Universidade de Trás-os-Montes e Alto Douro

Emotion vs cognition in e-learning process

The role of affective computing

Tese de Doutoramento em Informática

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Sob orientação da Professora Doutora Ana Almeida

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Resumo

As emoções desempenham um importante papel no processo de aquisição e processamento de informação de um indivíduo, pelo que inevitavelmente afetam o seu processo de aprendizagem. Algumas emoções podem ter um efeito positivo, enquanto outras interferem negativamente neste processo. Assim, entender as emoções e o seu efeito sobre a cognição no processo de aprendizagem é um tema atual e muito relevante.

Num contexto de aprendizagem tradicional o professor atua como um intermediário entre o aluno e o seu curso de aprendizagem, ele percebe o estado de espirito dos alunos e tenta adaptar o processo de ensino ao seu comportamento e às suas necessidades. Num ambiente de aprendizagem *online* este papel não existe em tempo real. Assume-se como solução possível para este problema, a introdução de mecanismos que permitam a detecção do estado emocional e a interferência no decurso do processo quando o aluno requer ajuda ou motivação para prosseguir a sua aprendizagem com sucesso. Os alunos, enquanto indivíduos, diferem nas características étnicas, no seu desenvolvimento social, intelectual, físico, psicológico e emocional. Além disso, divergem no que respeita à taxa de aprendizagem, objetivos e motivação, o que torna o seu comportamento enquanto alunos, bastante imprevisível.

Neste trabalho suportados na metodologia Design Science Research, propomos uma nova arquitetura para o desenvolvimento de plataformas de aprendizagem. Esta arquitetura permite a detecção do estado emocional do aluno num ambiente de aprendizagem *online* através da introdução de técnicas de *Affective Computing* que podem capturar o estado emocional do aluno e assim, permitir adaptar o processo de aprendizagem às suas características e necessidades.

A arquitetura desenvolvida, assume que não é apenas a emoção a única variável a considerar numa plataforma de aprendizagem *online*. A personalidade e o estilo de aprendizagem são fatores de distinção no que respeita à caracterização do aluno, sendo independentes do domínio. Esta arquitetura foi testada por um grupo de estudantes do ensino superior. Os resultados obtidos permitem concluir que a mesma pode suportar e melhorar os resultados de aprendizagem dos alunos.

Ab

Abstract

Emotion plays an important role in knowledge acquisition and processing of an individual. Thus it is assumed that emotions affect the way people learn and that some emotions can help or hinder the learning process. So, the importance of understanding affects and its effect on cognition and it's in the learning process.

In a traditional learning context the teacher serves as a facilitator between the student and his learning course, he easily perceives the student state of mind and adjusts the teaching process to the student's needs and behaviour. In an online learning environment this real time role does not exist. A possible solution to this problem can be the addition of mechanisms that enable computers to detect and interfere when the student requires help or motivation to proceed with success. Hence, the proposal of a new architecture that applied to learning platforms will try to near the gap between the students and online learning platforms in respect to emotion influence.

This architecture will assess the emotional state of the student in an online learning environment by introducing techniques of Affective Computing that can capture the student emotional state and based on that, adapt the course to the characteristics and needs of the student in order to get an improvement in the learning results. Students, as individuals, differ in their social, intellectual, physical, psychological, emotional, and ethnic characteristics. Also, differ in their learning rates, objectives and motivation turning, their behaviour rather unpredictable. Added to emotion, and in order to obtain an effective architecture for online learning, student's personality and learning style are also considered.

The architecture developed was tested by a group of students of higher education in Oporto. The results indicated that the architecture created used can support and improve

the student’s results, verifying that a negative emotional state could influence the learning process.

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Palavras-chave

Emoção - A emoção é um estado afetivo com objetivos, refletindo uma avaliação subjacente a um determinado tipo de situação. Além de informações sobre o valor, experimentando uma emoção específica informa um, que um conjunto específico de critérios de avaliação foi cumprido. Diferentes emoções da mesma valência podem ter efeitos diferentes, que podem ser previstos com base na avaliação subjacente (Clore & Huntsinger, 2007).

Affective Computing - foi desenvolvido por Rosalind Picard em 1995 como uma ferramenta para melhorar a interface homem-máquina, incluindo conotações afetivas.

Afeto – É a representação de valor pessoal (ou seja, a bondade ou maldade). Tais representações podem ser de foro neurológico, fisiológico, experiencial, cognitivo, expressivo e comportamental, entre outros (Clore & Huntsinger, 2007).

Estado afetivo - a coocorrência de diversas reações constitui um estado afetivo (Clore & Huntsinger, 2007).

Disposição - difuso, estados afetivos sem objeto (Clore & Huntsinger, 2007).

Aprender - é um processo complexo que é frequentemente entendida como uma atividade intelectual de adquirir conhecimentos ou como uma combinação de dimensões intelectuais e físicas, necessário para desenvolver uma certa habilidade (News, 2004).

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Keywords

Emotion – Emotion is an affective state with objects, reflecting an underlying appraisal of a particular kind of situation. In addition to value information, experiencing a specific emotion informs one, that a specific set of appraisal criteria has been met. Different emotions of the same valence can have different effects, which can be predicted on the basis of the underlying appraisal (Clore & Huntsinger, 2007).

Affective Computing - was developed by Rosalind Picard in 1995 as a tool to improve the interface human-machine by including affective connotations.

Affect - representations of personal value (i.e. the goodness or badness of things). Such representations can be neurological, physiological, experiential, cognitive, expressive and behavioural, among others (Clore & Huntsinger, 2007).

Affective state - the co-occurrence of several such reactions constitutes an affective state (Clore & Huntsinger, 2007).

Mood - diffuse, objectless affective states (Clore & Huntsinger, 2007).

Learning - is a complex process that is frequently understood as an intellectual activity of gaining knowledge or as a combination of intellectual and physical dimensions, required to develop a certain skill (News, 2004).

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Ac

Acronyms

In this thesis are used common designations of abbreviations are only showed when it first use:

AU - Action Units

ANEW - Affective Norms for English Words

BPMS - Body Posture Measurement System

DDN - Dynamic Decision Networks

DSR - Design Science Research

ECG - Electrocardiogram

EDA- Electro dermal Activity

EEG - Electroencephalography

EMG - Electromyograms

EOG - Electrooculogram

ERP - Event-Related Potential

FACS - Facial Action Coding System

FER - Facial Expression Recognition

fMRI - Functional Magnetic Resonance Imaging

GENSES - Geneva Expert System on Emotion

IADS - International Affective Digitized Sounds IHCI - Intelligent Human–Computer Interaction

IAPS - International Affective Picture System

ILS - Index of Learning Styles

IR - Individual-Response IS - Information Systems

LIVs - Law of Initial Values

LIWC - Linguistic Inquiry and Word Count

LSI - Learning Style Inventory

MAUI - Multimodal Affective User Interface

MDS - Multidimensional scaling

MHCI - Multimodal Human-Computer Interaction

OCC - Ortony, Clore, and Collins

OCEAN - Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism

PT - Placement test

SER - Speech Emotion Recognition

SC - Subject Content

SR - Stimulus-Response

ST - Subject Test

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1. Introduction

Human to human communication depends on the interpretation of a mix of audio-visual and sensorial signals. To simulate the same behaviour in a human-machine interface the computer has to be able to detect affective state and behaviour alterations and modify its interaction accordingly. The field of affective computing develops systems and mechanisms that are able to recognize, interpret and simulate human emotions (Picard et al., 2004) so closing the gap between human and machine. Affective Computing concept was introduced by Rosalind Picard in 1995 as a tool to improve human-machine interfaces by including affective connotations.

Emotion plays an important role in the decision process and knowledge acquisition of an individual. Therefore, it directly influences the perception, the learning process, the way people communicate and the way rational decisions are made. So the importance of understanding affects and its effect on cognition and in the learning process. To understand how the emotions influence the learning process several models were developed. Models like Russell's Circumplex model (James a. Russell, 1980) are used to describe user's emotion space and Kort's learning spiral model (Kort, Reilly, & Picard, 2001) are used to explore the affective evolution during learning process.

In a traditional learning context the teacher serves as a facilitator between the student and his learning material. Students, as individuals, differ in their social, intellectual, physical, emotional, and ethnic characteristics. Also, differ in their learning rates, objectives and motivation turning, their behaviour rather unpredictable. The teacher has to perceive the student state of mind and adjust the teaching process to the student's needs and behaviour. In a learning platform this feedback process does not take place in real time and, sometimes it is not what the student requires to overcome the problem at hand. This overtime can

become a major problem and cause difficulties to the student learning process. A possible solution to this problem could be the addition of mechanisms, to the learning platforms, that enable computers to detect and interfere when the student requires help or motivation to complete a task. The major difficulties of this work will be the detection of these situations and how to interfere. The method of detection cannot be too intrusive, because that would affect the student behaviour in a negative way that would cause damage to his learning process. Another important issue is the selection of the variable to monitor. This can include the capture of emotions, behaviour or learning results among others. Finally, determining which will be the computer intervention when a help situation is detected in order to reverse the help situation.

1.1. Research Problem, Background and Context

The impact of emotions on learning process and especially in online learning has recently grow as shown in literature (Kort et al., 2001; Li, Cheng, & Qian, 2008; Shen, Wang, & Shen, 2009). The increasing examination of the complex set of parameters related to online learning discloses the significance of the emotional states of learners and especially the relationship between emotions and affective learning (Kort et al., 2001). Therefore the problem for this thesis is to near the gap between a student and his online learning environment. This can be achieved through the development of an architecture that can assess the student emotional state, using affective computing techniques and developing a proper response to induce a positive stimulus in order to facilitate the learning process and improve the student's learning results.

Initially a hypothesis was created regarding emotions effects in an online learning process. The hypothesis considers that student's negative emotions have negative effects on his behaviour, attention, motivation and ultimately in the learning process outcomes. On the other hand, positive emotions would benefit the learning process. This hypothesis is collaborated by some previous studies (Kort et al., 2001; Stafford, 2004; Um & Plass, 2007). Another hypothesis was made regarding the influence of the student's learning preferences and personality in his learning process. This hypothesis was also established by previous studies (Fleming & Baume, 2006; Ibrahimoglu, Unaldi, Samancioglu, & Baglibel, 2013; Komarraju, Karau, Schmeck, & Avdic, 2011; Morgan & Baker, 2012).

1.2. Significance of the research and contribution to science

Online learning, in particular e-learning platforms, have, over time, become increasingly important as learning tools. This fact is reflected in both, educational institutions as well as in the corporate level. Any age group can be taught, from teens to senior (Anglin, 2000; Mason, 2006; Repetto & Trentin, 2008; Weller, Pegler, & Mason, 2005). In spite of its unquestionable importance and success, e-learning is far from being a problematic issue in many ways. Studies point out different problems of making e-learning as part of the current learning process. These problems include e-learning system's cost that poses a problem for certain institutes and corporations (Weller, 2004). This added to the cost of keeping instructors and teachers that require awareness about online teaching, because they must use teaching methods that diverge from the ones used in traditional teaching process. In this context a key point remains, why people not always liked e-learning and are hesitant to partake in courses and in e-learning sessions (Juutinen, 2011). This happens because of several factors from the degree of technical skills necessary to the students to work the courses from the emotional state of the student (like boredom or frustration) that results on the student dropping out or to be left behind in their studies or in their work trainings (Juutinen, 2011). In a traditional teaching process the teacher takes the role of facilitator of the learning process and tries to lessen these problems by using several teaching techniques to recapture the student's attention to the learning process.

In an online learning environment this real time role does not exist, which worsens the problem faced by the students, therefore the significance of the research is to try to near the gap between students and their learning platforms. This will be achieved by introducing techniques of Affective Computer that can capture the student emotional state and based on that, change the course parameters (flow, organization or difficulty) in order to recapture student's attention.

Contributions of this work include; the development of a new architecture for assessment of the role of emotion vs. cognition in the learning process; the accomplishment of a comprehensive study of the emotions in an online learning environment, their positive and negative impact in the learning process and what stimuli can be provided to improve

student ability to learn. Added to emotion, and in order to obtain an effective architecture for online learning, student's personality and learning style will be considered

1.3. Study objectives and research questions

Learning is understood as an educational activity which aims to help develop the capacities of individuals. These capabilities make individuals able to establish a personal relationship with the environment in which they are inserted. The learning process helps the development of an individual, has he uses sensory, motor, cognitive, affective and linguistic functions (Anglin, 2000). Thus, the main research goal to find out if the consideration of student's emotional state influences their learning process. Also, if learning results can be improved through the utilization of a learning platform that takes into account the referred student's emotional state.

To carry out a study on the emotions role in online learning systems some related research issues were formulated:

- Identify and use the student's personality and learning preferences to present content and interact with the student.
- The capture student's emotional state cannot be evasive that will change his emotional state therefore Affective Computing techniques will be used.
- Another issue and possibly one of the biggest challenges will be to identify, with a certain degree of reliability, the student's emotional states. This process will also include the study of emotional states that can be recognized and what it is influence on teaching and learning process.
- The last issue is the recognition of the emotional state that provides a positive mood for learning and which incentives can be introduced to reverse a negative emotional state.

To research emotional factors in online learning and their impact in the learning process, some research questions were introduced. The main research question of this research is:

"Does a learning platform that takes into account the student's emotions, learning preferences and personality improve the student's learning results?"

To be able to research into this question, other sub-questions were developed. The sub-questions are:

Is it possible to identify and quantify correctly and accurately student's emotions during a session in an online learning environment?

Does Affective Computing techniques help improve the student learning process?

What are the stimuli that can be used to induce or change the student state of mind in order to improve the learning process?

1.4. Methodological Approach

This work applies a research methodology known as Design Science Research (DSR), to address the research problem under consideration. DSR is problem-solving paradigms in which innovations are created (Cheong, Cheong, & Filippou, 2013).

The choice of use of DSR as a research methodology for this work lies in several motives:

- The need to increase the relevance of research for education (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007) (Nieveen et al., 2006). Educational research has been questioned for its poor connection with practice (McKenney & Reeves, 2013). DSR can add to more practical approach to the research (Nieveen et al., 2006).
- Beside directly practical applications, DSR can be design to conduct experiments that examines the effects of educational interventions in actual classrooms (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). This ca be developed through combined study of both the process of learning and the means that support that process (Cobb et al., 2003) (Nieveen et al., 2006).
- The need of robustness of design practice (Nieveen et al., 2006). It is necessary to create an extract more explicit design (Nieveen et al., 2006) for the study of emotion in learning.

- The possibility of use different types of participants that can contribute in different ways, regarding their experiences, to the data gathering and analysis (Barab & Squire, 2004).
- This kind of studies is regarded as progressive since the design is continuously being revised by including new evidences achieved along the research process (Molina, 2003). As there is a continuous cycle between the design, design application, data analysis and redesign, the use of this methodology allowing researchers to constantly refine their assumptions.

In short, DSR allows creating new knowledge from the problem, it profits from unpredictable situations that can produce alterations to the design and bringing improvement, invention and demonstration of academic qualities to the research (Oates, 2006). Furthermore several studies carried out in similar work fields used DSR as the research methodology (Cheong et al., 2013; Hevner, March, Park, & Ram, 2004; McKenney & Reeves, 2013; Molina, 2003; Nieveen et al., 2006).

The DSR methodology is a settled on a set of steps to carry out the research in Information Systems (IS). It supports the design of a new artefact and the analysis of its use and performance, in order to understand and improve the behaviour of aspects of IS (Vaishnavi & Kuechler, 2004). The DSR methodology is constituted by in six steps: Problem Identification and Motivation, Objective of the Solution, Design and Development, Demonstration, Evaluation and Communication. The Problem Identification and Motivation step consists in defining the precise research problem and substantiate the solution's significance. This can be done by studying literature, findings in another work field, expressing the need for something or new improvements in technology. The Objective of the Solution step entails on deducing the objectives of the solution from the problem. Producing an experimental idea of how the research problem might be approach. The Design and Development step consists in the creation of the artefact from the experimental idea. The artefact could be in the form of constructs, models, methods among others. The Demonstration step exhibits the use of the artefact to solve the problem. This could include experimentation, simulation, case study or other suitable action. The Evaluation step consists in witnessing and measure how well the artefact could be a solution to the problem.

This step it can lead to new awareness of problem or to conclusion of it. The communication step consists in communication the of problem significance, the artefact usefulness, innovation and effectiveness to other researchers and other appropriate audiences (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008) (Hevner, 2004). Next figure illustrates the DSR steps previous described.

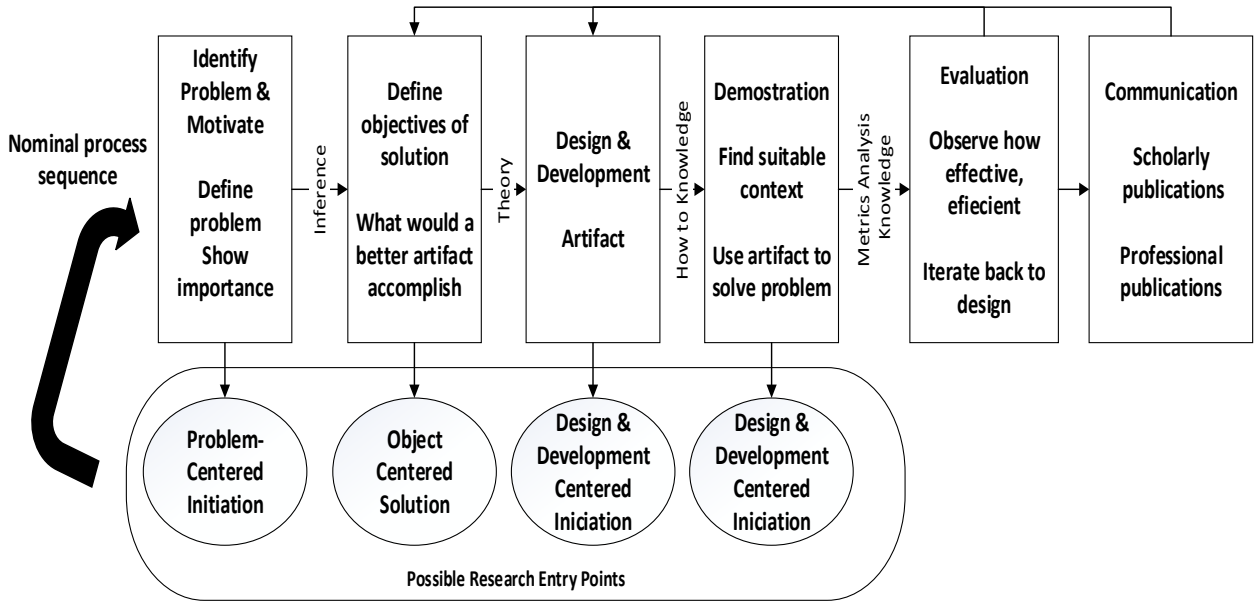

Figure 1 - DSR Methodology Process Model (Peffers et al., 2008)

To answer the question "Does a learning platform, that takes into account the student's emotions, learning preferences and personality improve the student's learning results?", after observing it is proposed, on the aim of this work, the development of a new architecture and subsequently the building of a new prototype of a learning platform entitled Emotion Test.

