statements using a Likert scoring system with a Cronbach alpha coefficient of 0.95. Item-to-total correlations reveal good internal consistency with r values greater than 0.50. Factor analysis was used to determine the dimensions that explain attitude. Principal component analysis with varimax and oblique rotation (Gable & Wolf, 1993) resulted to a four factor solution which was collapsed into three.

The three subscales were identified as Motivação e Interesse (Motivation and Interest), Desconforto (Anxiety), and Competência Percebida (Perceived Competence). The 20-item scale developed through factor analysis showed homogeneity of the items and high reliability. Split-half reliability for the total scale and the subscales indicates good internal consistency.

Several attitude dimensions are highlighted in various attitude instruments (e.g. Fennema & Sherman, 1976; Tapia & Marsh, 2000; Wong & Chen, 2012; da Silva, 2013), yet only four were operationally considered in this study. There is evidence of content validity. The 3-factor solution of the revised IAFM matches the domain of attitudes' towards mathematics highlighted by the literature. Motivação and Prazer (motivation and enjoyment) were reflected in Factor I. Confiança and Desconforto (confidence and anxiety) were reflected in Factor II. Items which initially belong to confiança, interesse and motivação were reflected in Factor III. Items belonging to the component Valor Percebido (Perceived Value) were dropped as item-to-total correlations were low. Moreover, a goal of developing the instrument was to reduce the number of items to be used, especially considering time constraints and classroom-related issues.

The development of a short version of an "attitude towards mathematics" self-inventory have followed a simple statistical process as recommended for novice investigators, and especially because of the preliminary nature of the entire study and practical use. Although the instrument showed signs of respectable validity and reliability and can be used for future researches of the same parameters, further improvements still has to be done in order for it to be more effective. The pilot study was limited only to a special population which was assumed to have responses closely similar to the intended subpopulation for which the final instrument was administered. It is possible that the instrument may not be useful if applied to groups of students other than first year college students, as responses may change due to the university instruction experience.

Writing and compiling items for an attitude questionnaire using a Likert summated rating scale is no easy task as there has not been many attitude questionnaires in the Portuguese (EU) language specially catered to college students. The validation of the instrument against the presumed conceptual structure is quite a challenging task as it requires a considerable amount of statistical work and practical interpretations.

B. *Profile of the Students*

The second research question was: *What is the profile of students?* This question was designed to outline the basic description of the freshmen students and detail the external factors that may have a relationship to their attitude. About 56% of the students were females and around 79% of the students were at the age of 17 to 19 years. It also revealed that students spend less than 3 hours a week for activities related to math outside their regular class schedule.

In terms of their academic achievement, roughly equated to the previous math rating prior to entering college, and their general weighted average in high school, their levels revealed to be low, following the descriptions given by the Decreto Lei no. 42/2005 de 22 de Fevereiro. About 55% of the students were classified to have a Suficiente previous math rating and about 62% of them were classified at the same level for their high school general weighted average.

With the difficulty of gathering a random sample and discrepancies of enrolment data, the courses from which the students come from were grouped based on the academic discipline for which they are closely related to. It was found out that majority of the students come from courses related to commerce, followed by hard science and social science. Respondents coming from courses related to agricultural science and engineering have the same frequency.

C. *College Students' Attitudes Towards Mathematics*

The third and fourth research questions were: "How is the attitude of students characterized?" and "What is the level of students' attitude in terms of the subscales?" Major findings are discussed based on the overall perspective and the independent variables.

First, the freshmen college students' overall attitude towards mathematics varies in extent. Contrary to popular belief, out of the 278 students surveyed, 73.0% scored within the positive range, with 34% to have a moderately positive attitude towards the subject. On the subscales level, majority of the students have high levels of motivation and interest level, and perceived competence. Anxiety or discomfort in math revealed to be low.

Strong positive correlations were found between the overall attitude and the subscales. Higher levels of attitude towards math were associated with higher sores in the attitude subscales. This suggests that attitude is likely determined by how motivated, interested, and at ease the student is in math, as well as how he recognize his ability.

Second, in terms of gender, there were no female students who have a strongly negative attitude towards math yet male students tend to have a more positive attitude than them. High levels of motivation and interest and perceived competence, and low level of anxiety were observed in both genders. Small differences were seen on the subscale scores so there is not much association between attitude and gender, but revealed that male students tend to have favorable ones than female students.

Third, there is no strong correlation between age and attitude. Students who are between the ages of 17 and 19 tend to have a more positive attitude than those above 20. Consistent with this are the subscale scores. Motivation and interest and perceived competence are generally high for students between 17 and 19 and anxiety level is generally low.

Fourth, no student whose time spent in studying math outside school for more than 3 hours has a strongly negative attitude towards mathematics. In general, students who spent more time in studying math tend to have a positive attitude towards math. Consequently, motivation and interest and perceived competence levels tend to be high and anxiety levels to be low.

Fifth, in terms of previous achievement, students with good previous math ratings generally have a positive attitude towards math, and otherwise for those with failing marks. There is an association between previous math rating and attitude, but it is not strong enough to say that attitude level tend to be positive when grades go high (e.g. TIMSS). Attitude subscales also follow the same trend.

None of the students with a general weighted average that is greater than 14 have a strongly negative attitude towards math. It is remarkable that students with a Suficiente classification generally have a more positive attitude than the other students and obtained the highest scores on the subscales.

Sixth, in terms of academic discipline, no student has a negative attitude towards mathematics who is taking a course related to agricultural science, commerce and hard sciences. It is interesting to note that students coming from the social science related courses have a more positive attitude than students coming from courses which use mathematics extensively, such as commerce, engineering and hard science disciplines. Students taking a course related to agricultural science have a more negative attitude towards mathematics.

On the subscales, students in commerce related courses generally have high levels of motivation and interest and perceived competence and low level of anxiety despite the fact that their attitude levels are generally in the slightly positive degree. Although with a more positive attitude towards math, students in social related courses scored low on the anxiety and perceived competence subscales.