As was previously referred, in a traditional learning process the teacher has a role of intermediary between the message to be learned and the student. Teacher realizes the student's state of mind and behaviour and then can adjust the teaching process to the individual student. In a learning platform that feedback does not occur in real time, which over time can become a problem and will cause difficulties for the learning process, this may lead the student to give up the whole learning process. So, one faces the question, "will a

learning platform can perceive the student's emotions, personality and learning preferences, lead to an improvement of the student's learning results?"

The objective is to develop an architecture, able to help students improve their learning results in a learning platform. Based on the architecture a prototype of a learning platform will be developed. This platform will take into account student's emotions, personality and learning preferences. The major challenges include the capturing emotions process in a way that is not too intrusive to the student so that does not interfere with his learning process. Another major challenge is to correctly map the diversity of profiles of a group of students and assign appropriate actions in every moment.

After that, the architecture will enter in the step of design and development. In this step the architecture and the prototype will be planned and built. Once the architecture and prototype are developed, this will be demonstrated and evaluated by a target audience.

The work performed under the development of this thesis will be published in academic conference proceedings scientific and journal. Six publications in conferences are being planned and one in journals.

The next Figure illustrates the DSR methodology steps for this project.

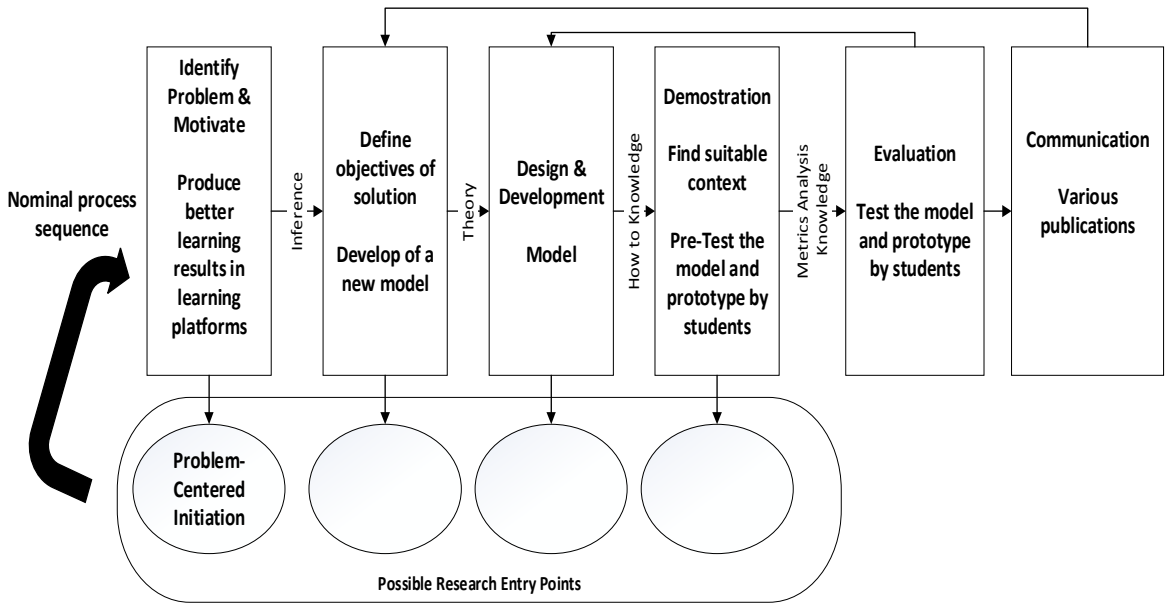

Figure 2 - DSR Methodology Process Model for this project

1.5. Organization of the document

This document is divided in five chapters. First chapter consists in the introduction of this work, already presented in this chapter.

Chapter two starts by giving an overview of the background research developed under the aim of this project. Some important related concepts are exposed, the concept of learning and e-learning and its relation with human emotions. Also, describes emotion theories and their importance in the development of systems that can capture the user emotions. In this chapter it is also given an outlook on the relationship between emotion and learning and all the models that attempt to comprehend and explain the effect of emotion in learning process.

This is followed by chapter three that outlines the architecture and prototype developed, highlighting each of the model of the architecture and the description of the used Affective Computing techniques and implementation details.

Chapter four introduces again the research objectives, the participants and data collection method. Finally presents all the data analysis and results obtained in the demonstration and evaluation steps. In sum it does an analysis of all the tests and results of the work developed.

The document ends with chapter five, in which some conclusions are made, that includes a critical overview of the performed work, limitations, recommendations for future work and final remarks.

2

2. Background Research

This chapter presents a review of the literature in which this work is based upon. This step was a crucial step, in the adopted research methodology, because it shows what previous researchers have learnt, helping to better define the research problem under consideration. It also, helps to answer the question about the existence of any research that already fills the need of the research problem, or any other needs that are very similar to the research at hand. This background research will help to establish the design criteria by defining your target user and objectives.

This chapter starts by giving an overview of the basic concepts where this work is based on, such as: Learning, e-learning and the different theories and branches of psychology are used in related research works, emotions and the theories of emotions that throughout the years tried to explain the world of emotion, affective learning and some models proposed by the different researchers, and finally affective computing and the several lines of research and different techniques that try to capture human emotion.

2.1. Learning

The education, training, skills development, learning is a process that is performed continuously almost from the second people are born. These characteristics together with the ability to learn and teach, allows us to evolve as a person. Thus, learning is inevitably linked to History of Man, to its construction as a social being capable of adapting to new situations. The learning concept is described as the act of acquiring knowledge, behaviours, abilities, standards or preferences and the study of learning was been closely linked to the development of psychology as a science (Carroll, 1997). However, this study did not proceed in a uniform and consistent manner.

The learning process research has been focused on different aspects, according to the different psychology branches. These branches did not agreed on regarding the study of learning, so there are different theories. Behaviourists Theories defended by Pavlov (R. G. G., 1928), Thorndike (Thorndike, 1913) and Skinner (Skinner, 1974), focused on the relationship between Stimulus-Response, and sought to know the laws that presided over the establishment of this relationship. Humanist theories particularly stressed the uniqueness of the experience of each one and therefore have difficulty in making laws. Cognitive theories directed their attention to cognitive processes, that is, to what is happening in the subject's head between receiving a stimulus and the execution of a response.

In a traditional learning environment the student and the teacher are the key elements inside of classroom. In this environment the teacher plays an essential role in providing an engaging learning and teaching environment. Together the teacher and students take a set of physical, social, emotional and mental characteristics and needs to the classroom. These, influence the way one relates with the other and consequently affect the way learning process will progress. The teacher is able to learn about the necessities and educational philosophy and about the nature of their students, this will improve teacher position to facilitate student's learning (Tylee, 2012).

2.2. E-learning

"Once we free ourselves from the mental limits of viewing this technology as a weak sister to face-to-face synchronous education, the potentials to revolutionize education and learning become readily apparent." – Turoff

E-learning is usually used to distribute online teaching materials. A number of other terms are also used to define this way of teaching and learning online. They include online learning, virtual learning, distributed learning, network and web based learning (Naidu, 2006). Basically, they all refer to learning processes that use information and communications technology to facilitate asynchronous as well as synchronous learning and teaching activities. In the following table is shown the type of tools and the technology that can be used in an e-learning environment.

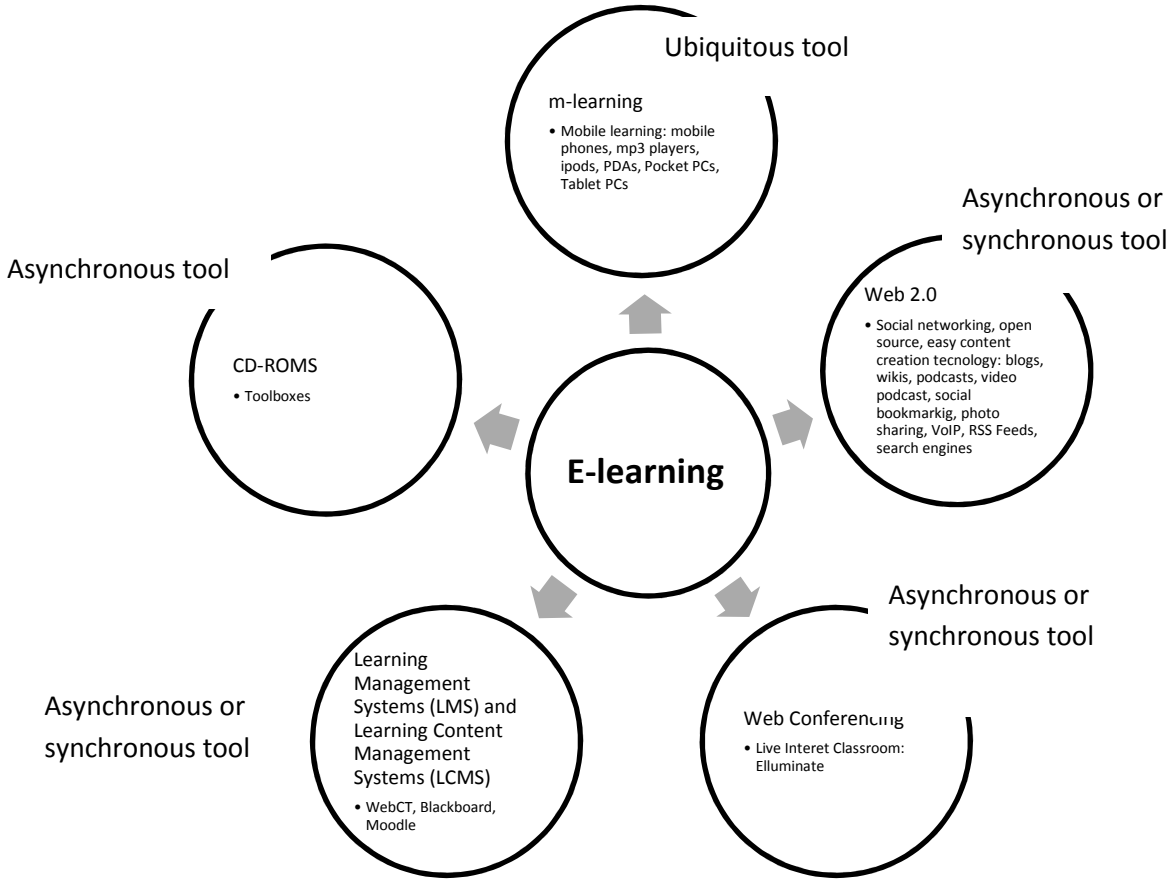

Figure 3 - E-learning Tools ("E - learning," 2009)

2.2.1. Advantages of E-learning

An E-learning environment has several advantages over traditional classroom training. The most common phase associated with E-learning is "Anytime, Anyplace, Any pace learning" ("E-Learning: A Revolutionary Approach to Teaching-Learning Process | Globe Magazine - J&K's first infotech magazine," 2012) the students are able to access E-learning materials and courses at any time that is convenient for them at any pace, using any technology available in any place. This also confers to the students the responsibility of been responsible for their own learning and the flexibility to access e-learning materials in a non-sequential way, allowing students to navigate the course content.

E-learning is cost effective, large numbers of students can have access to the same materials or the same student-to-tutor support services therefore decreasing the cost of delivery. As the learning content is located in the same place is easy to keep and updated. It is also possible to modify the learning material to suit user's needs and requirements. These learning experiences can include materials that are focused in the most relevant information

so it can be easier to capture and remember. An E-learning environment can also have interactive features like simulations and quizzes, which will reinforce the learning process.

The students can learn in a relatively anonymous environment without the embarrassment of failure and/or socio-cultural prejudice from personal contact. All the students get the same standardized set of learning materials from the e-learning environment.

E-learning environment are collaborative. The use of groups and teams working together in collaborative learning contexts allow interactions which enforce employability skills. Teaching others subjects they have learnt help them to reinforce learning process.

The student usage of the learning materials can be monitored and early possible dropout can be discovered and counteractive support can be offered. E-learning environments can be used to give instant feedback from online self-assessment or formative assessment particularly through multiple choice question formats. In addition, the students can be offered automatically marked self-assessment exercises to ascertain skill/knowledge levels and learning needs before engaging with course content. It can also assist students with certain disabilities.

2.2.2. Disadvantages of E-learning

In E-learning environments, students need to access a machine of minimum specification as indicated by the e-learning supplier or access to a service with a high bandwidth to transfer the learning materials in a suitable manner. Some of the learning materials that are intended for one specific system will not work properly on another. The e-learning environment may be unsuitable for certain types of training like any skill that needs an inter-personal contact these courses could be supplemented by e-learning. They also, can be unsuitable for certain types of students. E-learning involves a high-level of self-discipline and personal time management. The students need to be highly self-motivated to take advantage the online learning experience that can be impersonal.

The start-up of an E-learning service is expensive and the cost of production of online training materials is very high. In addition, E-learning is still reliant on human help on either

the course materials or the software. E-learning and its electronic communication does not necessarily provide a face-to-face communication, which could be pedagogically unsound. The online environment does not offer a pedagogically enhancing learning environment. Also learners may have limited IT skills, or be uncomfortable with electronic communication and need to learn how to use the medium effectively. Flexibility may be lost in adjustments to the course in response to student reaction are not easy to make once the course is underway. Furthermore Students with visual or physical impairments may be disadvantaged.

2.3. Emotions

Emotion plays an important role in the decision process and knowledge acquisition of an individual. Therefore, they directly influence perception, learning process, the way people communicate, and the way rational decisions are made. Emotions have two components: the mental component (cognitive) and the physical component (body) (Khurana, 2007) and can be classified in categories: primary, secondary and tertiary emotions. Primary emotions occurs as a response to some kind of event, which can cause a detectable physical response and trigger emotions such fear, joy, love, sadness, surprise, anger. From these emotions can result the other sub-categories (Shaver, Schwartz, Kirson, & O'Connor, 1987) as shown in Table 1.

Primary Emotions	**Secondary Emotions**	**Tertiary Emotions**
Fear	Nervousness	Anxiety, Apprehension, Distress, Dread, Tenseness, Uneasiness, Worry
	Horror	Alarm, Fright, Hysteria, Mortification, Panic, Shock, Terror
Joy	Cheerfulness	Amusement, ecstasy, gaiety, euphoria, bliss, elation, delight, happiness, jubilation
	Zest	Enthusiasm, excitement, exhilaration, thrill, contentment, relief, optimism, pride, enthrallment
Love	Affection	Fondness, attraction, adoration, sentimentality, caring
	Lust	Arousal, desire, passion, infatuation, obsession
	Longing	Longing
Sadness	Suffering	Agony, hurt, anguish
	Disappointment	Dismay and displeasure
	Shame	Guilt, remorse and regret
	Neglect	Insecurity, alienation, homesickness, embarrassment, humiliation
	Sadness	Depression, unhappiness, misery, melancholy, gloom, despair
	Sympathy	Pity, sympathy
Surprise	Surprise	Astonishment, amazement
Anger	Rage	Fury, wrath, bitterness, loathing, resentment, hate, loathing, Frustration and exasperation
	Irritation	Agitation, aggravation, grouchiness
	disgust	Revulsion, contempt, jealousy and torment
	Exasperation	Exasperation, frustration
	Envy	Envy, jealousy
	Torment	Torment

Table 1- Emotions (Shaver et al., 1987)

One of the problems of studying affect is the definition of what emotion is. Moreover, the definition and the terms associated to it. Nearly hundreds of definitions of emotion have been registered (Kleinginna & Kleinginna, 1981).

2.3.1. E-learning emotions

Literature shows that there is a connection between emotion and the learning process (Juutinen & Saariluoma, 2010; McDaniel et al., 2007; Regan, 2003). Although accord this connection is a long way from being simple and direct. It is accepted that positive and negative emotion states can cause different kinds of thinking and can have an effect under the learning perspective.

From the ample variety of human emotions one is forced to ask the question. What emotions are associated with e-learning? Previous study (Regan, 2003) show that the emotion could be deduced to five groups of emotions.

1. Frustration
2. Fear, anxiety, apprehension
3. Shame/embarrassment
4. Enthusiasm/excitement
5. Pride

Frustration seems to be the most prevalent emotion associated with online learning. Frustration is an emotion that arises in circumstances where a person is blocked from reaching a wanted result. There are several reasons why students feel frustration when interacting in an e-learning context. The most common are:

- When they have lack of time to learn how to use an e-learning system;
- When there is a computer or a system crash;
- When they can’t follow the link system or the links lead nowhere;
- When there is a lack of clear instructions to how to move in the e-learning system;

The most common response to frustration include anger, giving up, loss of self-esteem and self-confidence, stress and depression.

The reversion of the sense of frustration consists of relaxation and exercise. Relaxation tools such as deep breathing and relaxing imagery can assistance to relax feelings of frustration and anger. Also, repeating sodding phrases like "relax", "calm down" or "take it easy" can help to reverse the sense of frustration. Exercise can also calm and relax your muscles or help work off your frustration.

The use of an e-learning system, especially when the user is not skilful, can cause anxiety. Also, this emotion tends to diminish when the familiarly with the e-learning system increases. The most common reasons for anxiety are:

- When there are delays in the e-learning system;
- When faced with a problem and not knowing what to do;
- When faced with the unknown;
- When waiting to receive assignments.