Conclusions and Recommendations

The need to know and understand the nature of students' attitude towards math is supported by previous researches done across all levels (e.g. All levels – Aiken, 1970; College level – Hodges & Kim, 2013) especially when success and achievement in the discipline and in future endeavors is impacted by a positive attitude towards the subject. In particular, work by Hodges and Kim (2013) indicates that students' attitude can be changed and no better way than to begin the first step than by applying valid and reliable instruments (Wong & Chen, 2012) that can raise awareness of the initial attitudes of the students (Sundre, Barry, Gynnild & Ostgard, 2012).

This current study has provided the necessary tool to determine the attitude of future incoming freshmen students, as well as the baseline data of the current first year students, which can be used to track changes and improvement of their attitudes. Overall, although varying in magnitude, majority of this particular group of first year students at the Universidade de Évora have positive attitudes towards math. This shows that the common impression that students entering the university generally have negative attitudes towards math may no longer be true at the present time. This could also mean that it is perhaps the time to be more objective in judging students' attitude and rely on more trusted sources than unfounded information.

The dimensions of attitude which were looked into in this study have showed considerably high correlations to the overall attitude of students. Indeed, for students to have a more positive attitude towards math, they must exhibit a strong motivation and interest towards the subject, be less anxious and feel at ease in mathematical related activities, and have more confidence on their ability to be successful in math.

The 76% variance covered by the subscales motivation and interest, anxiety and perceived competence means that there are still other variables which could explain attitude. The search for these unknown variables confirms the continued search of other explanatory factors to explain attitude. As this study was explanatory in nature and used a non-random sample, it is expected that not everything can be determined, defined and discovered in the initial attempt. The data, however, can still offer insights as to the practices and intervention to address the lack of positive attitudes among some students, and fortify those who already have a positive one. It also can be used by relevant stakeholders (e.g. professors, parents, administrators) to find means to support the students.

The instrument developed in this study may be the first attempt to produce a formal questionnaire which has undergone a series of validity and reliability tests, catered to a specific and select group of students at the Universidade de Évora (i.e. freshmen undergraduate students). The fact that it was administered to only a select population opens opportunities for improvement in terms of the questioning technique (ex. Open-ended questions), sampling method (i.e. more representative and comprehensive), attitude dimensions, scaling technique (e.g. Thurstone scale, Guttman scale) and mathematical related affect content. Known literature such as Tapia and Marsh (2000) recommended the development of attitude questionnaires to relate attitude towards math among other variables, such as ethnic background, to better understand its context.

The characterization of the attitude of students towards math in this study is basically descriptive and quantitative. For the purpose of creating a baseline, it seems to be a good first step. There are established frameworks for analyzing attitudes towards math, yet has only been applied to students at the basic education level. It is recommended that future researches utilize these frameworks in getting a more in depth understanding of the nature of college students' attitude towards mathematics.

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Appendices

Appendix A – Pilot Study Data Statistics

Preliminary Results of the Pilot Study (N=40 items)

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
187.29	896.256	29.938	40

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.943	.941	40

Item-Total Statistics

Item No.	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
1	182.31	883.901	.157	.	.944
2	182.11	832.874	.749	.	.940
3	181.98	884.795	.168	.	.944
4	183.16	845.043	.681	.	.941
5	182.60	854.882	.677	.	.941
6	182.09	884.446	.200	.	.943
7	181.96	883.998	.245	.	.943
8	183.47	859.255	.492	.	.942
9	182.69	846.719	.542	.	.941
10	182.78	841.859	.649	.	.941
11	184.09	846.083	.543	.	.941
12	183.44	842.343	.625	.	.941
13	182.62	834.695	.590	.	.941
14	181.80	902.709	-.104	.	.946
15	183.29	868.392	.323	.	.943
16	183.53	876.982	.198	.	.944
17	183.42	839.022	.713	.	.940
18	182.02	866.022	.417	.	.942
19	183.89	848.965	.466	.	.942
20	182.67	866.955	.489	.	.942
21	183.42	867.704	.325	.	.943
22	181.73	879.291	.366	.	.943
23	182.51	822.301	.789	.	.939
24	182.42	838.068	.707	.	.940
25	182.27	835.336	.700	.	.940
26	182.53	830.845	.741	.	.940
27	182.18	863.104	.418	.	.942
28	182.07	841.700	.641	.	.941
29	182.16	867.725	.354	.	.943
30	182.40	830.473	.745	.	.940
31	182.36	834.689	.657	.	.940
32	181.73	877.473	.312	.	.943
33	183.29	815.346	.763	.	.939
34	182.71	841.665	.595	.	.941
35	182.44	836.207	.768	.	.940
36	182.36	839.325	.721	.	.940
37	184.11	830.056	.560	.	.942
38	181.84	861.362	.545	.	.942
39	181.60	876.382	.491	.	.942
40	182.22	830.949	.823	.	.939

Results of the Pilot Study after Item Deletion (N=20 items)

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
91.96	465.271	21.570	20

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.955	.958	20

Item-Total Statistics

Item No.	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
2	86.78	415.540	.825	.904	.951
4	87.82	427.286	.702	.834	.953
5	87.27	433.609	.722	.813	.953
10	87.44	424.253	.682	.785	.953
12	88.11	431.601	.532	.616	.955
13	87.29	417.528	.638	.711	.954
17	88.09	423.674	.721	.792	.953
23	87.18	410.422	.818	.902	.951
24	87.09	420.674	.757	.781	.952
25	86.93	420.336	.718	.753	.953
26	87.20	415.936	.781	.792	.952
28	86.73	422.018	.711	.798	.953
30	87.07	418.882	.729	.859	.952
31	87.02	420.568	.662	.853	.953
33	87.96	405.543	.787	.780	.952
34	87.38	427.559	.565	.737	.955
35	87.11	423.510	.741	.847	.952
36	87.02	423.477	.737	.870	.952
37	88.78	419.131	.535	.602	.956
40	86.89	416.465	.861	.917	.951

Appendix B – Pilot Study Questionnaire

QUESTIONÁRIO SOBRE ATITUDES FACE À MATEMÁTICA

Instruções: Neste questionário pretende-se descrever a sua atitude em relação à matemática. Por favor, responda de uma forma sincera às várias questões, pois não há respostas certas ou erradas, nem boas ou más. A sua verdadeira opinião será a melhor resposta. Leia com muita atenção antes de responder. Escolha a letra que corresponde à afirmação que melhor descreve os seus sentimentos. O questionário é confidencial. Se tiver dúvidas solicite o seu esclarecimento. Não deixe qualquer item sem resposta. Muito obrigado pela sua colaboração!

1. Sexo: Masc. __ Fem. __ 2. Idade: _____
3. Número de horas dedicadas a estudar matemática, por semana: _____
4. A minha nota na disciplina de Matemática no 12º ano (ou no último ano antes da entrada na universidade foi): _____
5. A minha média de entrada na universidade foi: _____
6. Curso: __________________________

Por favor, utilize os códigos de resposta:

(A) Concordo totalmente	**(D)** Discordo ligeiramente
(B) Concordo medianamente	**(E)** Discordo medianamente
(C) Concordo ligeiramente	**(F)** Discordo totalmente

_____1. Eu não vejo nenhuma conexão entre a matemática e o meu dia-a-dia.
_____2. Eu nunca gostei de matemática e é o meu assunto mais temido.
_____3. Uma sólida formação matemática poderia ajudar-me na minha vida profissional.
_____4. Eu sou bom a resolver problemas de matemática.
_____5. Eu entendo o que é explicado nas aulas de matemática.
_____6. Eu sou capaz de entender a ligação da matemática com vida quotidiana (por exemplo, relatórios e anúncios sobre preços, vendas, percentagens, etc.)
_____7. Acredito que estudar matemática me ajuda com a resolução de problemas noutras áreas.
_____8. Eu sou capaz de resolver problemas de matemática, sem dificuldade.
_____9. Fico nervoso quando penso em resolver um problema de matemática.
_____10. Eu desisto facilmente quando os problemas de matemática são difíceis.
_____11. Eu gosto de ir para além do trabalho atribuído, tentando resolver novos problemas de matemática.
_____12. Estou disposto a aprender mais matemática do que o necessário.
_____13. Eu preferiria fazer uma composição a fazer um trabalho de matemática.
_____14. Inscrevi-me numa disciplina de matemática apenas por passatempo.
_____15. Eu sou bom a usar matemática para resolver problemas da vida real.
_____16. Eu gostaria de ter mais projetos e trabalhos de casa que me ajudassem a aprender mais.
_____17. Estou à vontade para expressar as minhas ideias sobre como procurar soluções para um problema difícil de matemática.
_____18. Eu acho que a matemática é apenas útil para resolver as perguntas nos testes.
_____19. Gastar muito tempo na resolução de um problema de matemática deixa-me frustrado.
_____20. Eu gostaria de ter desafios que me fizessem aprender mais.

_____21. Ter que aprender temas difíceis em matemática não me preocupa.
_____22. Eu fico muito satisfeito quando resolvo problemas de matemática.
_____23. Não fico muito entusiasmado com matemática.
_____24. Eu fico completamente em branco e não me lembro de nada quando estou prestes a resolver um problema de matemática.
_____25. Não há nada de criativo sobre a matemática, é só memorizar fórmulas e coisas.
_____26. Não importa o quanto estude, a matemática é sempre difícil para mim.
_____27. Eu quero desenvolver as minhas habilidades matemáticas.
_____28. Nos dias que tenho matemática, não tenho vontade de ir à universidade.
_____29. A disciplina da matemática no ensino secundário é muito útil, independentemente do que se venha estudar no ensino superior.
_____30. Os desafios da matemática não me agradam.
_____31. Estou sempre sobre uma pressão terrível nas aulas de matemática.
_____32. Estudar matemática é um completo desperdício de tempo.
_____33. De todas as aulas, as que mais gosto são as de matemática.
_____34. Se não consigo resolver um problema de matemática, continuo a pensar nele até o conseguir resolver.
_____35. Acho a matemática aborrecida porque não deixa espaço para a opinião pessoal.
_____36. Eu costumo gostar da disciplina de matemática na escola.
_____37. Eu não tenciono inscrever-me noutras disciplinas de matemática que não sejam obrigatórias.
_____38. Eu não entendo a utilidade da matemática.
_____39. A matemática ajuda a desenvolver a mente e ensina uma pessoa a pensar.
_____40. Eu não gosto de resolver problemas de matemática.

Appendix C – Final Study Questionnaire

Inventário de Atitudes Face à Matemática

Instruções: Neste questionário pretende-se descrever a sua atitude em relação à matemática. Por favor, responda de uma forma sincera às várias questões, pois não há respostas certas ou erradas, nem boas ou más. A sua verdadeira opinião será a melhor resposta. Leia com muita atenção antes de responder. Escolha a letra que corresponde à afirmação que melhor descreve os seus sentimentos. O questionário é confidencial. Se tiver dúvidas solicite o seu esclarecimento. Não deixe qualquer item sem resposta. Muito obrigado pela sua colaboração!