Students tend to feel embarrassment when they feel exposed and have the sensation of incompetence facing a task that they should be able to do, or when they feel they are following behind and that could even stop being an active participant.

One of the positive emotion students can experience is the emotion of enthusiasm or excitement and it is believed that they play major part in the learning process. In an e-learning environment one of the most common reasons for the students to experience enthusiasm or excitement is when they experience a new way of learning and sometimes using new technology.

Pride is another emotion that students experience studying online. This emotion incites a positive disposition to learn. Usually online students get this emotion from the positive feedback of others. Other questions remain to be answered: What are the teaching-learning contexts of these emotions? How do they relate to student learning? What are the practical implications for teaching and learning online?

2.3.2. Stimulus

A stimulus is often defined as something external that can influence a stimulus response or behaviour. To provoke the stimulus response, stimulus must be sensed, processed and

interpreted by an individual. The stimulus is received by the senses and this information reported to different parts of the brain that generates a response to the stimulus. This activity is produced by the nervous system that produces neuro-electrical response, which travels along the central nervous system. The electrical change is then conducted from the brain along the nervous system, commanding the mind and body on which action to take.

The senses are continuously looking for changes in the environment, so the mind and body can adjust the stimulus response for a given moment. The process has to be filter otherwise the stimulus capture by the senses would cause an overload of normal thinking and could even stall the mental function. The brain is responsible for the filtering process in particular the thalamus (LeDoux, 2003). The thalamus filters the excessive stimuli allowing the necessary stimuli through to other parts of the brain to be process. The stimulus is processed in the region of the Amygdala, Hippocampus, and Hypothalamus(Gerber et al., 2008). The Amygdala scans for past experience and determines if strong emotion should be enclosed. This is the functioning “fight and flight centre”. It scans and links stimuli with past experience and personal perception. The Hippocampus function is to find other information in memory to link to the received stimuli (LeDoux, 2003). Its function is to cross-referencing the stimulus received with the past memory. Hypothalamus is the hormone or chemical control centre (Saper, 2014). Hormones are chemical couriers within the body. Once stimulus is understood, neurons carry the message along with the all emotions to the different parts of the body, preparing it for action or inaction (Saper, 2014).

How use to stimuli in an e-learning environment (Khan & Mohamed, 2015):

- People prefer familiar stimuli over very unusual examples. What is familiar is easier to process;
- Symmetry is valued more than non-symmetry, particularly vertical symmetry;
- Ground contrast makes graphics clear and text legible;
- Visual clarity creates an effortless experience;
- Less information is preferred over more information.

How to trigger emotions in an e-learning environment:

- Happiness (“Happiness,” 2002)

    - Happiness can be triggered by show images or playing sounds that can remind of happy things like comedies or up-beat music;
    - Another trigger for happiness is the written word. To read phases that contain words such as 'new', 'exciting' and 'wonderful' it will trigger a feel good sensation;
    - Happiness can also be trigger by a positive experience such as receiving good news or achieving a goal.
- Fear ("Fear," 2002)
    - Fear is triggered by clear an immediate threat. Fear to reach an objective or to have a bad grade;
    - Fear can be triggered by an internal forecast of the future. Afraid of what is to can;
    - Fear can also be triggered by playing sounds of danger or of immediate threat (i.e. the roar of a lion or the scream of a terrified child or sounds that can send shivers down your spine).
    - Fear can occur when confusion settles and meaning cannot be discovered. The notion that the unknown can harm us so one feels frightened, whether or not justified.
- Shame ("Shame," 2002)
    - Shame can be triggered when people are reminded what they have done and that is considered not a good thing. (I.e. a bad grade, failure to deliver an assignment);
    - Shame can be trigger when other people known what one has done.
- Sadness ("Shame," 2002)
    - Sadness can be triggered by remind of sad moments and can be caused by down-beat music, tragic plays or pictures, depressing news or people.

2.4. Affective Computing

The study of affect is included in different fields of science such as psychology, cognitive science, neuroscience, engineering, computer science, sociology, philosophy, and medicine.

This has contributed to different understanding of basic terms related to affect such as emotions, feelings, moods, attitudes, affective styles, temperament, motivation, attention, reward, and so many others (Picard et al., 2004). One of the problems in studying affect is the definition of what emotion is. Moreover, the definition and the terms associated to it. Nearly hundreds of definitions of emotion have been registered (Kleinginna & Kleinginna, 1981). To analyse emotion, there are several theories, which attempted to specify the interrelationships of all the components involving an emotion and the causes, the reasons and the function of an emotional response. Although there are several works summarizing these approaches, some of these theories are very controversial among the intellectual community. Nevertheless, they were the starting points for most of the research works done today in affect recognition.

2.4.1. Emotion Theory - Emotional Features

Darwin was the first to develop a theory about emotions (Darwin, 1956). According to Darwin observations, human face and body expressions were alike to other animals. He found out that the behaviour corresponds to emotional experiences, therefore it was a consequence of the evolutionary process. He also concluded that emotion expressions evolved through a natural selection process and they had a corresponding universal cross-culturally emotional expression.

Darwin proposed three principles: the serviceable associated habits, antithesis, and expressive habits, or nervous system discharge. The first principle reinforced the idea that expression could be used to discover a state of mind. This principle stated that useful habits reinforced previously by the course of an experience were genetically inherited by offspring. One of the examples he used was the example of contracting the eyebrows. Darwin noticed that eyebrows were a function used to prevent too much light from entering the eyes. He also noticed that the raise of the eyebrows increased the field of vision. To link this facial expression to a human behaviour, he mentioned examples of people trying to remember something and raising their brows, as though they could see what they were trying to remember (Hess & Thibault, 2009). The second principle proposed that some actions or habits were carried out simply because they were opposite in nature to a serviceable habit, but were not serviceable themselves. The example used was the shoulder shrugging, passive

action to an aggressive expression (Darwin, 1956). The third principle suggested that some habits were created because of a build-up in the nervous system, which caused a discharge of the excitement. The examples of this principle included foot and finger tapping, as well as vocal expressions (Darwin, 1956).

Even though, Darwin failed to explain some emotional expression and behaviours, there are a number of expressions that are still considered as universal, although several studies have been carried out to challenge this point of view like the ones in (Ortony & Turner, 1990), (J a Russell, 1994), (James a Russell, Bachorowski, & Fernandez-Dols, 2003). Other researchers tried to expand Darwin theories like Paul Ekman and assumed that the emotion expressions are universal and share basic emotions like fear, sadness, happiness, anger and disgust. His research was focused on the physical displays of emotion including body language. In fact, most of Facial Expression Recognition (FER) research is based on his work (P Ekman, 1993). FER is a nonintrusive technique that enables the discovery of the emotional state without having sensors and wires attached to the human body.

2.4.2. Emotion Theory - Emotional Embodiments of Physiological Changes

James-Lange Theory of Emotion was one of the first theories to attempt to describe the process of emotional reactions. James-Lange Theory states that emotions are the embodiments of certain physiological changes (physiological changes cause an emotion). The physiological changes are triggered by the autonomic nervous system and include alterations in the heart rate, muscular tendencies, and skin conductance. An example, “You're late leaving work, and as you head across the parking lot to your car, you hear footsteps behind you in the dark. Your heart pounds and your hands start to shake. You interpret this physical response as fear. (“Theories of Emotion - What, Why, How?,” 2011) ”

This theory did not clarify which physiological alteration that can produce an emotion, but was has a step in stone for the gathering of physiological data for emotion analysis.

With the advances in physiological sensors, it is possible to determine the emotional state with accuracy. Nevertheless these methods are a little bit intrusive, but possible to mitigate with the development of wearable sensors. Wearable sensors can be used in a wide variety of areas from health care to social behaviour motoring and gaming applications.

2.4.3. Emotion Theory - Cognitive appraisal to an Emotion

In emotion psychology, the term appraisal particularly refers to the cognitive evaluation antecedent of an emotional episode. The cognitive theory of emotions states that reason is a part of emotion, in essence this theory gives the notion that different individuals (with different reasons, objectives, rules…) will appraise the same experience in a different way and, consequently, present diverse emotional reactions (Manstead, Tetlock, & Manstead, 1989), (Revelle & Scherer, 2005) and (Smith & Ellsworth, 1985). Magda Arnold was the first to introduce the "cognitive theory" in the 1960s, which indicated that the first step in emotion is an appraisal of the situation. This line of research was followed by: Lazarus, 1968; Scherer, 1981; Roseman, 1982, Smith & Ellsworth, 1985; Frijda, 1986 and Ortony, Clore & Collins, 1988. All these psychologists had influenced affect recognition research with their theories of emotion (R. a Calvo, Member, & Mello, 2010).

Lazarus's cognitive-motivational-relational theory of emotion (Abramson & Rosenfeld, 2010) states that all emotions are the result of cognitive appraisals of the personal meaning of events and experiences. Therefore, emotions occur because of the individual cognitive understanding of an external stimulus or event in order to determine if it was positive, negative or neutral. So, in order to predict how an individual will act, all expectations and goals related to the situation must be known (R. a Calvo et al., 2010).

Roseman, developed a model where emotions are the result of a multidimensional appraisal process. The model establishes a relationship between appraisals that are defined in terms of motivational and situational state, and emotion rising (Roseman, Spindel, & Jose, 1990). The model is composed of five cognitive dimensions to determine whether an emotion arises and which one it is (R. a Calvo et al., 2010).

1) Consistency motives - The first dimension describes whether an individual will be positively or negatively influenced by an event;

2) Probability - The second dimension describes whether a situation involves uncertainty or certainty about what is happening;

3) Self/other-agency - The third dimension describes whether events are controlled by the self or another person. This dimension knows the conditions "certain" and "uncertain";

4) Attention activity - The fourth dimension describes whether a person is trying to devote attention to a stimulus or divert attention from it;

5) Anticipated effort. The fifth dimension, finally, describes the amount of effort considered as needed to deal with a situation. This dimension knows “the states”, "the circumstances", "others" or "oneself".

The cognitive theory by Ortony, Clore, and Collins (OCC) consider emotions as reactions to situational appraisals of events, actors, and objects (Colby, Ortony, Clore, & Collins, 1989). The OCC model has recognized itself as the standard model for emotion synthesis, and it is often used to model user emotional states. The model specifies twenty-two emotion categories based on the reactions of a subject to an event, the reactions of the subject to an action of a responsible agent and the reactions of the subject that approaches an attractive or unattractive object. The emotions can be divided in three categories: goal-based emotions, standard-based emotions and attitude-based emotions. Goal-based emotions depend on the interest of an unconfirmed or confirmed event producing emotions like joy, distress, hope, fear, satisfaction, disappointment, relief, fears-confirmed, happy-for, resentment, gloating and pity. Standard-based emotions depend on the value of the agent action as the result of an affected standard. The set of emotions include pride, shame, admiration and reproach. Attitude-based emotions depend on the interest of an object producing emotions like love or hate.

Roseman and Ortony models are alike in several points. Both are based in the universality of the appraisal process, and both can be used to predict user emotional state (Roseman et al., 1990).

Scherer‘s Geneva Expert System on Emotion (GENSES) (K. R. Scherer, 1993) is described as a system motivated by the need to: ”use computer modelling and experimentation as a powerful tool to further theoretical development and collect pertinent data on the emotion-antecedent appraisal process” (K. R. Scherer, 1993). Thus creating a computational model to

evaluate, modify and improve emotional theories. The system was composed by a computer application, which invites the subject to think of an experience, containing a strong emotion. This is performed with the purpose of diagnosing the emotion felt. The system was built upon a knowledge base that links appraises to different emotions predicted in Scherer theory. The system mapped over 200 emotional situations with an accuracy of 78% (Wehrle et al., 2001). Despite the system significance as a tool to test emotional theories, it was too limited for most real life applications (R. a Calvo et al., 2010).

In the context of the interaction with pedagogical agents designed to improve the effectiveness of computer-based educational games, a model was proposed by (Conati, 2002) called Dynamic Decision Networks (DDN). The model is based on the OCC cognitive theory of emotions, but relies on deterministic rules to model the appraisal process. It is used to enable pedagogical agents for educational games to generate interactions custom-made to the user's learning.

2.4.4. Emotion Theory - Emotional socio-culturally Theories

Averill (Averill, 1980) argued that emotions could not be explained strictly based on physiological or cognitive terms, suggesting that, emotions are socio-culturally constructed, which determine the behaviour and value patterns. The relationship between emotion language and consciousness is an important factor of human interaction as part of the emotion experience. Social constructionists sustain that emotions are influenced by a social consciousness concerning when, where, and what to feel as well as when, where, and how to act. This led to the questioning of Ekman work universality by the social constructivists. Certain cultures might not have a correspondent word to an emotion or have labels that cannot be translated (James a Russell, 2003).

Psychology has focused over time on the importance of the social process to explain the emotional phenomenon. The review "Sociological Theories of Human Emotions" presents five theoretical perspectives on human emotions: Dramaturgical Theories, Symbolic Interactionist Theories, Interaction Ritual Theories, Power and Status Theories and Exchange Theories (Turner & Stets, 2006). Although some progresses were made by these theories, some questions still persist, like the nature of emotions, feelings, and affect. To point to

which emotions are biologically based or socially constructed; the breach between social psychological theories on emotions and macro structural theorizing; and the relatively narrow array of emotions theorized, joined with the structural and cultural conditions creating these emotions (Turner & Stets, 2006).

2.4.5. Emotion Theory – Neuroscience advances

Emotions are believed to be associated to brain activity. There are brain areas directed linked to the people attention, influencing the behaviour, and controlling the understanding of what is going on around us. Neuroscience has given several contributes to the study of emotion and its relation with the brain, mainly the field of Affective Neuroscience which aids in the understanding of the neural process behind an emotional experience (Dalgleish, Dunn, & Mobbs, 2009) (Franks, 2006) (Davidson, 2003). The techniques used in the Affective neurosciences include imaging (e.g. Functional Magnetic Resonance Imaging (fMRI)), lesion studies, genetic, and electrophysiology (R. a Calvo et al., 2010).

The last decades have provided evidence that the neural substrates of emotion and cognition significantly overlap (Dalgleish et al., 2009). Disproving the idea that emotion is strictly subcortical and limbic, whereas cognition is cortical. Cognitive processes take place continuously throughout the emotional experience.

Neuroscience methods like Electroencephalography (EEG) that record electrical activity along the scalp produced by the firing of neurons within the brain, provide an alternative method to self-reports and have been increasing appearing in AC literature (Liu, Sourina, & Nguyen, 2010)(Shen et al., 2009)(Fairclough, 2009)(Frantzidis et al., 2010).

Besides the traditional theories of emotion other ideas can be highlighted such Russell framework (James a Russell, 2003) which can help mitigate the differences between the different theories of emotion. Russell´s theory is based around the “core affect” a consciously neurophysiological state analogous to what is call feelings. The theory gives a significant importance to the context separating an emotional experience from an emotional category. So, emotions consist of an array of components like physiological responses, bodily expressions and appraisals (R. a Calvo et al., 2010).

2.5.Recognizing Emotions

An important question can be made “how to recognize emotions?” An affective computing purpose is to get this this information from the human body. First it should be able to recognize the physical aspects of the human body, such as facial expression, voice intonation, gestures or movements. Affective computing also aims at recognizing physiological aspects such as respiration, skin colour, temperature, heartbeat, blood pressure and pupillary dilation.

2.5.1. Facial Expressions Recognition

A facial expression is the result of the movements or positions of face muscles. Facial expression recognition plays an important role in natural human-machine communication (Chibelushi & Bourel, 2003). Most of Facial Expression Recognition (FER) research was influenced by the theories described in section 2.4.1 based on the work of Ekman (P Ekman, 1993). His work was based on the assumption that the emotions are universal across individuals as well as human ethnics and cultures (Fischer, 2004). Nowadays advances in facial recognition software make basic facial expressions like anger, disgust, fear, happiness, sadness and surprise recognition possible.

A study carried out by Ekman and Friesen (Paul Ekman & Friesen, 1978) developed the Facial Action Coding System (FACS), which is a manual technique for the measurement of facial movement. FACS can code practically any anatomically possible facial expression, decomposing it into the specific Action Units (AU) that identifies independent face motion in a temporal order. In Annex A there is a list Action Units and Action Descriptors (with underlying facial muscles) provide by (J. F. Cohn, Ambadar, & Ekman, 2007). Manually coding a segment of video is a timely and expressive method performed by highly trained human experts. Each minute of video take nearly an hour to code (Donato, Bartlett, Hager, Ekman, & Sejnowski, 1999). Studies have been made trying to automate this method, see (Bänziger, Grandjean, & Scherer, 2009; Bartlett et al., 2006; Gunes & Piccardi, 2007; McDaniel et al., 2007; Pantic & Patras, 2006).

Emotion recognition has been explored within three main types of databases: represented emotions, natural spontaneous emotions and provoked emotions. The best

results have been achieved with the acted emotion databases because they enclose strong emotional expressions (Alepis, Stathopoulou, Virvou, Tsihrintzis, & Kabassi, 2010).

2.5.2. Body language

Recognizing emotion through analysis of body language and posture appears to be an overlooked area in detriment of facial and speech in Affective Computing (AC) literature (R. a Calvo et al., 2010). There are some studies indicating the advantages of recognizing body language (Bull, 1987)(de Meijer, 1989). One of the first systems created using automated posture analyses to determine a student affective state in a learning environment is Tekscan's Body Posture Measurement System (BPMS) (Mota & Picard, 2003).

The BPMS system recognizes postures related with affective states linked to a child's interest level while carrying out a learning task on a computer. This system consists of two pressure sensors mounted on the chair, from those sensors the student postures are extrapolated in real time. There is a neural network to classify the postures with an accuracy of 87.6%. Later this model was improved by Mello et al. (D'Mello & Graesser, 2009) creating a system that can detect learners' affect by monitoring their gross body language (R. a Calvo et al., 2010). This system was designed to detect boredom, confusion, delight, flow and frustration with accuracy between 73% and 83% (Mota & Picard, 2003).

2.5.3. Eye Tracking

Eye tracking is the process of measuring either the point of gaze (what one is looking at) or the motion of an eye in relation to the head position. The analyses of eyes properties can be used to measure the human response to visual, auditory or sensory stimuli (De Lemos, Reza Sadeghnia, Ólafsdóttir, & Jensen, 2008; Partala & Surakka, 2003). Emotion is measured through the eye tracking hardware and a statistical program which determines the excitement level to a visual image (De Lemos et al., 2008). Parameters analyses include: pupil size, blink properties and gaze. The pupil size is related to an emotional reaction, a study performed by Partala and Surakka (Partala & Surakka, 2003) indicates there is an alteration in pupil size when a subject faces a positive or negative stimulus opposite when facing a neutral stimulus. Blink has also been associated with emotional responses, for example with defensive reactions, the eye is modulated blink startle (Dawson & Schell,

1999). Finally, gaze patterns have been linked to emotional reactions (M. G. Calvo & Lang, 2004).

There are several areas where the eye tracking process can be applied: neuroscience, psychology, computer science, industrial engineering and marketing (Duchowski, 2002).

2.5.4. Emotional Speech Recognition

Speech recognition consists in the ability of a machine or program in identifying words or phrases from the spoken language. The main application of speech recognition resides in assisted technology to help people with disabilities. The vocal aspect of a communication also carries information about speech emotional contents. So, speech can be divided in two parts: an explicit message, consisting of what was said; and an implicit emotional expression, entailing how the message was said. Speech Emotion Recognition (SER) aims to recognize the user emotional state in his speech signal (Wu, Falk, & Chan, 2011).

Most acoustic features that have been used for emotion recognition can be divided into two categories: prosodic and spectral. Prosodic features have been shown to provide key speaker emotional cues (Wu et al., 2011). Prosodic features include pitch, intensity, delta-pitch, delta-intensity and speaking rate. The recognition performance improves when used to augment prosodic features, providing an overall recognition rate of 91.6% (Wu et al., 2011).

Literature in SER reached important conclusions that can be used in AC applications (James a Russell et al., 2003)(K. R. (University of G. Scherer, Johnstone, & Klasmeyer, 2003). The major conclusion relies in the possibility to recognize emotion from a speech. Although there is some difficulty in recognizing certain kind of emotions like disgust, there are others that can be recognize with more accuracy like sadness and fear. Also, the pitch of a speech seems to be connected to the level of arousal. In addition affect discovery in speech has accuracy rates lower than facial expression for recognizing basic expressions.

2.5.5. Physiology

Affection recognition by identifying patterns in the physiological activity was inspired by the theories (detailed in section 2.4.2.) areas like psychology and psychophysiology try to

understand what physiological patterns are behind them and what the implications in behaviour are. To monitor these physiological patterns, the electrical activity produced by brain, heart, eyes, skin and muscles is recorded. The methods of recording include Electroencephalography (EEG) that measures brain activity, Electrocardiogram (ECG) that measures heart activity, Electrooculogram (EOG) that measures eye movement, Electro dermal Activity (EDA) that measures electrical conductivity of the surface of skin, and Electromyograms (EMG) that measures muscles activity (R. a Calvo et al., 2010).

In Andreassi book (Andreassi, 2007) there is a review of some affect detection relevant concepts to the based in physiology (R. a Calvo et al., 2010). These concepts include Law of Initial Values (LIVs), Stimulus-Response (SR) specificity, Individual-Response (IR) specificity, Cardiac-somatic features, habituation and rebound. The LIVs is a physiological and psychological concept, which states that with a certain level of stimulation, the degree of alteration produced tends to be greater when the initial value of that variable is low. The SR specificity concept states that for specific stimulus conditions an individual will react with a particular physiological pattern. The IR specificity complements the SR specificity, while SR specificity aims to find a pattern of similar responses for most individuals; the IR specificity tries to find the individual responses to different stimulus. Cardiac-somatic features are related to the heart activity modification triggered by a body behaviour response. Habituation and rebound are the result of a stimuli situation; for instance, if subject to a repeated stimulus the physiological response diminishes, which causes habituation to a given stimulus. On the other hand the presence of a stimulus can cause, after a time period the return to the level of pre-stimulus. Stimulus or elicitation techniques used in most studies submit the subjects to the use of personal and mental images to generate an emotion response (R. a Calvo et al., 2010).

2.5.6. Brain Imaging Techniques

The field of Affective Neuroscience tries to map the neural circuitry that occurs during an emotional experience (Dalgleish et al., 2009)(Paradiso, 2002), the techniques used by neuroscientists include fMRI, EEG, among others. fMRI is based on the MRI technology. It is a non-invasive test that uses a strong magnetic field and radio waves to create detailed body images. It monitors the blood flow in the brain to detect activity areas. Therefore fMRI

provides a map of which parts of the brain are active during an emotion or feeling. A study performed by Yang and Damasio (Immordino-Yang & Damasio, 2007) with brain damaged patients show that the emotional course was required for learning and it is essential to the decision making process.

EEG records brain spontaneous electrical activity through mapping. Due to the absence of an emotion neural model this method is limited and frequently supported by other techniques like the fMRI. One of the measures taken with EEG is the Event-Related Potential (ERP). ERP is a measured brain response that is directly the result of a thought or a perception. It basically measures any electrophysiological response to an internal or external stimulus. Most of the focus of AC researchers is on using ERP (Olofsson et al., 2008).

2.5.7. Emotion Detection in Text

Affective detection in a written text consists in determine the emotional or attitude context within the written language or transcripts of oral communication. The initial work on this matter aimed to understand how text could express an emotion or how text could generate different emotions. These studies began by find resemblance in how people of different cultures communicate (Osgood, May, & Miron, 1975) (C. Lutz, 1986). Osgood (Osgood et al., 1975) used a Multidimensional scaling (MDS) procedure to create models of affective words based on words evaluations provide by diverse cultures. The dimensions considered in these studies were: evaluation, potency and activity. Evaluation refers to quantification of a word in relation with an event it portrays, if that event is pleasant or unpleasant. Potency refers to how the word is related with a level of intensity, strong words as opposed to weak words. Activity refers to a word as active or passive (R. a Calvo et al., 2010).

Other research includes lexical analysis of the text so the affective state can be inferred (M. a. Cohn, Mehl, & Pennebaker, 2014)(Shields et al., 2005)(Hancock, Landrigan, & Silver, 2007). Most of these studies use the Linguistic Inquiry and Word Count (LIWC) (Pennebaker, Booth, & Francis, 2007). LIWC is text analysis software that determines if the text has positive or negative emotions, self-references, causal words, in over 70 language dimensions.

Other approaches accept that people sharing the same language have comparable notions for different emotions. Based on this, a lexical database was built containing emotional terms. Databases like WorldNet (George a Miller & Fellbaum, 2007), an on-line lexical reference system which design was inspired by psycholinguistic theories of human lexical memory. WordNet-Affect domain has an additional hierarchy of affective domain labels representing affective concepts annotated, this database is used in several studies like (Bracewell, 2008)(Strapparava, Strapparava, Valitutti, & Valitutti, 2004).

Affective Norms for English Words (ANEW) (Bradley & Lang, 1999) was developed to offer a set of normative emotional ratings for a large number of words in the English language. The objective is to construct a series of verbal materials that were rated in terms of pleasure, arousal and dominance. ANEW complements the International Affective Picture System (IAPS) (Bertron et al., 1997) and the International Affective Digitized Sounds (IADS), which are collections of photographs and sounds stimuli, respectively, that also contain affective ratings.

Sentiment and opinion analysis refers to the application of natural language processing, computational linguistics, and text analytics to recognize and mine subjective information, like emotion, in text. This subject was reviewed in (Pang & Lee, 2006).

2.5.8. Multimodality of Emotion Recognition

Several points of view state that an emotion response has multiple manifestations both physical and behavioural. Also, the human computer paradigm advocates that in the future human centred interfaces should have the capacity to sense changes in user affective behaviour. So, the development of affective Multimodal Human-Computer Interaction (MHCI) is growing (R. a Calvo et al., 2010).

MHCI relies on several research areas such as computer vision, artificial intelligence, psychology and others. The study of MHCI entails the knowledge of three variables: user, system and the interaction between them (Jaimes & Sebe, 2007). To understand the dynamic between these variables is possible to construct new systems more friendly and intuitive thus, more practical. Therefore in a near future is likely to include new ways of interaction between humans and computers, such as: visual interaction (facial expression,

head pose, gesture, body movement and postures), auditory (pitch, loudness, speaking rate), tactile (heart rate, skin conductivity), brain signals (EEG) and many others.

Examples of affective MHCI include Multimodal Affective User Interface (MAUI) (Lisetti & Nasoz, 2002) designed to combine facial expression and physiological signals to recognize user's emotions and to adjust an animated interface agent to mirror user's emotion. The multimodal system described in (Duric et al., 2002) relates the technologies and tools for an Intelligent Human–Computer Interaction (IHCI), which applies a model of embodied cognition that can map user's affective states in the types of interface adaptations. The Gaze-X: Adaptive Affective Multimodal Interface (Maat & Pantic, 2007) is able to learn and analyse user's behavioural patterns and adapt the interface accordingly. The automated Learning Companion (Kapoor, Burleson, & Picard, 2007) assembles data from cameras, a sensing chair, a mouse, wireless skin sensor, and task state in order to find and detect frustration so that it can predict when the user requires assistance. The Multimodal Computer-aided Learning System ("Multimodal Human Computer Interaction Project," 2011) creates a computer avatar based on the information of user's facial expression, keywords, eye movement, and task state generates suitable tutoring plan.

2.6.Affective learning

There are several types of learning. In 1956 Benjamin Bloom (Best, Floyd, & McNamara, 2008), identified three domains of educational activities:

- cognitive: mental skills (Knowledge);
- affective: growth in feelings or emotional areas (Attitude);
- psychomotor: physical or manual skills (Skills).

The combination of all domains influences the way one learns and the way rational decisions are made. So what is Affective Learning according to recent definitions, "Affective learning involves the melding of thinking and feeling in how people learn. Importance is placed on social learning environments for knowledge construction and application wherein deeper awareness and understanding of the role played by mental dispositions in how a person views, engages, and values learning can result in better understanding and use of

knowledge and skills. Learning outcomes are focused on enculturation of norms, values, skilful practices, and dispositions for lifelong learning." (Stricker, 2009)

2.6.1. Affective learning models

The goal of using a model is to understand how emotions are evolving in the learning process. So, learning systems can be developed in order to recognize and responded appropriately to an emotional state. In 2004 Picard stated that the theories that influenced learning process need to be verified and further developed. Most of the models have been developed like a model for pervasive e-Learning platform (Shen et al., 2009). They had as a starting point models like Russell's Circumplex model (James a. Russell, 1980) to describe user's emotion space and Kort's learning spiral model (Kort et al., 2001) to explore the affective evolution during learning process.

2.6.1.1. Russell's Circumplex Model of Affect

The Circumplex Model of Affect proposed by Russell in 1980 (James a. Russell, 1980) consists in the distribution of emotions in a system of coordinates. In this system of coordinates the x-axis measures the valence, from positive to negative emotions. The y-axis measures the level of arousal. Affective model falls to in a circle and where is possible to find emotions like pleasure (0°), arousal (90°), displeasure (180°), and sleepiness (270°).

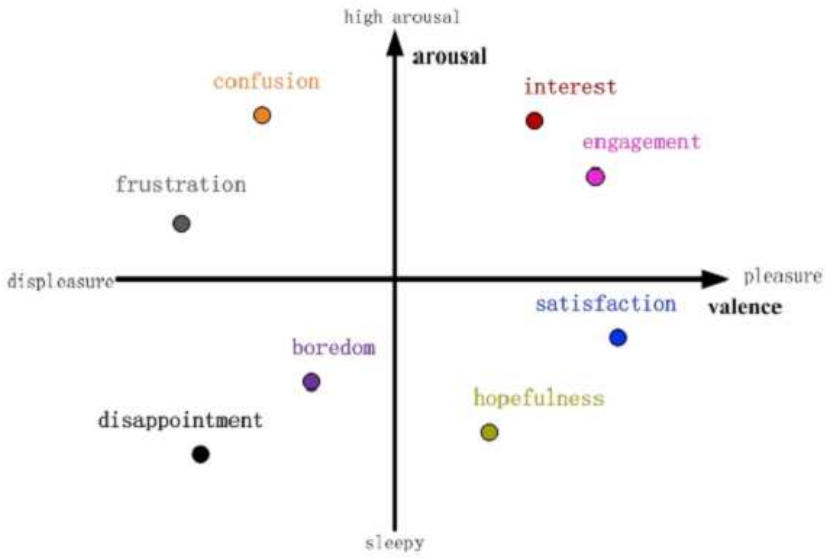

Figure 4 - A Russell's circumplex model of affect (James a. Russell, 1980).

2.6.1.2. Kort's Learning Spiral Model

According to Kort's learning Spiral Mode the learning process typically begins in quadrant I or II in which the quadrant I the student investigates a problem, one experiences emotions like curiosity or satisfaction (Figure 5). But if something happens it will take the student to fail. This causes the student to move to quadrant II. In quadrant II the student will feel confusion or disappointment towards the problem. If the situation failure is kept the student falls into quadrant III. In this quadrant the student experiences feelings of frustration and begins to discard the old ideas. This allows the student to move to the quadrant IV bringing a new approach to the problem that originates feelings of hope and determination. Circular flow of emotion through the learning process is represented on Figure 6.

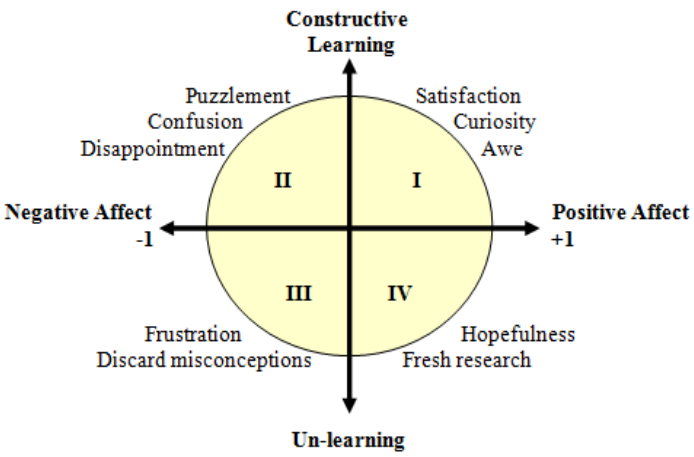

Figure 5 - Learning cycle (Kort et al., 2001)

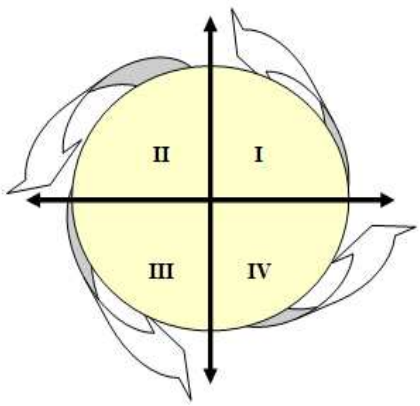

Figure 6 - Circular flow of emotion through the learning process (Kort et al., 2001)

2.6.1.3. The role of affect in learning

Research shows that a slight positive mood can produce an effect on memory, fosters clear-headed, well-organized open-minded, flexible problem solving and thinking as well as more efficiency and thoroughness in decision-making. This can be found in groups of different ages and professions (Picard et al., 2004) (Isen, 2001). The effect on cognition is not

restricted to positive states of mind. Negative affective states like anger, sadness or fear can influence the brain activity affecting the thought process (Isen, 2001).

The challenges that affective learning faces is the bringing together of theorists and practitioners from different fields in order to refine the language used with respect to affect and learning (Picard et al., 2004). To create a model that can provide effective results in the learning process, the model built has to take into account other factor like the model or profile of the user and also the learning style. In the subject literature there are several models proposed.

2.6.2. Emotion vs. Cognition

Cognition refers to mental processes, like attention, memory and understanding. Cognitive science is and interdisciplinary study of the mind researched by several disciplines such as philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology. Cognitive science studies began in 1950's; it originated the theories of the mind based on complex representations and computational procedures (G a Miller, 1981).

> "The mind is a charioteer driving twin horses of reason and emotion. Except cognition is a smart pony, and emotion an elephant" (Peota, 2002).

The traditional view of learning theories treats emotion and cognition as occupying two different dominions. In this scenario the cognitive domain plays the predominant role over the emotions. More recent approaches advocate that a dynamic integration should be considered between cognitive and emotion variables (Blanchette & Richards, 2010). This integration is also recognized to influence attention, memory, reasoning, interpretation, judgment and decision making, which are essential in the learning process (Blanchette & Richards, 2010).

2.6.2.1. Attention

Attention is the cognitive process of paying attention to one aspect of the environment but disregarding others. "Pay attention!" is a phrase repeated by so many teachers all over world, and the explanation for this is simple. Attention is the first step in the learning process. Students cannot learn or understand or even remember if they do not listen

properly, so, they will fail in the learning process. For almost everyone, is easy to pay attention to subjects or things that are interesting or stimulating to them. Emotions also play a fundamental role in the process of paying attention. If a person feels anxious, sad or depressed it's very hard to concentrate and to pay attention. Furthermore it is very hard to pay attention if people are tired, sick or not feeling well.

To explain how learning is processed it is possible to use the learning cycle introduced by Bybee (Bybee, 1989). The learning cycle has five steps: Engagement, Exploration, Explanation, Elaboration, and Evaluation and it is shown in Figure 7.

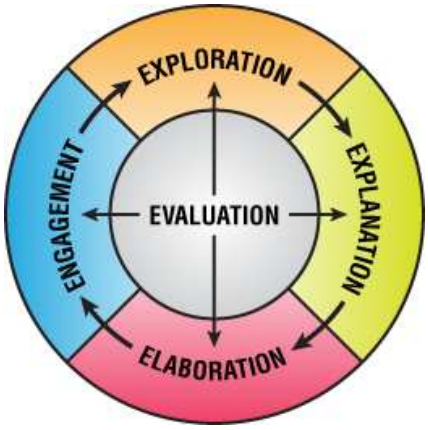

Figure 7 - Learning Cycle ("Learning Cycle," 2014)

The main objectives of engagement step are to:

- Focus the student attention on the subject;
- Assess the student prior knowledge;
- Inform the students about the lesson's objective(s);
- Remind students of what they already know that they will need to apply to learning the topic at hand;
- Pose a problem for the students to explore in the next phase of the learning cycle.