Parte 1: Identificação

2. Sexo: Masc. __ Fem. __ 2. Idade: _____
7. Número de horas dedicadas a estudar matemática, por semana: _____
8. A minha nota na disciplina de Matemática no 12º ano (ou no último ano antes da entrada na universidade foi): _____
9. A minha média de entrada na universidade foi: _____
10. Ano de entrada na universidade: _____
11. Curso: ________________________

Parte 2: Atitudes relativamente à matemática
Por favor, utilize os códigos de resposta:

(A) Concordo totalmente	**(D)** Discordo ligeiramente
(B) Concordo medianamente	**(E)** Discordo medianamente
(C) Concordo ligeiramente	**(F)** Discordo totalmente

____1. Eu nunca gostei de matemática e é o meu assunto mais temido.
____2. Eu sou bom a resolver problemas de matemática.
____3. Eu entendo o que é explicado nas aulas de matemática.
____4. Eu desisto facilmente quando os problemas de matemática são difíceis.
____5. Estou disposto a aprender mais matemática do que o necessário.
____6. Eu preferiria fazer uma composição a fazer um trabalho de matemática.
____7. Estou à vontade para expressar as minhas ideias sobre como procurar soluções para um problema difícil de matemática.
____8. Não fico muito entusiasmado com matemática.
____9. Eu fico completamente em branco e não me lembro de nada quando estou prestes a resolver um problema de matemática.
____10. Não há nada de criativo sobre a matemática, é só memorizar fórmulas e coisas.
____11. Não importa o quanto estude, a matemática é sempre difícil para mim.
____12. Nos dias que tenho matemática, não tenho vontade de ir à universidade.
____13. Os desafios da matemática não me agradam.
____14. Estou sempre sobre uma pressão terrível nas aulas de matemática.
____15. De todas as aulas, as que mais gosto são as de matemática.
____16. Se não consigo resolver um problema de matemática, continuo a pensar nele até o conseguir resolver.
____17. Acho a matemática aborrecida porque não deixa espaço para a opinião pessoal.
____18. Eu costumo gostar da disciplina de matemática na escola.
____19. Eu não tenciono inscrever-me noutras disciplinas de matemática que não sejam obrigatórias.
____20. Eu não gosto de resolver problemas de matemática.

Appendix D – Decreto Lei no. 42/2005 de 22 de Fevereiro

(See next page)

MINISTÉRIO DA CIÊNCIA, INOVAÇÃO E ENSINO SUPERIOR

Decreto-Lei n.º 42/2005

de 22 de Fevereiro

A 19 de Junho de 1999, os ministros da educação de 29 Estados europeus, entre os quais o Estado Português, subscreveram a Declaração de Bolonha, acordo que contém como objectivo central o estabelecimento, até 2010, do espaço europeu de ensino superior, coerente, compatível, competitivo e atractivo para estudantes europeus e de países terceiros, espaço que promova a coesão europeia através do conhecimento, da mobilidade e da empregabilidade dos seus diplomados.

Consolidado sucessivamente em reuniões dos ministros da educação consagradas à realização do espaço europeu de ensino superior, primeiro em 2001 em Praga, depois em 2003 em Berlim, o Processo de Bolonha representa um vector determinante para o cumprimento da Estratégia de Lisboa para 2010, aprovada em Março de 2000 pelos presidentes e chefes de governo dos países da União Europeia, que visa tornar a Europa, até 2010, o espaço económico mais dinâmico e competitivo do mundo, baseado no conhecimento e capaz de garantir um crescimento económico sustentável, com mais e melhores empregos e com maior coesão social.

No plano do ensino superior preconiza-se uma importante mudança nos paradigmas de formação, centrando-a na globalidade da actividade e nas competências que os jovens devem adquirir, e projectando-a para várias etapas da vida de adulto, em necessária ligação com a evolução do conhecimento e dos interesses individuais e colectivos.

São especialmente considerados:

i) O reconhecimento da necessária adaptação do processo de aprendizagem aos conceitos e perspectivas da sociedade moderna e aos meios tecnológicos disponíveis;

ii) A percepção da necessidade de tornar o ensino superior mais atractivo e mais próximo dos interesses da sociedade, permitindo aos jovens uma escolha que lhes traga maior satisfação pessoal e maior capacidade competitiva no mercado europeu;

iii) A percepção de que o conhecimento é um bem universal, na abertura que se preconiza deste espaço do conhecimento a países terceiros.

São objectivos fundamentalmente sedimentados na colaboração institucional transnacional e no intercâmbio cultural, sustentado este na mobilidade de estudantes e profissionais.

No sentido da prossecução dos objectivos identificados, os Estados que aderiram ao Processo de Bolonha comprometeram-se a adoptar um conjunto de acções de reformulação em organização, em métodos e em conteúdos dos seus sistemas do ensino superior.

Assim, em coerência com os compromissos resultantes dos desenvolvimentos do Processo de Bolonha, foi elaborado o presente diploma, que institui os princípios reguladores dos instrumentos para a criação do espaço europeu de ensino superior consubstanciado, designadamente:

i) Na estrutura de três ciclos no ensino superior segundo as orientações basicamente adoptadas por todos os Estados signatários da Declaração de Bolonha;

ii) Na instituição de graus académicos intercompreensíveis e comparáveis;

iii) Na organização curricular por unidades de crédito acumuláveis e transferíveis no âmbito nacional e internacional;

iv) Nos instrumentos de mobilidade estudantil no espaço europeu de ensino superior durante e após a formação.

A criação de um novo sistema de créditos curriculares (ECTS — *european credit transfer system),* que virá substituir o sistema de créditos consignado no Decreto-Lei n.º 173/80, de 29 de Maio, constitui um dos instrumentos mais relevantes desta política europeia de evolução do paradigma formativo.

Nesta nova concepção, o estudante desempenha o papel central, quer na organização das unidades curriculares, cujas horas de contacto assumirão a diversidade de formas e metodologias de ensino mais adequadas, quer na avaliação e creditação, as quais considerarão a globalidade do trabalho de formação do aluno, incluindo as horas de contacto, as horas de projecto, as horas de trabalho de campo, o estudo individual e as actividades relacionadas com avaliação, abrindo-se também a actividades complementares com comprovado valor formativo artístico, sócio-cultural ou desportivo.