The evaluation of engagement consist in pre-asses the prior knowledge of the subject, this can be performed by simple questions which the students can answer written or orally.

The purpose of exploration step is to:

- Have students gathering information that they can use to resolve the problem that was posed.

The evaluation of exploration is made through the evaluation of the gathering information process. In this stage questions like the following should be asked:

- How well are the students gathering information?
- Are they implementing the procedures correctly?
- How do they record the information?
- Is it in a logical from or is it random?

In the explanation step the students use the gathered information to resolve the problem and report what they have done and also try to work out the answer to the presented problem. The evaluation of explanation focus on how well the students are using the gathered information and what new ideas they have come up with.

In the elaboration step the student is given new information that extends what they have been learning. Also, in this stage students are resolving problems that require the knowledge acquired during learning process in order to solve them.

The evaluation of elaboration usually is the test at the end of the subject, the test which measures how well students comprehended what they have learned.

2.6.2.2. Memory

"I see and I forget, I hear and I remember, I do and I understand." - Confucius

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Memory helps us to store information that later can be retrieved. Memory and learning are interconnected and it is not possible to have one without the other, but they remain two different processes. Specialists define learning as the process that will over time modify behaviors, while memory is the capacity of remembering the past. If one wants to learn a computer language it can do so by studding or by programing and remembering the language syntax. Memory records the result of the learning process (S. T. Lutz & Huitt, 2003).

Figure 8 represents the cone of learning based on the work of Edgar Dale in 1969. Dale looked at the most effective ways of learning by teaching people with comparable material

in different ways and noted the capacity to remember the information after the learning process was over. Although the cone is based on Dales work the figure percentages were added later.

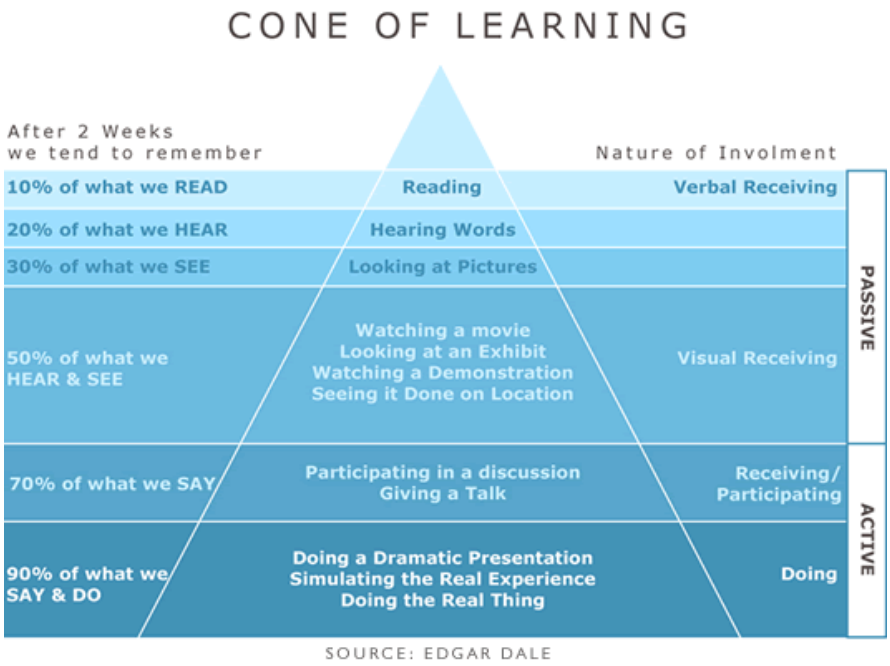


Figure 8 - Cone of Learning (Thalheimer, 2006)

2.6.2.3. Interpretation

Interpretation is the cognitive process through which sense is taken out of ambiguous information in order to build a mental representation (Blanchette & Richards, 2010). Day to day interaction creates great amount of ambiguous emotional information that needs to be processed. Emotion research about the way emotional state can affect interpretation has followed several lines of research. They have studied how the ambiguous information is processed and how this process leads to individual differences in the interpretation.

"Life is like an inkblot – an 'experiential Rorschach,' so to speak. Life doesn't have an objective or assigned meaning. We give it meaning by our individual values, beliefs, relationships, careers, hobbies, and other life experiences" (Yapko, 1997)

Figure 9 – Rorschach Inkblot Test

The capacity to interpret ambiguous emotion information is vital because enables us to read, among others, danger signs that are essential to individual adaptive functioning. There are several forms about the way interpretation of ambiguous information can be studied. These forms can be classified in verbal and non-verbal, these categories cover almost every forms of communication from word recognition and lexical ambiguity (homophones or homographs words) to even facial expressions. In these researches it is used a collection of dependent measures consisting in self-reports, ratings of alternative meanings, spellings, recognition, lexical decisions, reading times, naming and comprehension. Most of the research about the way emotion influenced interpretation is centered on the emotion of anxiety (Blanchette & Richards, 2010).

Studies made in the subject established differences between interpretation made by anxious and non-anxious people (Mathews, 1986). Anxious people have the tendency of making more negative interpretations about situations that have a mix of threat/neutral ambiguous signs. Anxious people have a very negative view of the world and portrait a picture that only negative events happen to them and positive ones happen to others.

2.6.2.4. Judgment

Judgment is the process by which individuals consider and evaluate evidence and estimate the likelihood of making a decision. Research on people's judgment and how it is influenced by emotions, indicates that people tend to judge everything (from consumer products (Yeung & Wyer, Jr., 2004) to life satisfaction (Schwarz & Clore, 1983)) more positively when they are happy and negatively when they are sad (Clore & Huntsinger, 2007).

There are two key mechanisms that account for the effects of mood/affect on judgment. First the heuristic availability based on the memory process. Second the affect-as-information hypothesis involves the tactical use of affect in the judgment process (Blanchette & Richards, 2010).

The heuristic availability describes the process by which the participants' judge based on relative frequency of an event that often depends upon the availability or accessibility of objects or events, in the processes of perception, memory or construction in the

imagination. For example "*it is easier to retrieve an instance of a brown dog than a white dog from memory precisely because one has encountered a greater number of brown dogs, because there are indeed more brown dogs* (Blanchette & Richards, 2010)". Usually what is kept in memory is vivid, unusual, or emotionally charged examples. These memories usually are consciously or unconsciously associated with positive and negative emotions tags, thus affect may serve as a cue for many important judgments (Slovic, 2002).

The affect-as-information hypothesis proposed that participants use the information taken by affective states strategically during the judgment process. When judging a question is asked, ''How do I feel about this?'' and the response is used to provide a judgment about the object or event.

The emotion of anxiety seems to be an additional complication when studding judgment, emotion and individual differences. High-anxious individuals assume that negative events are more probable to occur due to increased experience of negative personal events. If judgments of likelihood are based on memory recovery, and anxious individuals are anxious because of frequent negative past experiences, this would lead to enlarged probability of likelihood of negative events (Blanchette & Richards, 2010).

2.6.2.5. Decision-making

"When dealing with people remember you are not dealing with creatures of logic, but creatures of emotion" – Dale Carnegie

Decision making is a cognitive process by which an option or a course of actions is chosen from among a set of alternatives based on certain conditions (Wang & Ruhe, 2007). One of the key elements of decision-making is judgment so the emotions mechanisms that effect judgment should necessarily influence decision making process (Wang & Ruhe, 2007).

When facing a decision one evaluates the motivation value behind each available choice, using cognitive and emotional processes. When the decision is complex or has conflicting choices the cognitive process overloads and one is unable to make a decision. In these circumstances somatic markers can help. The somatic-marker hypothesis (SMH) proposes a mechanism by which emotional processes can guide behavior and decision-making. This hypothesis was formulated by Antonio Damasio. According to him, emotion is

defined has a set of modifications in the body and brain in reaction to a stimulus (Damasio, 1994). Over time, emotions and their analogous bodily modifications become related with particular situations. In the future when facing a decision these physiological signal or somatic makers and its analogous emotions are consciously or unconsciously associated with their past experiences thus leading the decision-making towards certain behavior while avoiding others.

2.6.2.6. Reasoning

"Emotions have taught mankind to reason." - Marquis De Vauvenargues

Reasoning is the process by which people use the information available to them to draw inferences. This process contributes to construct an understanding of the surrounding world. Damasio research also made a link between emotion and reasoning (Damasio, 1994). Although is generally believed, since the time of Plato that emotions can lead reason astray, this could not necessary be true. The formulation by Damasio, of SMH, help to tag situations that in the future can help to reason and to make a decision that can be potentially harmful or advantageous. The implications of emotional reasoning could lead to same problems like depression or anxiety. Depression usually settles when an individual feels worthless and bad and if emotional reasoning misinterprets his feelings of being bad as evidence that he must have done something awful and he feel depress and powerless to escape these emotions. Individuals that suffer from anxiety usually feel scared and the emotional reasoning interprets these feelings as a possible threat to then.

2.7. User Model

Systems used to interact with users in an intelligent and supportive way need to have a detailed characterization about the individuals they are interacting. This information can be used and represented in different ways (Finin & Orager, 1986). As a group this information is called a user model. Therefore user model is a collection of personal data associated to a specific user. A model can store characteristics of an individual and this information can be used by systems that personalize the human computer interaction like adaptive hypermedia or emotional sensitive systems (Finin & Orager, 1986).

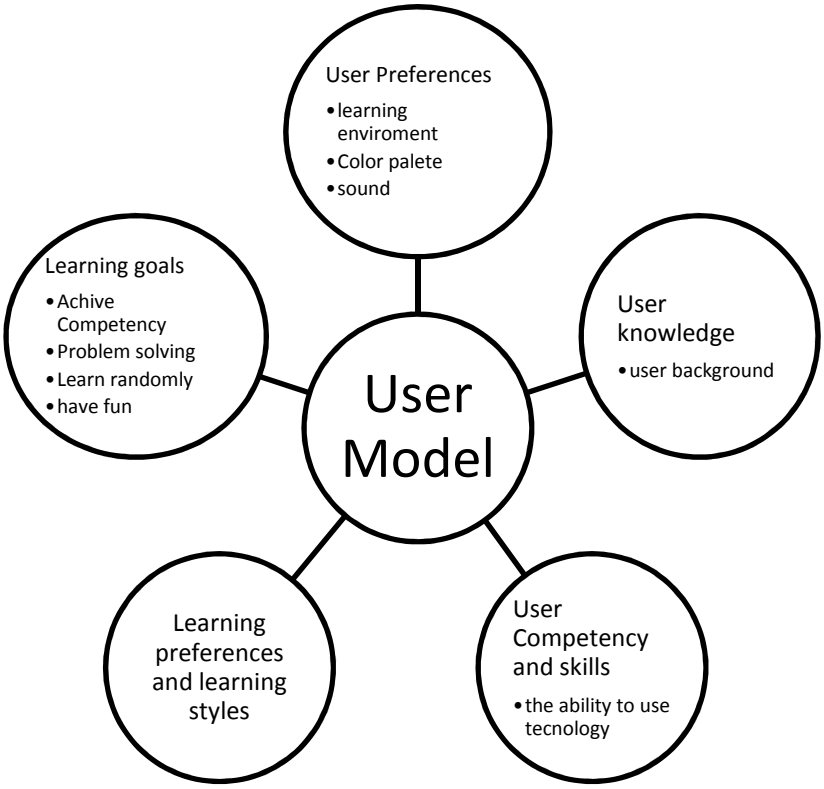


Figure 10 - User Model

2.7.1. User Modelling

User modeling develops cognitive, learning and emotional models of human users, including modeling of their skills and knowledge. User models can be used to predict human error and learning time. User models can be used to guide user interface designers to minimize error rates and learning time. The model can include personal information like name and age, interests, skills and knowledge, user aims and plans, preferences and dislikes or information about user's behavior and their interactions with the system. To create a user model there are different design patterns that can be used and can often be mixed. User models can be divided in four design patterns: static user models, dynamic user models, stereotype based user models, highly adaptive user models (Kangassalo, H. Jakkola, Hannu Kawaguchi, 2002).

- Static user models are the basic user models are composed by data that is never changed. Modifications in user preferences are not taken into account and no learning algorithms are used to change the model.

- Dynamic user models keep a current representation of the user. The model registers modifications to the user interests, learning progress or interactions with the system that can have an effect on the user model. The model also keeps an up to date record of the user requirements and goals.
- Stereotype based user models are constructed on demographic statistics. The data is collected from the users and categorized into common stereotypes. Therefore Stereotype based user models do not take in consideration personal attributes but allow predictions about the user.
- Highly adaptive user models aim to characterize a specific user as a result they have a very high adaptively nature. These types of models also need to collect lots of information first.

When designing a user model several question have to asked like who is being modeled; what aspects of the user are being modeled; how is the model to be initially acquired; how will it be maintained; and how will it be used (Finin & Orager, 1986). Who is being modeled, is the first thing to be established than if one is modeling single users or a group of users and if the model as short or long term life. In a model, which the individual user information will persist over time, it has to be taken into account that information may change or grow. Also, what user aspects are being modeled, if this information should represent generic facts that are common for the majority of users or particular facts that portraits user's knowledge, beliefs and general understanding of others, subjects or things of the user or a combination of both. The user model can be initially acquired by selecting one of the existing stereotypes (if provide) in the system (Rich & Rich, 1979). The selection of a suitable stereotype can be achieved by a number of techniques. These techniques include: the user being able to decide which model wants to use, surveying the user and from his answers choosing the most appropriate model or even having an expert system to analyze the user and selecting one of the models. Also the initial model can be chosen from information collected in existing database, for instance from an LDAP database. As soon as the initial user model is selected it can be updated, maintained with particular information about the user.

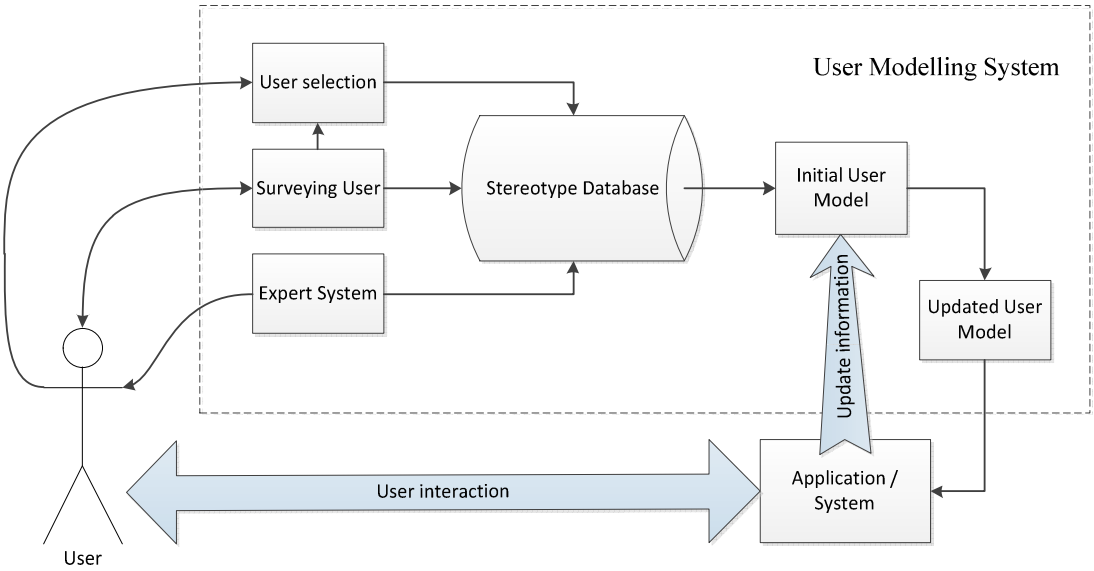


Figure 11 - User Modelling System

In order to create a user model one needs to know the data to gather, Table 2 portraits the common characteristics use in a user modeling extracted from (A. C. Martins, Faria, & Carvalho, 2008).

Profile	Characteristics	Descriptions / examples
Generic Profile	Personal information	Name, email, telephone, etc.
	Demographic data	Gender, race, age, etc.
	Academics background	Technological studies versus economics etc.
	Qualifications	Certificates, etc.
	Knowledge (background knowledge)	A collection of knowledge translated in concepts. Possibility of a qualitative, quantitative or probabilistic indication of concepts and knowledge acquired for the user
	Deficiencies: visual or others	Sees well, uses eyeglasses, etc.
	Domain of application	Localization of the user etc.
	Inheritance of the characteristics	Creation of stereotypes that allow to classify the user
Psychological Profile	Learning style	Definition of the learning style
	Cognitive capacities	
	Traces of the personality	Psychological profile (introverted, extrovert, active, etc.).
	Inheritance of characteristics	Creation of stereotypes that allow to classify the user
	Objectives	Questionnaires that allow to determine with objectives the user intends to use the system
	Planning / Plan	
	Complete description of the navigation	Kept register of each page accessed
	Knowledge acquired	A collection of knowledge translated in concepts. Possibility of a qualitative, quantitative or probabilistic indication of concepts and knowledge acquired for the user
	Results of assessment	Data of all the tests, exercises, etc.
	Context model	Data related with the environment of the user (resolution of the monitor, etc.)
	Aptitude	Definition of aptitude and the capacity to use the system
	Interests	Definition of the interests of the individual with the objective to adapt the navigation and contents
	Deadline extend	Long, short or normal stated period

Table 2 - Common characteristics in User Modeling

2.7.1. Generic Profile and Psychological Profile

The generic profile is composed by personal identifiable information that can be used to uniquely identify, to contact, or locate a single person. This also includes the Academic background, qualifications, deficiencies, and any characteristic that will help define the student. The psychological profile contains personality traits and learning preferences that help to define and differentiate a particular individual.

2.7.1.1. Personality

The personality research aims to study what distinguishes one individual from another (Santos, 2010). Personality research depends on quantifiable concrete data that can be used to comprehend what people are like. In several published papers is acknowledged that personality traits has influence in user's performance in numerous life areas (Diseth, 2003; Kumar, Bakhshi, & Rani, 2009; Molleman, 2005; Rothmann & Coetzer, 2003). Also, the relationship between personality and learning is largely (Busato, Prins, Elshout, & Hamaker, 1998; Diseth, 2003; Ibrahimoglu et al., 2013). One of the models largely used is the Big Five Model (Komarraju, Karau, & Schmeck, 2009; Komarraju et al., 2011; Kumar et al., 2009).