Por sua vez, a instituição do suplemento ao diploma, que deve ser emitido na língua original e numa língua de ampla divulgação na União Europeia, facilitará a mobilidade e a empregabilidade com base em informações sólidas e precisas sobre as qualificações, designadamente a natureza, nível, contexto e conteúdo dos estudos realizados pelo seu titular.

Deve ainda realçar-se o alcance e o impacte de outras inovações consagradas pelo presente diploma, tais como a adopção de uma escala europeia de comparabilidade de classificações e, no contexto da mobilidade, o contrato de estudos, o boletim de registo académico e o guia informativo do estabelecimento de ensino.

Foram ouvidos o Conselho Consultivo do Ensino Superior, o Conselho de Reitores das Universidades Portuguesas, o Conselho Coordenador dos Institutos Superiores Politécnicos e a Associação Portuguesa do Ensino Superior Privado.

Assim:

Nos termos da alínea *a*) do n.º 1 do artigo 198.º da Constituição, o Governo decreta o seguinte:

Princípios reguladores de instrumentos para a criação do espaço europeu de ensino superior

CAPÍTULO I

Objecto, âmbito e conceitos

Artigo 1.º

Objecto

O presente diploma aprova os princípios reguladores de instrumentos para a criação do espaço europeu de ensino superior.

Artigo 2.º

Âmbito

1 — O presente diploma aplica-se:

a) A todos os estabelecimentos de ensino superior, adiante designados genericamente por estabelecimentos de ensino;

b) A todas as formações ministradas por estabelecimentos de ensino superior conducentes à obtenção de um grau de ensino superior, adiante designadas genericamente por cursos.

2 — O presente diploma aplica-se igualmente aos cursos não conferentes de grau ministrados por estabelecimentos de ensino superior, que sejam objecto de avaliação e de certificação.

Artigo 3.º

Conceitos

Entende-se por:

a) «Unidade curricular» a unidade de ensino com objectivos de formação próprios que é objecto de inscrição administrativa e de avaliação traduzida numa classificação final;
b) «Plano de estudos de um curso» o conjunto organizado de unidades curriculares em que um estudante deve obter aprovação para:

i) A obtenção de um determinado grau académico;
ii) A conclusão de um curso não conferente de grau;
iii) A reunião de uma parte das condições para obtenção de um determinado grau académico;

c) «Ano curricular», «semestre curricular» e «trimestre curricular» as partes do plano de estudos do curso que, de acordo com o respectivo instrumento legal de aprovação, devam ser realizadas pelo estudante, quando em tempo inteiro e regime presencial, no decurso de um ano, um semestre ou um trimestre lectivo, respectivamente;
d) «Duração normal de um curso» o número de anos, semestres e ou trimestres lectivos em que o curso deve ser realizado pelo estudante, quando a tempo inteiro e em regime presencial;
e) «Horas de contacto» o tempo utilizado em sessões de ensino de natureza colectiva, designadamente em salas de aula, laboratórios ou trabalhos de campo, e em sessões de orientação pessoal de tipo tutorial;
f) «Crédito» a unidade de medida do trabalho do estudante sob todas as suas formas, designadamente, sessões de ensino de natureza colectiva, sessões de orientação pessoal de tipo tutorial, estágios, projectos, trabalhos no terreno, estudo e avaliação;
g) «Créditos de uma unidade curricular» o valor numérico que expressa o trabalho que deve ser efectuado por um estudante para realizar uma unidade curricular;
h) «Créditos de uma área científica» o valor numérico que expressa o trabalho que deve ser efectuado por um estudante numa determinada área científica;
i) «Estrutura curricular de um curso» o conjunto de áreas científicas que integram um curso e o número de créditos que um estudante deve reunir em cada uma delas para:

i) A obtenção de um determinado grau académico;
ii) A conclusão de um curso não conferente de grau;
iii) A reunião de uma parte das condições para obtenção de um determinado grau académico;

j) «Diploma» o documento emitido na forma legalmente prevista, comprovativo da atribuição de um grau académico emitido pelo estabelecimento de ensino que o confere. São diplomas, para os efeitos deste diploma legal:

i) As cartas de curso;
ii) As cartas magistrais;
iii) As cartas doutorais;
iv) As certidões que comprovem a titularidade de um grau académico;
v) O documento oficial comprovativo da conclusão de um curso não conferente de grau emitido pelo estabelecimento de ensino que o ministra e as respectivas certidões;

l) «Parte de um curso superior» um conjunto de unidades curriculares que integram o plano de estudos de um curso e cuja ministração, a tempo inteiro e em regime presencial, não excede um ano lectivo;
m) «Estudante em mobilidade» o estudante matriculado e inscrito num estabelecimento de ensino superior e curso que realiza parte desse curso noutro estabelecimento de ensino superior;
n) «Estabelecimento de origem» o estabelecimento de ensino, nacional ou estrangeiro, em que se encontra matriculado e inscrito o estudante em mobilidade;
o) «Estabelecimento de acolhimento» o estabelecimento de ensino, nacional ou estrangeiro, em que o estudante em mobilidade frequenta parte de um curso superior.

CAPÍTULO II

Sistema de créditos curriculares

Artigo 4.º

Expressão em créditos

1 — As estruturas curriculares dos cursos de ensino superior expressam em créditos o trabalho que deve ser efectuado pelo estudante em cada área científica.

2 — Os planos de estudos dos cursos de ensino superior expressam em créditos o trabalho que deve ser efectuado pelo estudante em cada unidade curricular, bem como a área científica em que esta se integra.

Artigo 5.º

Número de créditos

O número de créditos a atribuir por cada unidade curricular é determinado de acordo com os seguintes princípios:

a) O trabalho é medido em horas estimadas de trabalho do estudante;
b) O número de horas de trabalho do estudante a considerar inclui todas as formas de trabalho previstas, designadamente as horas de contacto e as horas dedicadas a estágios, projectos, trabalhos no terreno, estudo e avaliação;
c) O trabalho de um ano curricular realizado a tempo inteiro situa-se entre mil e quinhentas e mil seiscentas e oitenta horas e é cumprido num período de 36 a 40 semanas;
d) O número de créditos correspondente ao trabalho de um ano curricular realizado a tempo inteiro é de 60;

e) Para períodos curriculares de duração inferior a um ano, o número de créditos é atribuído na proporção que representem do ano curricular;
f) O número de créditos correspondente ao trabalho de um curso realizado a tempo inteiro é igual ao produto da duração normal do curso em anos curriculares ou fracção por 60;
g) Os créditos conferidos por cada unidade curricular são expressos em múltiplos de meio crédito;
h) A uma unidade curricular integrante do plano de estudos de mais de um curso do mesmo estabelecimento de ensino superior deve ser atribuído o mesmo número de créditos, independentemente do curso.

Artigo 6.º

Trabalhos de dissertação e de tese

O número de créditos a atribuir aos trabalhos de dissertação e de tese previstos para a obtenção de graus académicos ou de diplomas de cursos não conferentes de grau é fixado tendo em consideração o tempo médio normal estimado como necessário à sua preparação e avaliação, medido em anos lectivos ou fracção, correspondendo um ano lectivo de trabalho a 60 créditos.

Artigo 7.º

Cursos ministrados em regime de tempo parcial

1 — Nos cursos ministrados em regime de tempo parcial, a atribuição de créditos a cada unidade curricular é feita com base na duração normal e na organização do plano de estudos do curso em regime de tempo inteiro.

2 — Consideram-se, designadamente, abrangidos pelo número anterior os cursos ministrados em regime nocturno prolongado.

Artigo 8.º

Ensino a distância

1 — Nos cursos ministrados total ou parcialmente em regime de ensino a distância aplica-se o sistema de créditos curriculares.

2 — Às unidades curriculares oferecidas, em alternativa, em regime presencial e a distância é atribuído o mesmo número de créditos.

Artigo 9.º

Casos especiais

1 — O órgão legal e estatutariamente competente do estabelecimento de ensino superior fixa as condições de aplicação do sistema de créditos curriculares aos cursos que não se organizem em anos, semestres ou trimestres lectivos.

2 — Na atribuição dos créditos são aplicados os princípios fixados pelo presente diploma.

Artigo 10.º

Cursos não conferentes de grau

1 — O órgão legal e estatutariamente competente do estabelecimento de ensino superior fixa as condições de aplicação do sistema de créditos curriculares aos cursos não conferentes de grau por ele ministrados.

2 — Na atribuição dos créditos são aplicados os princípios fixados pelo presente diploma.

Artigo 11.º

Regulamentação

O órgão legal e estatutariamente competente de cada estabelecimento de ensino superior aprova um regulamento de aplicação do sistema de créditos curriculares, o qual inclui, designadamente, os procedimentos e regras a adoptar para a fixação dos créditos a obter em cada área científica e a atribuir por cada unidade curricular.

Artigo 12.º

Normas técnicas

Por despacho do director-geral do Ensino Superior, a publicar na 2.ª série do *Diário da República,* são fixadas as normas técnicas a que deve obedecer a apresentação das estruturas curriculares e dos planos de estudos dos cursos e a sua publicação.

Artigo 13.º

Avaliação, acompanhamento e acreditação

A aplicação do sistema de créditos curriculares é objecto de apreciação no quadro do sistema de avaliação e acompanhamento do ensino superior e de acreditação dos seus estabelecimentos de ensino e cursos.

CAPÍTULO III

Avaliação, classificação e qualificação

SECÇÃO I

Princípios gerais

Artigo 14.º

Avaliação

1 — O grau de cumprimento por parte do aluno dos objectivos de cada unidade curricular em que se encontra inscrito é objecto de avaliação.

2 — A avaliação realiza-se de acordo com as normas aprovadas pelo órgão legal e estatutariamente competente do estabelecimento de ensino.

Artigo 15.º

Classificação das unidades curriculares

1 — A avaliação final de uma unidade curricular é expressa através de uma classificação na escala numérica inteira de 0 a 20.

2 — Considera-se:

a) Aprovado numa unidade curricular o aluno que nela obtenha uma classificação não inferior a 10;
b) Reprovado numa unidade curricular o aluno que nela obtenha uma classificação inferior a 10.

Artigo 16.º

Classificação final e qualificação dos graus e cursos

1 — Aos graus académicos e aos cursos não conferentes de grau, é atribuída uma classificação ou qualificação final nos termos estabelecidos pelas normas

legais reguladoras do regime jurídico de atribuição de graus e diplomas.

2 — A classificação ou qualificação final é atribuída pelo órgão legal e estatutariamente competente do estabelecimento de ensino.

3 — A classificação final é expressa no intervalo 10-20 da escala numérica inteira de 0 a 20.

4 — A qualificação final é expressa nos termos estabelecidos pelas normas legais a que se refere o n.º 1.

Artigo 17.º

Menção qualitativa

Por decisão do órgão legal e estatutariamente competente de cada estabelecimento de ensino, às classificações finais pode ser associada uma menção qualitativa com quatro classes:

a) 10 a 13 — *Suficiente;*
b) 14 e 15 — *Bom;*
c) 16 e 17 — *Muito bom;*
d) 18 a 20 — *Excelente.*

SECÇÃO II

Escala europeia de comparabilidade de classificações

Artigo 18.º

Escala

A escala europeia de comparabilidade de classificações para os resultados de aprovado é constituída por cinco classes, identificadas pelas letras *A* a *E*.