The Big Five model development was originally a resultant of two independent research teams Paul Costa and Robert McCrae (Costa & McCrae, 1992) (at the National Institutes of Health), and Warren Norman (at the University of Michigan)/Lewis Goldberg (at the University of Oregon) (Goldberg, 1990). These research teams although following different directions in their research, arrived at the same result: most human personality traits can be summarized in five wide-ranging dimensions that can be used to describe the human personality. The Big Five dimensions are Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (OCEAN).

The next figure shows, for the five dimensions of personality the tendencies and the mechanisms used.

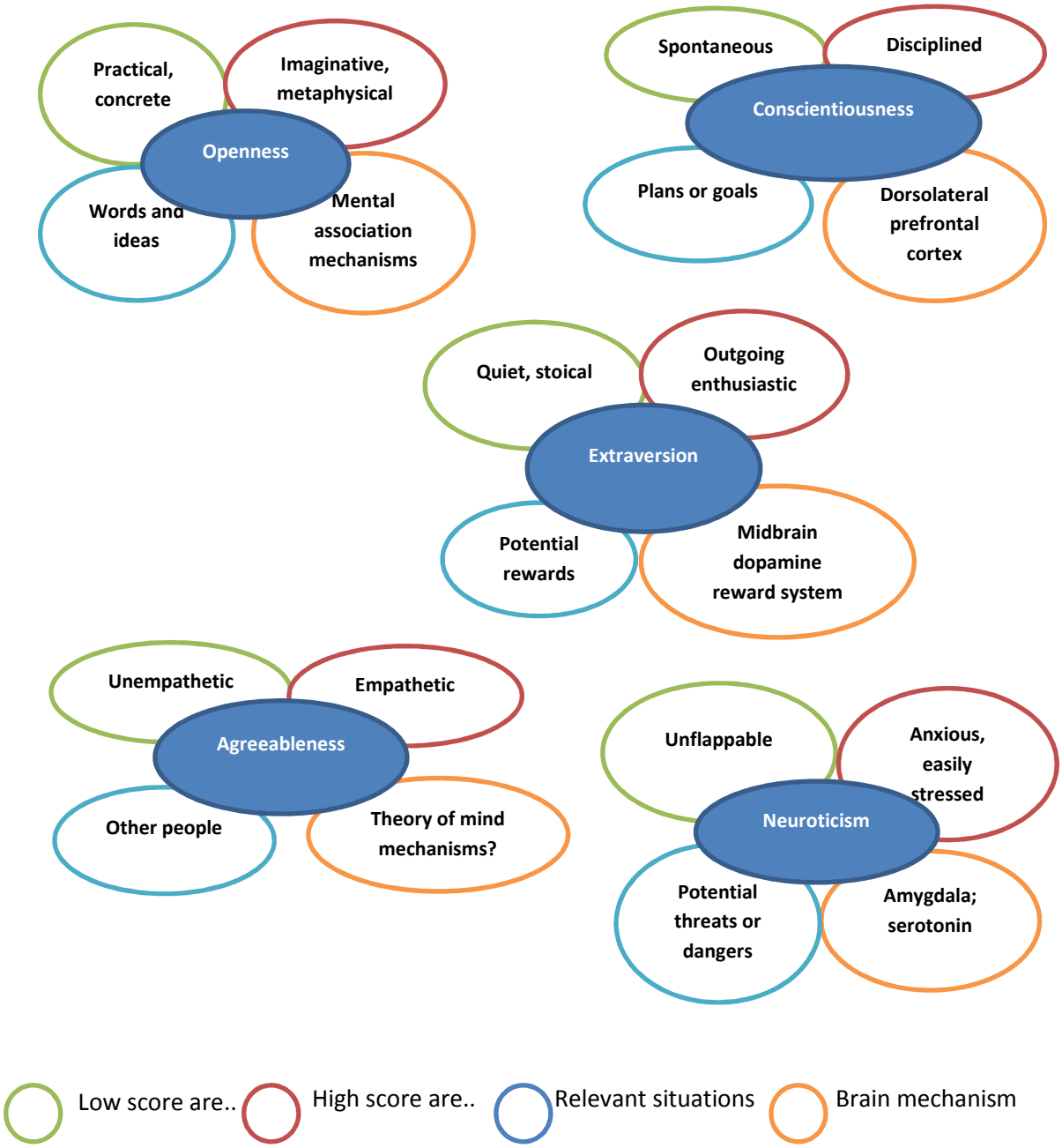


Figure 12 – Big Five (Roth, 2011)

Trait	Description
Openness	Curious, original, intellectual, creative, and open to new ideas
Conscientiousness	Organized, systematic, punctual, achievement oriented, and dependable
Extraversion	Outgoing, talkative, sociable, and enjoys being in social situations
Agreeableness	Affable, tolerant, sensitive, trusting, kind, and warm
Neuroticism	Anxious, irritable, temperamental, and moody

Table 3- Big Five

- Openness dimension include personalities that are open to experiences, like art, emotions, adventure, uncommon ideas and a wide range of experiences. Openness dimension returns an amount of intellectual curiosity, originality and an inclination for innovation and variety;
- Conscientiousness dimension it has a tendency to self-discipline, sense of duty, and aims for achievement. It is organized and dependable; he plans rather than acts spontaneous;
- Extraversion is mirrored as energy, positive emotions, confidence, sociability and the tendency to seek stimulation in the company of others, and talkativeness.
- Agreeableness has the tendency to be empathetic and accommodating rather than suspicious and antagonistic towards others;
- Neuroticism has the propensity to experience disagreeable feelings easily, such as anger, anxiety, depression, or vulnerability. Neuroticism also refers to the degree of emotional stability and impulse control.

The Big Five personality test is more accurate than any other personality, although some psychologists object to the model because it disregards other domains of personality like religiosity. To find out which is the personality of a certain student, the student has to answer a questionnaire like the example in Annex B. Annex B consists in the Ten Item Personality Measure (TIPI) questionnaire that contains 10 questions used to measure the Big Five Model dimensions. This questionnaire is design for studies that required short measures for personality or in which the study of personality it is not the primary objective (Gosling, Rentfrow, & Swann, 2003).

2.7.1.1.1. Motivation

Intrinsic motivation is defined as the accomplishment of an activity for its inherent satisfaction rather than for some separable consequence (Ryan & Deci, 2000). Extrinsic motivation is a construction that pertains whenever an activity is performed in order to attain some separable outcome (Ryan & Deci, 2000).

Regulatory Styles	Amotivation	Extrinsic Motivation				Intrinsic Motivation
		External regulation	Introjection	Identification	Integration	
Associative processes	Perceived non-contingency Low perceived competence No relevance No intentionality	Salience of extrinsic rewards or punishments. Compliance /Reactance	Ego involvement. Focus on approval from self and others	Conscious valuing of activity Self-endorsement of goals.	Hierarchical synthesis of goals. Congruence	Interest /Enjoyment Inherent satisfaction
Perceived locus of causality	Impersonal	External	Somewhat External	Somewhat Internal	Internal	Internal

Table 4 - Taxonomy of the human motivation. (Ryan & Deci, 2000)

2.7.1.2. Learning Styles

A learning style is the method that permits an individual to learn best (Morgan & Baker, 2012). Different people learn in different ways and each one preferring a different learning style. Everyone has a mix of learning styles, but some people may find that they have a dominant style of learning. Others may find that they have a different learning style in different circumstances. There are several models developed by several authors that try to represent the way people learn (Morgan & Baker, 2012).

2.7.1.2.1. Learning Style Inventory Model

The Learning Style Inventory (LSI) model, proposed by educational theorist David A. Kolb, is based on the Experiential Learning Theory, as explained in (Kolb, 1984). The LSI is a helpful resource that assesses the manner individuals like better to learn through the way they take a grip on different situations, problem solving and the way they think. The LSI test aids to define the individual strengths and weaknesses, what stage one is at in the Cycle of Learning, and what Learning-Style Type best suits him. Kolb (Kolb, 1984) propose a model in which the learner used four different skills: concrete experience, reflective observation, abstract conceptualization and active experimentation and four types of learning styles: Divergent, Assimilative, Convergent and Accommodative .

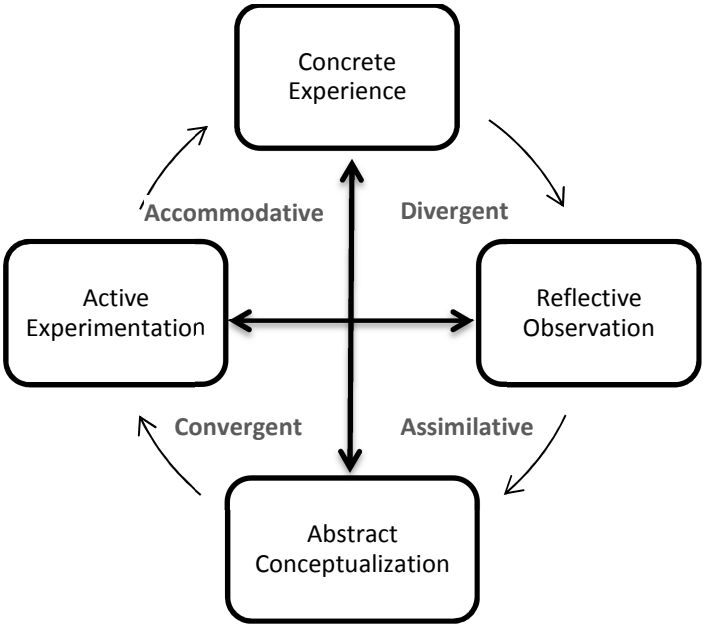


Figure 13 – Kolb's Cycle of Experiential Learning (Kolb, 1984).

The cycle shown in figure 13, starts with an experience that the student has to have, followed by a chance to reflect on that experience. Then students can conceptualize and draw conclusions about what they experienced and observed, resulting into future actions in which the students experiment different behaviors. This begins the cycle again as students have new experiences based on their experimentation.

- Divergent learners have, as dominating dimensions, concrete experience, and reflective observation. This learning style type includes learning from feeling, seeing and listening. This type of student approaches a problem by exploring all view points and possible answers to it.
- Assimilative learners have, as dominating dimensions, concrete experience and active experimentation. This learning style type learns by thinking, watching and listening. These students have good understanding about a wide variety of information, abstract thoughts and notions. They learn best by placing everything into a logical, succinct from.
- Convergent learners have, as dominating dimensions, abstract conceptualization and active experimentation. This learning style type learns by thinking and doing. These types of student are strong in solving problems and making decisions by logically using ideas and theories.

- Accommodative learners have, as dominating dimensions, concrete experience and active experimentation. This learning style type learns from feelings and learns by doing. These students are practical and prefer experiencing over logic and facts, and prefer stimulating experiences and joining other people's opinions in their decision-making process.

2.7.1.2.2. Felder-Silverman Model

The Felder-Silverman (Felder, 1988) model covers four learning dimensions Sensing/Intuiting, Visual/Verbal, Active/Reflective and Sequential/Global.

- Sensing/Intuiting learners (Felder, 1988) are the ones that tend to behold the world. Sensing undertake noticing and collecting data through senses. Intuition includes indirect perception by way of the unconscious: conjecture, imagination, and feelings. Learners will use both of these abilities; most will prefer using one to the other.
- Visual/Verbal learners (Felder, 1988) are individuals that intake information in 3 different ways: (1) visual – sights, images, drawings, symbols; (2) verbal – sounds and words; and, (3) kinesthetic – taste, touch, and smell. Visual and auditory learning are both related with learning processes that observe information, and kinesthetic learning is related with both perception such as taste, touch, and smell, and information processing such as moving, relating, or doing something active.
- Active/Reflective learners as stated in (Kapadia, 2008) process information, so convert perceived information into knowledge, this can be performed in two ways: active experimentation and reflective observation. Active experimentation implicates doing something with information in the external world, such as debating it, clarifying it, or testing it in some way. Reflective observation implicates investigative and manipulating the information introspectively.
- Sequential/Global learners (Felder, 1988), the sequential learners learn on a sequential manner while the global learners summaries the information. Sequential learners easily learn information that is presented in a logically ordered progression. They follow linear reasoning processes when solving problems, and can work with material even when they only have a partial or superficial understanding of it.

Global learners tend to learn in bit at the time until they can see the big picture. As result, they may comprehend the material well enough to apply it to problems that leave most of the sequential learners lost.

The Index of Learning Styles (ILS)[1] determines an individual's preferred dimensions of the learning style model by asking 11 items for each of the four dimensions (for a total of 44 questions).

2.7.1.3. Learning preferences - VARK

VARK (Fleming & Baume, 2006), consists on a questionnaire (16 questions) that provides users with a profile of their learning preferences. A sample of this questionnaire can be found in Annex C or online[2]. These preferences are about the ways that they want to take-in and give-out information. VARK preferences can be used to help develop, effective strategies for learning and for improving communication skills. VARK covers four dimensions Visual, Aural, Read/Write and kinetic.

2.7.1.3.1. Visual

The students prefer using pictures, images, colors, and maps to organize information and interconnect with others. They can, without difficulty visualize objects. They have a good spatial sense and a good sense of direction. Visual students can easily visualize any imagery, so the visualizations presented to then need to stand out, so they can later remember what they had seen. The use of color, layout and spatial organization in associations, and the use of visual words in assertions are also important. Example: the use of words like see, picture, perspective, visual and map. They use of diagrams to assist in the visualization of connections between parts of a system. Exchange words with pictures, using color to highlight major and minor connections. The use of a visual story can help memorize procedures. The use of peg words for remembering a name given only a number or for memorizing numbered lists of items. The use of the swish techniques can help change

[1] Online questionnaire http://www.engr.ncsu.edu/learningstyles/ilsweb.html
[2] VARK online questionnaire http://vark-learn.com/questionario/

behaviors. The swish technique is from a branch of psychology known as NLP (Neuro Linguistic Programming). It is particularly suitable to help deal with situations where a change of behavior is needed. Example: a confidence boost. Next figure shows words and sentences that can be associated with a visual student.

Figure 14 – Words associated with a visual student.

2.7.1.3.2. Aural

The aural students prefer to use sound and music. They have a good sense of pitch and rhythm. They can usually sing, play a musical instrument, or identify the sounds of different instruments. The use of music can invoke strong emotions. The use of music allied with an event can become associated in the student mind. These students use in their learning process, sound, rhyme, and music. The use of aural content with visualizations helps them to remember what they are learning. The creation of mnemonics or acrostics to take advantage of the rhyme and rhythm can help the student remember. The aural students tend to use phrases like the ones shown in the next figure.

Figure 15 – Words associated with an aural student.

2.7.1.4. Read/ Write

With learning preference, students prefer the use of the written and the spoken word. The students find easy to express themselves, both in writing and verbally. Students enjoy playing with the meaning or sound of words, such as in tongue twisters, rhymes and limericks. With a verbal learner, techniques that involve speaking and writing should be used. For example, to record procedures and play back to the student so he can apply his sense of repetition. These students can use learning techniques such as the use word-base techniques such as assertions and scripting. The use of rhyme and rhythm to highlight the important parts of the subject and help the student memorize. The use of mnemonics and acronym to create a memorable sequence so the student can later remember. The use of scripting or even the use of recording of scripts can help the student because it can be used for later reviews. The use of a “dramatic” voice instead of a monotone voice, while reading aloud, can also help the student memorize. The students with this preference tend to use phrases like:

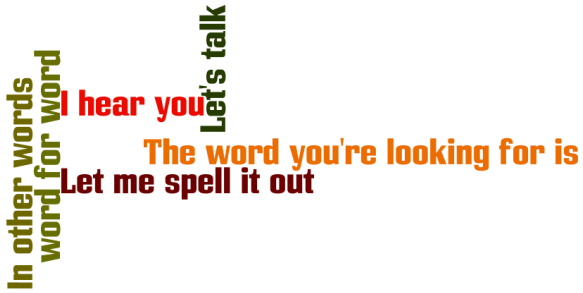


Figure 16 – Words associated with a Read/Write student.

2.7.1.5. kinetic

The students with this learning preference prefer using their body, hands and sense of touch. These students are likely to do sports or other physical activities. They are more sensitive to the physical world, appreciate textures and everything that can be touched or felt. Use typically larger hand gestures and other body language to communicate. For this student it’s quite boring to sit and listen. They prefer to play with a physical part of the problem. These students can use learning techniques such as the use touch, action, movement and hands-on work in your learning activities. For example, visualizations that can provoke physical sensation of movement work the best. They use assertions and

scripting that can describe physical feelings of events. These students tend to use phrases like:

Figure 17 – Words associated with a kinetic student.

In conclusion every learning preference as a prefer way to assimilate information. In the following figure is shown the different retention rates for each learning preference and the way the information is presented.

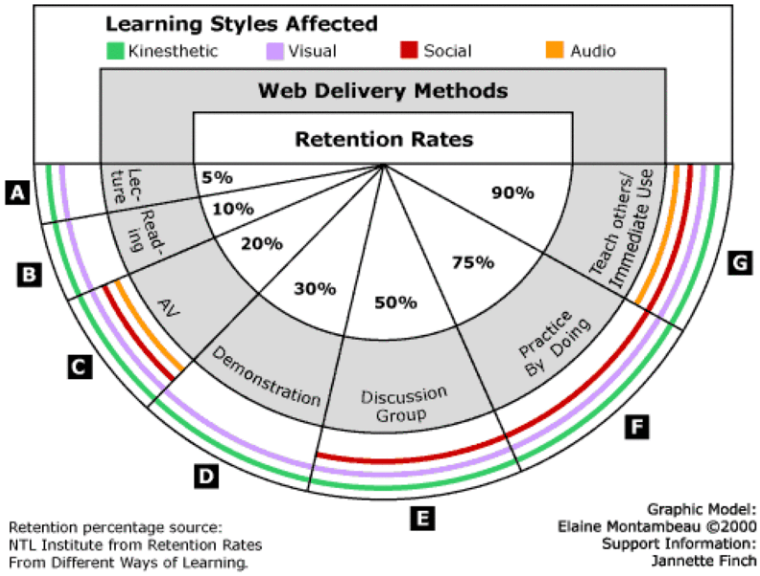


Figure 18 - Learning styles affected (Thalheimer, 2006)

2.8.Conclusions

This chapter gives an overview of the background research performed under the aim of this work. This was an essential step in the methodology by helping to clarify the research problem and objectives. This background research involves a wide spread of areas, from the different branches of phycology to technical advances in computers and computers programs, passing by education and learning areas. The chapter starts by defining learning

and e-learning and the advantages and problems they bring. Also, the emotions that an online student is susceptible to feel and the stimulus that can be introduce, in an online study, to change some of that emotions (Regan, 2003). There is also a brief description about affective computer technologies and their advances throughout the years. Some of the most significant emotion theories that attempt to explain what emotion is and what causes emotion are referred. The emotional theories can be grouped into three main categories: physiological, neurological, and cognitive. Physiological theories advocate that responses of the body are responsible for emotions. Neurological theories propose that activity within the brain leads to emotional reaction. Finally, cognitive theories say that thoughts and other mental activity play an important role in the construction of emotions (R. a Calvo et al., 2010). A review of affect detection techniques was performed, this include facial expressions recognition, body language, eye tracking, emotional speech recognition, physiology, brain imaging and EEG, emotional text analyses and methods that combines multiple way of detecting emotion.