Artigo 19.º

Correspondência entre escalas

Entre o intervalo 10-20 da escala numérica inteira de 0 a 20 e a escala europeia de comparabilidade de classificações, adopta-se a seguinte correspondência:

a) *A*: 20 a *p*, sendo *p* a classificação que permite abranger, nesta classe, 10% dos alunos;
b) *B*: *p*-1 a *q*, sendo *q* a classificação que permite abranger, no conjunto desta classe com a classe anterior, 35% dos alunos;
c) *C*: *q*-1 a *r*, sendo *r* a classificação que permite abranger, no conjunto desta classe com as classes anteriores, 65% dos alunos;
d) *D*: *r*-1 a *s*, sendo *s* a classificação que permite abranger, no conjunto desta classe com as classes anteriores, 90% dos alunos;
e) *E*: *s*-1 a 10.

Artigo 20.º

Princípios de aplicação da correspondência às classificações finais

1 — A fixação das classificações finais abrangidas por cada uma das classes da escala europeia de comparabilidade de classificações é feita pelo órgão legal e estatutariamente competente do estabelecimento de ensino no respeito pelos seguintes princípios:

a) É estabelecida para cada par estabelecimento/curso;
b) Considera a distribuição das classificações finais no conjunto de, pelo menos, os três anos mais recentes, e num total de, pelo menos, 100 diplomados;
c) Quando uma classificação abranja duas classes, considera-se, em princípio, na primeira delas.

2 — Quando não for possível atingir a dimensão da amostra a que se refere a alínea *b*) do número anterior, a utilização da escala europeia de comparabilidade de classificações é substituída pela menção do número de ordem da classificação do diploma no ano lectivo em causa e do número de diplomados nesse ano.

Artigo 21.º

Aplicação da correspondência às qualificações

Quando a um grau académico ou a um curso não conferente de grau tiver sido atribuída uma qualificação final, entre esta e a escala europeia de comparabilidade de classificações adopta-se a correspondência que for estabelecida pelas normas legais que determinam a adopção de qualificação final.

Artigo 22.º

Princípios de aplicação da correspondência às classificações das unidades curriculares

1 — A fixação das classificações das unidades curriculares abrangidas por cada uma das classes da escala europeia de comparabilidade de classificações é feita pelo órgão legal e estatutariamente competente do estabelecimento de ensino no respeito pelos seguintes princípios:

a) É estabelecida para cada unidade curricular;
b) Considera a distribuição das classificações finais dos estudantes aprovados nessa unidade curricular no conjunto de, pelo menos, os três anos mais recentes, e num total de, pelo menos, 100 diplomados:
c) Quando uma classificação abranja duas classes, considera-se, em princípio, na primeira delas.

2 — Quando não for possível atingir a dimensão da amostra a que se refere a alínea *b*) do número anterior, a utilização da escala europeia de comparabilidade de classificações é substituída pela menção do número de ordem da classificação do estudante no conjunto dos aprovados na disciplina no ano lectivo em causa e o número de aprovados nesse ano.

CAPÍTULO IV

Mobilidade durante a formação

SECÇÃO I

Contrato de estudos

Artigo 23.º

Contrato de estudos

A realização de parte de um curso superior por um estudante em mobilidade está condicionada à prévia celebração de um contrato de estudos.

Artigo 24.º

Intervenientes no contrato de estudos

O contrato de estudos é celebrado entre o estabelecimento de ensino de origem, o estabelecimento de ensino de acolhimento e o estudante.

Artigo 25.º

Conteúdo do contrato de estudos

O contrato de estudos para os estudantes cujo estabelecimento de origem é um estabelecimento de ensino superior português inclui, obrigatoriamente:

a) As unidades curriculares que o estudante irá frequentar no estabelecimento de ensino de acolhimento, a língua em que são ministradas e avaliadas e o número de créditos que atribuem;
b) As unidades curriculares do estabelecimento de ensino de origem cuja aprovação é substituída pela aprovação nas referidas na alínea *a*) e o número de créditos que atribuem em caso de aprovação;
c) Os critérios que o estabelecimento de origem adoptará na conversão das classificações das unidades curriculares em que o estudante obteve aprovação no estabelecimento de acolhimento;
d) O intervalo de tempo em que decorrerá a frequência do estabelecimento de ensino de acolhimento.

Artigo 26.º

Alterações ao contrato de estudos

As alterações ao contrato de estudos revestem obrigatoriamente a forma de aditamentos ao mesmo.

Artigo 27.º

Modelo do contrato de estudos

Os contratos de estudos e as suas alterações:

a) São elaborados de acordo com um modelo aprovado por portaria do Ministro da Ciência, Inovação e Ensino Superior;
b) São escritos em português e em inglês ou, em alternativa ao inglês, na língua do estabelecimento de acolhimento se assim for acordado entre os estabelecimentos de ensino.

Artigo 28.º

Valor do contrato de estudos

1 — O contrato de estudos subscrito por um estabelecimento de ensino superior português na qualidade de estabelecimento de acolhimento tem o valor de aceitação da inscrição no curso e nas unidades curriculares dele constantes.

2 — O contrato de estudos subscrito por um estabelecimento de ensino superior português na qualidade de estabelecimento de origem tem o valor de decisão de equivalência de unidades curriculares e vincula o estabelecimento à adopção do critério de conversão de classificações dele constante.

SECÇÃO II

Boletim de registo académico

Artigo 29.º

Boletim de registo académico

Ao estudante que realizou ou vai realizar parte de um curso superior como estudante em mobilidade é emitido um boletim de registo académico.

Artigo 30.º

Conteúdo do boletim de registo académico

1 — O boletim de registo académico indica as unidades curriculares em que o estudante obteve aprovação.

2 — Para cada unidade curricular são, designadamente, indicados:

a) A denominação;
b) O número de créditos que atribui;
c) A classificação segundo o sistema de classificação legalmente aplicável;
d) A classificação segundo a escala europeia de comparabilidade de classificações.

Artigo 31.º

Modelo do boletim de registo académico

1 — O boletim de registo académico é elaborado de acordo com um modelo aprovado por portaria do Ministro da Ciência, Inovação e Ensino Superior.

2 — O boletim de registo académico é um documento bilingue, escrito em português e inglês.

Artigo 32.º

Emissão do boletim de registo académico

1 — O boletim de registo académico é emitido, obrigatoriamente:

a) Pelo estabelecimento de ensino na qualidade de estabelecimento de origem, para instruir a candidatura do estudante à frequência de parte do curso no estabelecimento de acolhimento;
b) Pelo estabelecimento de ensino na qualidade de estabelecimento de acolhimento, para certificar a aprovação nas unidades curriculares frequentadas com aproveitamento pelo estudante.

2 — Pela emissão do boletim de registo académico não é cobrado qualquer valor.

Artigo 33.º

Valor legal do boletim de registo académico

O boletim de registo académico emitido pelo estabelecimento de ensino na qualidade de estabelecimento de acolhimento tem o valor legal de certificado dos resultados obtidos.

SECÇÃO III

Guia informativo do estabelecimento de ensino

Artigo 34.º

Guia informativo do estabelecimento de ensino

Cada estabelecimento de ensino elabora e disponibiliza um guia informativo.

Artigo 35.º

Conteúdo do guia informativo do estabelecimento de ensino

1 — O guia informativo do estabelecimento de ensino é uma descrição do estabelecimento de ensino e das suas unidades orgânicas, dos graus que confere e dos cursos que ministra, indicando para estes as suas condições de acesso, duração, unidades curriculares e seus conteúdos, cargas horárias, créditos que confere e métodos de ensino e de avaliação de conhecimentos. O guia

informativo inclui igualmente informação de natureza geral necessária à integração dos estudantes.

2 — O guia pode ser elaborado para o estabelecimento de ensino ou para as suas unidades orgânicas, separadamente.

3 — O guia é um documento bilingue, escrito em português e inglês.

Artigo 36.º

Responsabilidade pela elaboração do guia informativo do estabelecimento de ensino

A responsabilidade pela elaboração do guia informativo do estabelecimento de ensino é do seu órgão legal e estatutariamente competente.

Artigo 37.º

Disponibilização do guia informativo do estabelecimento de ensino

O guia informativo do estabelecimento de ensino é disponibilizado através da Internet, sem prejuízo da sua publicação por outras formas.

CAPÍTULO V

Mobilidade após a formação

Artigo 38.º

Suplemento ao diploma

O suplemento ao diploma é um documento complementar do diploma que:

a) Descreve o sistema de ensino superior português e o seu enquadramento no sistema educativo à data da obtenção do diploma;
b) Caracteriza a instituição que ministrou o ensino e que conferiu o diploma;
c) Caracteriza a formação realizada (grau, área, requisitos de acesso, duração normal, nível) e o seu objectivo;
d) Fornece informação detalhada sobre a formação realizada e os resultados obtidos.

Artigo 39.º

Modelo do suplemento ao diploma

1 — O suplemento ao diploma é emitido de acordo com modelo aprovado por portaria do Ministro da Ciência, Inovação e Ensino Superior.

2 — A descrição do sistema de ensino superior português e do seu enquadramento no sistema educativo é um texto comum, igualmente aprovado pela portaria a que se refere o número anterior.

3 — O suplemento ao diploma é um documento bilingue, escrito em português e inglês.

Artigo 40.º

Emissão do suplemento ao diploma

1 — O suplemento ao diploma é emitido obrigatoriamente sempre que é emitido um diploma e só neste caso.

2 — Pela emissão do suplemento ao diploma não pode ser cobrado qualquer valor.

Artigo 41.º

Competência para a emissão do suplemento ao diploma

O suplemento ao diploma é emitido pela entidade competente para a emissão do diploma.

Artigo 42.º

Valor legal do suplemento ao diploma

O suplemento ao diploma tem natureza informativa, não substitui o diploma nem faz prova da titularidade da habilitação a que se refere.

CAPÍTULO VI

Disposições finais e transitórias

Artigo 43.º

Prazos

1 — As normas técnicas a que se refere o artigo 12.º são aprovadas no prazo de um mês sobre a entrada em vigor do presente diploma.

2 — O regulamento a que se refere o artigo 11.º é aprovado no prazo de três meses sobre a entrada em vigor do presente diploma.

3 — O disposto no presente diploma aplica-se, com carácter obrigatório:

a) Aos cursos cuja criação, registo ou autorização de funcionamento seja solicitada depois de decorridos três meses sobre a sua entrada em vigor;
b) Aos restantes cursos, a partir do ano lectivo da entrada em funcionamento da sua reorganização decorrente do Processo de Bolonha.

4 — O prazo fixado no número anterior pode ser antecipado pelos estabelecimentos de ensino sempre que reúnam as condições para tal em data anterior.

5 — A antecipação pode concretizar-se para a totalidade ou apenas para parte das disposições aprovadas pelo presente diploma.

Artigo 44.º

Norma revogatória

1 — É revogado o artigo 68.º do Decreto n.º 18 717, de 2 de Agosto de 1930 (Estatuto da Instrução Universitária).

2 — É revogado o Decreto-Lei n.º 173/80, de 29 de Maio.

3 — Para os cursos que se encontrem organizados em unidades de crédito nos termos do Decreto-Lei n.º 173/80, de 29 de Maio, o disposto no número anterior entende-se sem prejuízo da aplicação deste decreto-lei até à entrada em funcionamento da reorganização dos cursos a que se refere o n.º 3 do artigo anterior.

Visto e aprovado em Conselho de Ministros de 23 de Dezembro de 2004. — *Pedro Miguel de Santana Lopes — Paulo Sacadura Cabral Portas — Daniel Viegas Sanches — Maria da Graça Martins da Silva Carvalho.*

Promulgado em 31 de Janeiro de 2005.

Publique-se.

O Presidente da República, JORGE SAMPAIO.

Referendado em 7 de Fevereiro de 2005.

O Primeiro-Ministro, *Pedro Miguel de Santana Lopes.*