According to recent definitions, "Affective learning involves the melding of thinking and feeling in how people learn. Importance is placed on social learning environments for knowledge construction and application wherein deeper awareness and understanding of the role played by mental dispositions in how a person views, engages, and values learning can result in better understanding and use of knowledge and skills. Learning outcomes are focused on enculturation of norms, values, skilful practices, and dispositions for lifelong learning." (Stricker, 2009). There are several affective learning models, the use of a model is to understand how the emotions are evolving in the learning process like Russell's Circumplex model (James a. Russell, 1980) to describe user's emotion space and Kort's learning spiral model (Kort et al., 2001) to explore the affective evolution during learning process.

In this chapter is given an overview of personality and learning styles subjects. Personality research aims to study what distinguish one individual from another (Santos, 2010), it depends on quantifiable concrete data that can be used to comprehend what people are like. Also, is detail the relationship between personality and learning (Busato et al., 1998; Diseth, 2003; Ibrahimoglu et al., 2013). One of the models largely use to map

personality is the Big Five Model (Komarraju et al., 2009, 2011; Kumar et al., 2009). The Big Five dimensions are Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (OCEAN) each of its dimension has its own tendencies and motivation. In the learning style subject it is possible to define a learning style as the method that permits an individual to learn best (Morgan & Baker, 2012). Different people learn in different ways and each one fitting a different learning style. Everyone has a mix of learning styles, but some people may find that they have a dominating style of learning. The best known models are Learning Style Inventory model, proposed by educational theorist David A. Kolb (Kolb, 1984) and the Felder-Silverman model (Kapadia, 2008).

3

3. Proposed Approach

After the definition of the research problem and its main objectives the next step is the definition and development of a new architecture. So, in order to find out if emotions can influence the learning process it was necessary to have a learning program in which the student's emotion would be capture (see section 2.5). Based on this capture several aspects of learning program that would be adapt to the student. According to background research, not only this adaption should be performed based on the student's emotions, but also based in other student's characteristics like: personality and learning preferences (see section 2.7). The inclusion of these characteristics helps the student to better learn and understand the information presented to them and possibly enhancing their learning results.

The development of a new architecture is due to the void found in the literature most of the systems developed, did not use the combined student's characteristics, to adapt the learning program, studies like (Shen et al., 2009) and (C. Martins et al., 2011). Initially, an effort was made to adapt an existent adaptive hypermedia platform, PCMAT (Mathematics Collaborative Learning Platform) (C. Martins et al., 2011) to the requirements that were need for this work, but this was not possible.

PCMAT is an adaptive learning platform for mathematics in basic school, based on a constructivist approach. The knowledge level of a student is accessed and subjects content and activities are adapt to the characteristics and learning style of the student. The main idea was to keep the existent structure of PCMAT and add the emotion and personality. This was proven to be technically very difficult to implement. PCMAT system architecture is

based on strategies used on AHAM model and by the system AHA (Adaptive Hypermedia for All)[3]. The AHA project developed as Open Source system by the Eindhoven University of Technology, in the Database and Hypermedia group headed by prof. Dr. Paul De Bra (C. L. Martins, 2012). Although the AHA project is discontinued, the problem was the system that was require for it run. This system rendered unable the emotion recognition system that led to abandonment of this idea.

So, a new architecture was required, one that would use the student's emotions, personality and learning preferences. The construction of this architecture went through several interactions in which it was refined. Based on the architecture a prototype was also developed. The prototype entitled Emotion Test was created to be used in a web environment. It was implemented to be an engaging learning environment with multimedia interactivity. Emotion Test prototype simulates the entire learning process, from the explanation of the subject, to exercises and assessment test. Through the entire process student's emotional state, personality traits and learning preferences are considered.

3.1.Architecture

Based on the initial objectives of this work, one could foresee several components emerging from them. From main research goal "to find out if the consideration of student's emotional state influences their learning process" the architecture began to be built. From this goal the two most obvious architecture models were created:

- The need to capture of the student's emotions originated the first model of the architecture (Emotional Model). This model kept its main objective of using a capture technique a technique that was not to invasive that would change the student emotional state.
- The architecture second model (Application Model) consisted in the knowledge that the student had to acquire and all the learning tasks the student had to complete.

[3] http://aha.win.tue.nl

So, at this stage the architecture was composed by two models the Emotional Model and the Application Model, as is shown in the figure bellow.

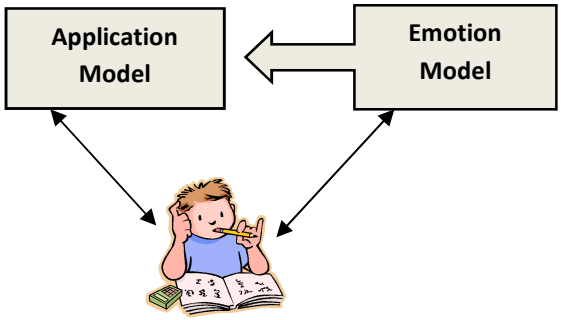


Figure 19 – Two Models Architecture

After the creation of this two model architecture other objectives came into view:

- The need of storing and using the student information originated a third model (Student Model). This information would be used to adapt the course to each individual student. It was also decided what was the information to be kept, as a base it was used Table 2 (see section 2.7.1). At this stage, it was also defined how the student's personality and learning preferences would be determine. This assessment could be performed by questionnaires and based on background research done, the most suitable seem to be the TIPI questionnaire for determine personality (example in Annex B) and the VARK questionnaire for determine learning preferences (example in Annex C) (see section 2.7.1.1. and 2.7.1.3.).
- The Application Model and Emotional Model at this stage were also refined:
    - In the Application Model it was enhance the way knowledge was presented to the students and how it was organized originated the Graph of Concepts. Also, at this time it was devised how would be used the student's personality traits a learning preference to present the knowledge, giving origin to the creation of stereotypes.
    - In the Emotional Model it was chosen the Affective Computing techniques to be used. Initially It was planned to use a multimodal system to recognize emotion in which would be used facial expression recognition, emotional speech recognition and emotion detection in text. These last two techniques were proven to be very difficult to implement.

- For emotional speech recognition it was used the microphone which raise security and privacy problems in online systems, the microphone sensitivity that did catch all of the words of the student and the language barrier was also a problem, most of the existent systems are developed for English not for Portuguese. Another problem was the accent of the students, which leads to misinterpretation of the words.
- For text emotion recognition there was also the problem of the language barrier, and the misspelling and the unknown abbreviations and emoticons that posed a problem to recognize emotion.

The architecture at this stage was composed by three models the Emotional Model, the Application Model and the Student Model, as is shown in the figure bellow.

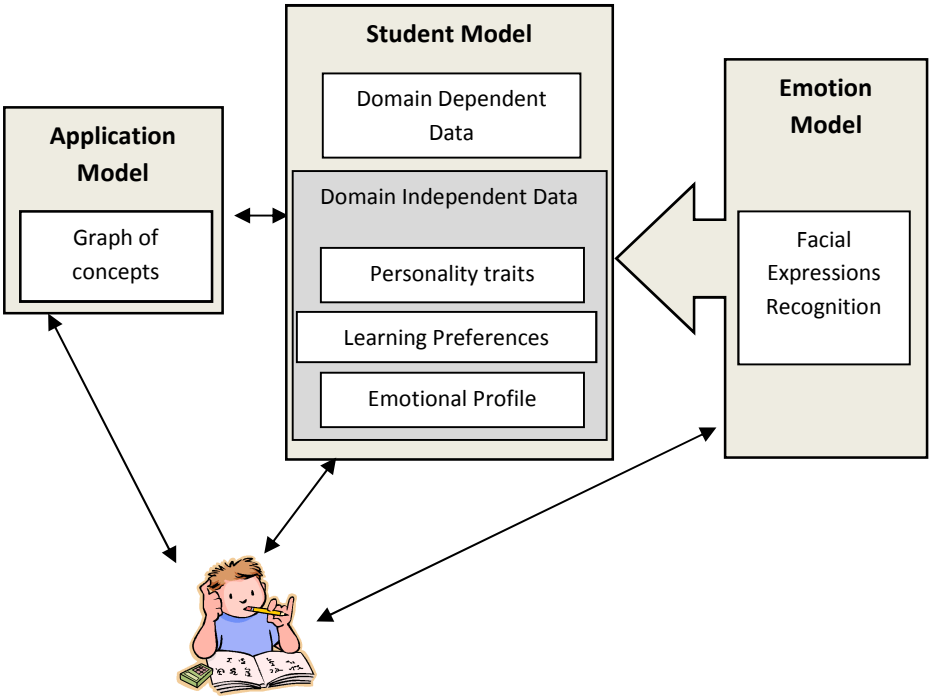


Figure 20 – Three Models Architecture

After the creation of this three model architecture another need emerged. The need for a model that would:

- Coordinate the adaption of the knowledge to be learned to the student's characteristics (Rules of Emotion Adaptability);
- Intervene in case the student failed to acquire this knowledge (Graph of Concepts in case of Failure);

- Interact with the student if he required an emotional intervention to recapture he's attention and motivation.

Also, at this stage it was refined the Emotion Model, due to need to gather the student's opinions about what they have learn. This created the Feedback sub-model.

The final architecture is illustrated by the next figure.

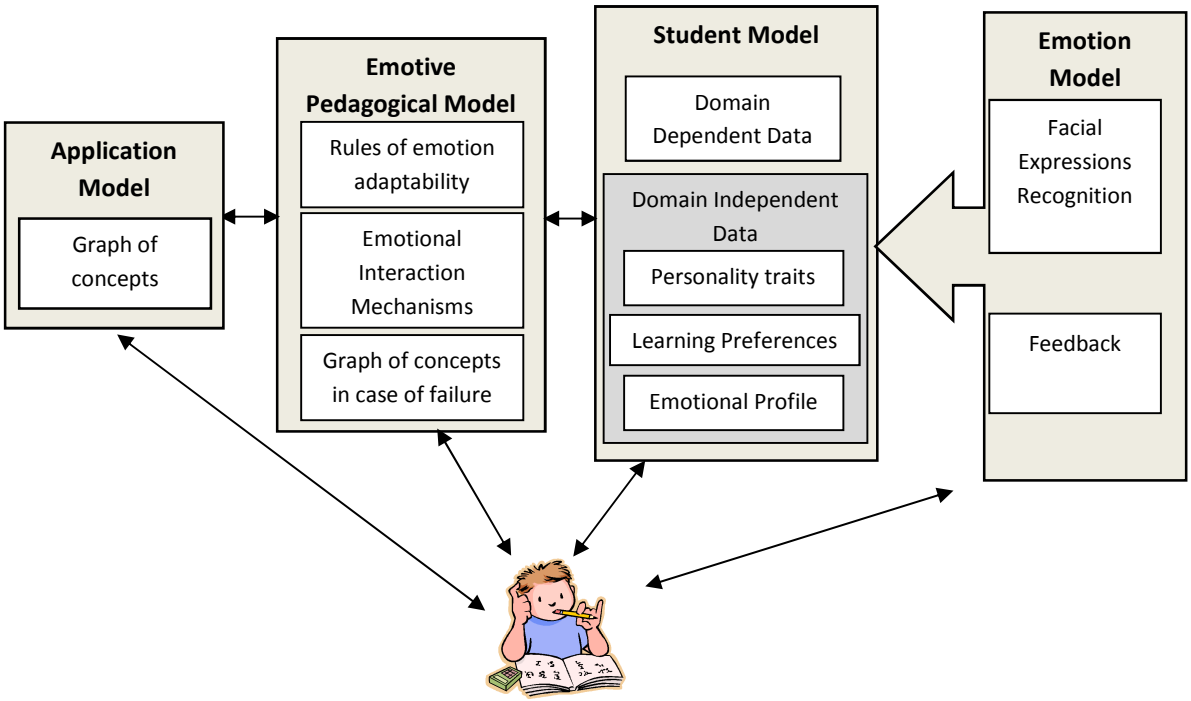


Figure 21 – Final Architecture

In summary the proposed architecture is composed of 4 major models:

1) Student Model consists in the student information and characteristics, from the domain dependent data like name and age to the domain independent data like learning preferences, personality traits and emotion profile;
2) Emotional Model consist in retrieving the raw emotional data of the student and its subsequently treatment so it can be late used by the platform;
3) Application Model is composed by a series of modules containing different subjects content that may or may not be interconnected;
4) Emotive Pedagogical Model consists in all the rules of emotion adaptability, emotional interaction mechanisms, and failure mechanisms.

3.2. Prototype of a Learning Platform

In order to prove and verify the validity of the architecture developed as a solution to the problem, a prototype was created. The prototype was entitle Emotion test and it allows students to consolidate knowledge, autonomously and with ongoing support through teaching methodologies, educational activities and emotional interactions. On this prototype educational activities and emotional interactions are based on the selection of activities and adapted to the student profile. The prototype content, activities and interactions are defined by the teacher, but dynamically adapted and personalized according to the knowledge level, learning preferences, personality, skills and student learning pathway. The domain chosen to evaluate the prototype was numerical conversion, to be more precise the conversion of decimal numbers to others bases, but the prototype can be used for any other domain.

Figure 22 –Emotion Test

The main objectives include:

- Definition of new strategies for the implementation of learning platform that can support and enhance the learning process;
- Definition of the Student Model attributes that describe the information, knowledge, learning preferences, personality and emotional profile needed to conduct the learning platform mechanisms;
- Design of an innovative hybrid system that allows relating the representation knowledge, learning preferences, personality and emotions with a learning model and adaptation rules.
- Development of an emotional interaction mechanism able to detect and induce the student's emotional state.

The developed system is built with PHP a server-side scripting language designed for web development, HTML5, JavaScript and Cascading Style Sheets (CSS). The Database Management System used was MySQL.

3.2.1. Student Model

Two different methodologies can be used to implement the Student Model: based on Knowledge and based on behaviour (Kobsa, 1993) (A. C. Martins et al., 2008). The student model consists in retrieving the student information and characteristics. This can include personal information (name, email, telephone, etc.), demographic data (gender, race, age, etc.), knowledge, deficiencies, learning styles, emotion profile, personality traits, etc. This information is used to adapt the learning content, activities and interactions to student requirements. The next table contains an example of information that can be gathered.

Profile	**Characteristics**	**Descriptions / examples**	**How to get it**
Generic Profile	Personal information	Name, email, telephone, etc.	Querying the student or LDAP if exists
	Demographic data	Gender, race, age, etc.	Can be estimated by the application
	Academics background	Technological studies versus economics etc.	Querying the student
	Qualifications	Certificates, etc	Querying the student
	Knowledge (background knowledge)	A collection of knowledge translated in concepts. Possibility of a qualitative, quantitative or probabilistic indication of concepts and knowledge acquired for the user.	
	Deficiencies: visual or others	Sees well, uses eyeglasses, etc.	The visual deficiencies can be estimated by the application
	Inheritance of the characteristics	Creation of stereotypes that allow to classify the user	
Psychological Profile	Learning preferences	Definition of the learning preferences	VARK questionnaires
	Emotion Profile	Emotions	Facial expression recognition
	Traces of the personality	Psychological profile (introverted, extrovert, active, etc.).	TIPI questionnaires
	Inheritance of characteristics	Creation of stereotypes that allow to classify the user	
	Objectives	Questionnaires that allow to determine with objectives the user intends to use the system	Questionnaires
	Planning / Plan		Plan registry
	Complete description of the navigation	Kept register of each page accessed	Page log
	Knowledge acquired	A collection of knowledge translated in concepts. Possibility of a qualitative, quantitative or probabilistic indication of concepts and knowledge acquired for the user	
	Results of assessment	Data of all the tests, exercises.	
	Context model	Data related with the environment of the user (resolution of the monitor, etc.)	
	Aptitude	Definition of aptitude and the capacity to use the system	
	Interests	Definition of the interests of the individual with the objective to adapt the navigation and contents	

Table 5 - Student model

The student model data is collected in different ways, this was done in order to facilitate student progress in the prototype and not put the student thru endless questionnaires. The questionnaires used were chosen taking in consideration the time the student needed to answer them. Generic information of the students (like name, email and other) was gathering from the school LDAP database and a small form in the beginning of the prototype. Other information like personality traits and learning preferences information are determined by questionnaires that are built in the prototype. To classify student personality traits it is used the Big Five model, so, students have to respond the TIPI questionnaire (Annex B), which allows classifying student personality traits according the Big Five model. This model is divided in five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. This questionnaire allows to brief measure the Big Five personality dimensions for each student. The choice of TIPI questionnaire lies on the fact that this questionnaire would take less time to respond than other personality measure questionnaires. Next figure shows a sample of the TIPI questionnaire developed in the prototype.

Figure 23 – Emotion Test – TIPI questionnaire

For the learning preferences, students have to answer the VARK questionnaire (Annex C). The acronym VARK stands for Visual, Aural, Read/write, and Kinect sensory strategies that are used for displaying learning information. The student's answers to the VARK questionnaire will allow choosing for each student the proper learning strategies. The choice of VARK strategy is due to the fact that it allows the discovery of the learning preferences in

a very simple way. The choice of the learning styles falls in the model proposed by Kolb (Kolb, 1984) that allows great flexibility to implement a solution. The mapping between Kolb learning styles and VARK strategy allows the prototype to choose a type of content or activity that will be more appropriate for the student (C. L. Martins, 2012). This mapping is shown in the next table.

Kolb Learning styles	VARK
Feel and see	Visual
Hear and think	Aural
Doing and thinking	Kinetic
Do and feel	Kinetic

Table 6 - Mapping of Kolb's Learning Styles and VARK Learning Preferences (C. L. Martins, 2012)

Next figure shows a sample of the VARK questionnaire developed in the prototype.

Figure 24 – Emotion Test – VARK questionnaire

3.2.1.1. Stereotypes

The prototype allows students to consolidate knowledge, autonomously and with ongoing support through teaching methodologies, educational activities and emotional interactions. The platform educational activities and emotional interactions are based on the selection of activities and adapted to the student profile. In the next table is shown the stereotypes used in the prototype. Each stereotype has a learning preference, a personality and a type of motivation associated.

Stereotype	Learning Preference	Personality	Motivation
SVO	Visual	**O**penness	Achievement Intrinsic motivation
SAO	Aural		
SRO	Read/write		
SKO	Kinetic		
SVC	Visual	**C**onscientiousness	Intrinsic and Extrinsic motivation
SAC	Aural		
SRC	Read/write		
SKC	Kinetic		
SVE	Visual	**E**xtraversion	Extrinsic motivation
SAE	Aural		
SRE	Read/write		
SKE	Kinetic		
SVA	Visual	**A**greeableness	Achievement
SAA	Aural		
SRA	Read/write		
SKA	Kinetic		
SVN	Visual	**N**euroticism	Amotivation
SAN	Aural		
SRN	Read/write		
SKN	Kinetic		
Neutral	-	-	-

Table 7- Stereotypes

3.2.2. Emotion Model

Emotion Model is composed by two sub-models, Facial Expression Recognition that deals with the capture of emotion and other features and the Feedback Model that tries to access the impression and feelings of the student after using the prototype.

3.2.2.1. Facial Expression Recognition

Facial Expression Recognition allows video analysis of images in order to recognise an emotion. This type of emotion recognition was chosen because it was the least intrusive with the student activities. The emotion recognition is achieved by making use of an API entitled ReKognition ("orbe.us | ReKognition - Welcome to Rekognition.com," 2015). This API allows detection of the face, eyes, nose and mouth and if the eyes and mouth are open or close. In addition specifies the gender of the individual and an estimate of age and emotion. In each moment a group of three emotions is captured. For each emotion is given a number that shows the confidence level of the emotion captured.

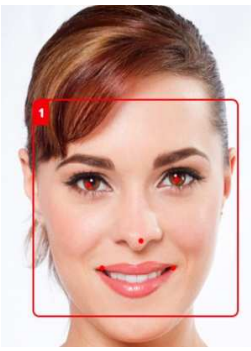


Figure 25 – Facial Expression Recognition ("orbe.us | ReKognition - Welcome to Rekognition.com," 2015)

For each set of three emotions there are 2 possible situations:

1. One of the emotions has a percentage of level confidence higher than 85%. In this case the emotion is considered a prevalent emotion;
2. The two emotions with highest percentage of level confidence are matched to produce primary, secondary or tertiary dyads.

ReKognition is able to detect 7 emotions, namely happiness, sadness, anger, disgust, surprise, confused and calm.

Based on Robert Plutchik's (Wilson, 1978) wheel of emotion it is conceivable to blend emotions in primary, secondary or tertiary dyads as it can be observed in the following table.

(Often felt)		(Sometime felt)		(Seldom felt)		Opposites	
Primary dyads		**Secondary dyads**		**Tertiary dyads**			
Fear	Surprise	Joy	Fear	Joy	Surprise	Joy	Sadness
Alarm		Guilt		Delight		Conflict	
Surprise	Sadness	Fear	Sadness	Fear	Disgust	Fear	Anger
Disappointment		Despair		Shame		Conflict	
Sadness	Disgust	Surprise	Disgust	Surprise	Anger		
Remorse		?		Outrage			
Disgust	Anger	Sadness	Anger	Disgust	Joy		
Contempt		Envy		Morbidness			
		Anger	Joy				
		Pride					

Table 8- Combinations and opposites

In Plutchik's wheel was use the emotion of joy, as the API used only detected happiness, joy was replaced by happiness in the prototype handling of emotions. This process is detailed in annex D. In the prototype to capture emotion there is a live video feed that films the student, takes a photo every 20 seconds to run emotional analysis, which allows to discover the students emotions. Next figure illustrates how this works.

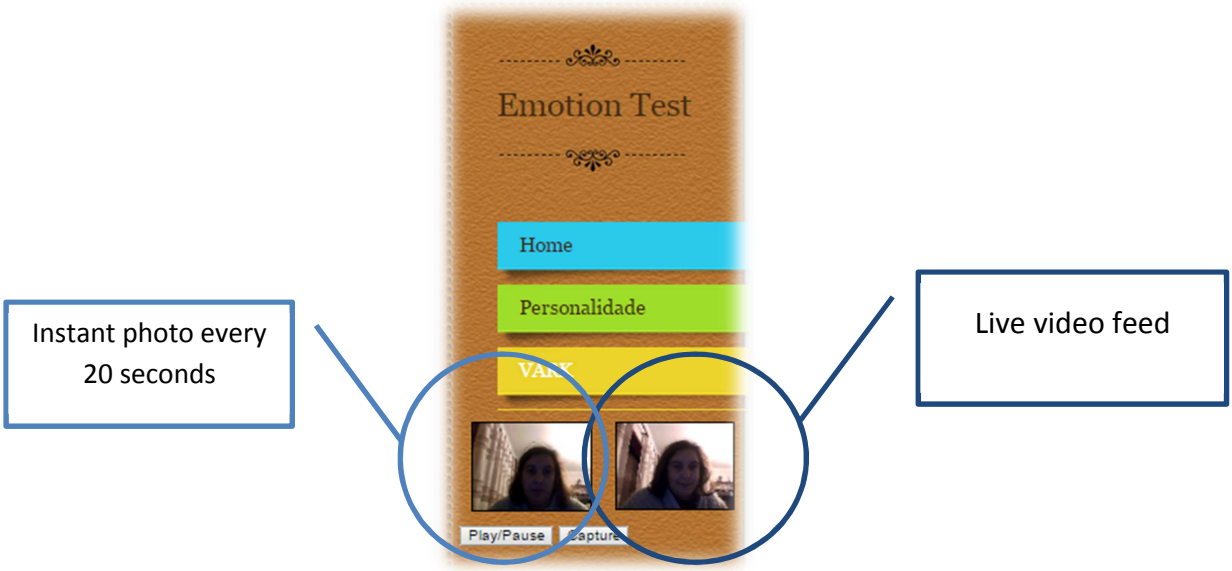


Figure 26 – Emotion Test – Video Feed

The emotion capture and mainly emotion capture online raise some problems. It was used a webcam the capture the student's face, this created security and privacy problems. The security problems were to some extent solved by using Hypertext Transfer Protocol Secure (HTTPS) which is a communications protocol for secure communication over the internet. The use of this protocol also solved the problem of privacy, but the user needed to grant access at least once for the browser to remember the user choice. Although this seemed to solve one problem it created another. If the user failed to grant access to the webcam in the beginning of the prototype use, the capturing of the user emotion would not work properly and entailing that the prototype would not adapt the course to the student's emotions.

3.2.2.2. Feedback

Feedback consists in a sequence of questions at the end of each subject. The aim of this process is to discover the student's thoughts and feelings about what he just learned. For that questions like: "Did you find this helpful?", "How would you rate this subject? ☆☆☆☆☆", "What emotion are you feeling?" are made.

Figure 27 – Emotion Test – Feedback

3.2.3. Application model

The application model is composed by a set of modules containing different subjects. Each subject consists in a number of steps that the student has to pass in order to complete his learning program. Some of these steps are optional others are not.

3.2.3.1. Concepts Graph

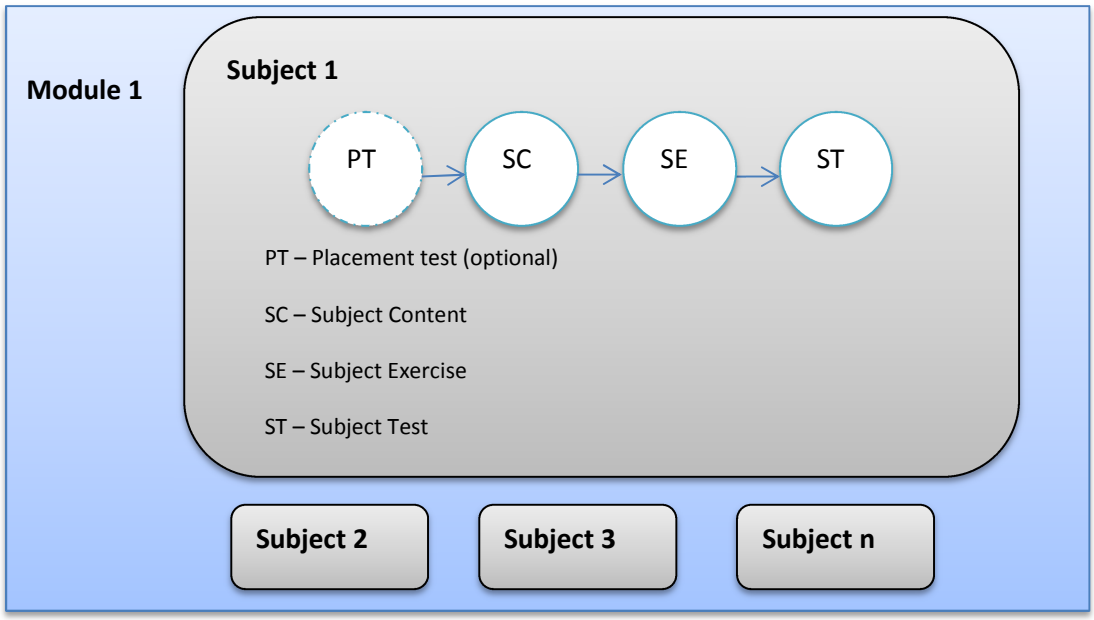


Figure 28 – Concepts Graph

The first step is the subject's Placement Test **(PT)** that can be optional. This is designed to give students and teachers a quick way of assessing the approximate level of student's knowledge. The result of the **PT** is percentage $\mathbf{PT}_s$ that is added to the student knowledge (K_s), on a particular subject, and places the student at one of the five levels of knowledge $kpt = \sum_{i=0}^{5} \text{exercise}_i$. If the **PT** is not performed $\mathbf{K_{sp}}$ will be equal to zero and the student will start with any level of knowledge.

The Subject Content **(SC)** contains the subject explanation. The subject explanation depends on the stereotype (which is based on Student Model and the combination of his learning styles, personality dimensions and motivations, section 3.2.1.1). Each explanation will have a practice exercise. These exercises will allow the students to obtain points to perform the final test of the subject. The student needs to get 80% on the $\mathbf{TotalK_{sc}}$ to undertake the subject test.

The Subject Test **(ST)** is the assessment of the learned subject. This will give a final value $\mathbf{k_{st}}$ that represents the student's knowledge on the subject, $kst = \sum_{i=0}^{5} \text{exercise}_i$

Only if the $\mathbf{k_{st}}$ is higher than 50% it can be concluded that the student has successful completed the subject. In this case the values of the $\mathbf{k_{sp}}$ and $\mathbf{k_{st}}$ are compared to see if there

was an effective improvement on the student's knowledge. This is represented in the following diagram.

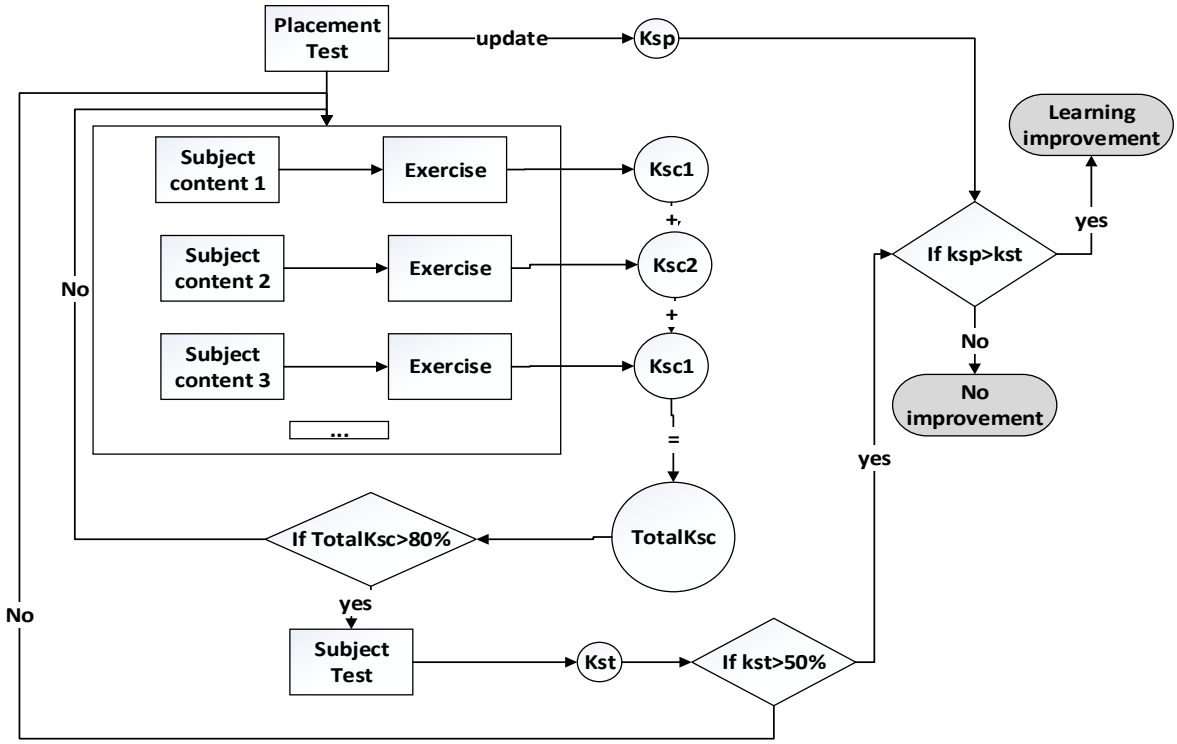


Figure 29 – Representation diagram

3.2.3.2. Subjects

As it was previously referred, the domain used for the prototype evaluation is Numerical conversion. Within this domain, the subject is the conversion of decimal numbers to another base (binary, octal and hexadecimal) with the following points.

Subject 1 - Conversion decimal to different base

- **A1 - Placement Test**
- B1 - Decimal to binary
- B2 - Decimal to binary exercises
- C1- Decimal to Octal
- C2- Decimal to Octal exercises
- D1 - Decimal to hexadecimal
- D2 - Decimal to hexadecimal exercises
- **E1 - Subject Test**

The students start by undertaking a placement test (A1) followed by the introduction of the conversion from decimal to binary (B1). The binary system of numeration consists in positional number systems. The base of the binary system is 2, which means that only two

digits (0 and 1) can occur in a binary representation of any number. The binary number system plays a central role in how information is stored on computers. This, later on, will be an interesting subject to the group of students selected to evaluate this model, because of the nature of the student's course. Four explanations are provided, considering the learning preference of each student.

For the students that preferred a visual learning process, it is given a graphical explanation in video about how to convert from decimal to binary using card with dots. The down face of the card is blank and in the up face of the card has a number of dots. Five cards are shown each card has twice as many dots as the card to its right, this representing the powers of two: 16, 8, 4, 2 and 1, as shown in the figure below.

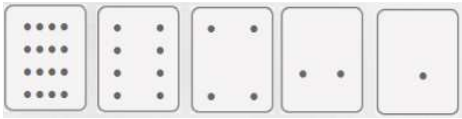


Figure 30 – Cards

When a binary number card is face down, it is represented by a zero. When it is face up, it is represented by a one. After that, the student only has to count the dots to convert a number to binary. For example, to convert the decimal number 22 the student needs the sixteen dots card facing up, the eight dots card facing down, the four and two dots cards facing up and the one dot card facing down. If the number of dots of the cards facing up is added they equal 22 (16+4+2=22). To convert to binary system the student has to place a 1 in the card facing up and a zero in the card facing down, as shown in the next figure, 22 equal to 10110 in binary.

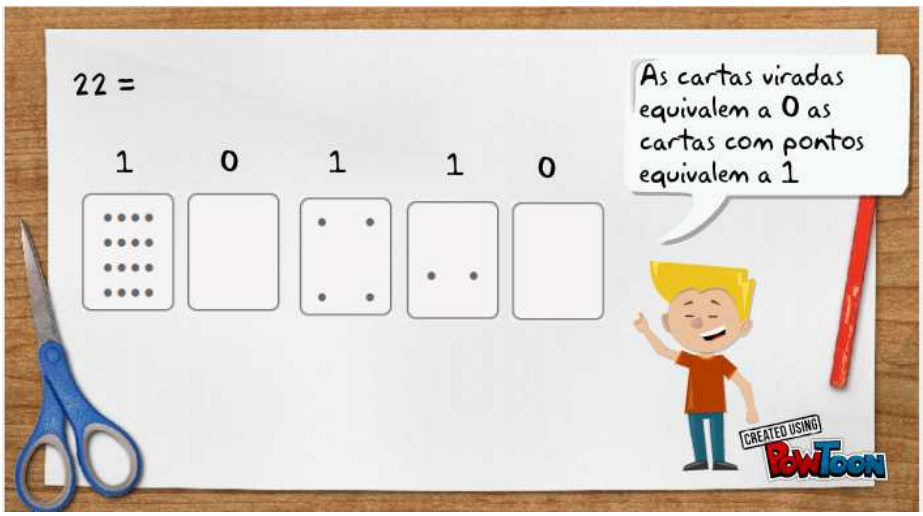


Figure 31 – Binary - Visual Explanation

For the students that preferred an aural learning process, is given an explanation in video about how to convert the number by successively dividing it by two until reaching zero and then from the bottom up collect all the remainders obtained, as presented in the next figure.

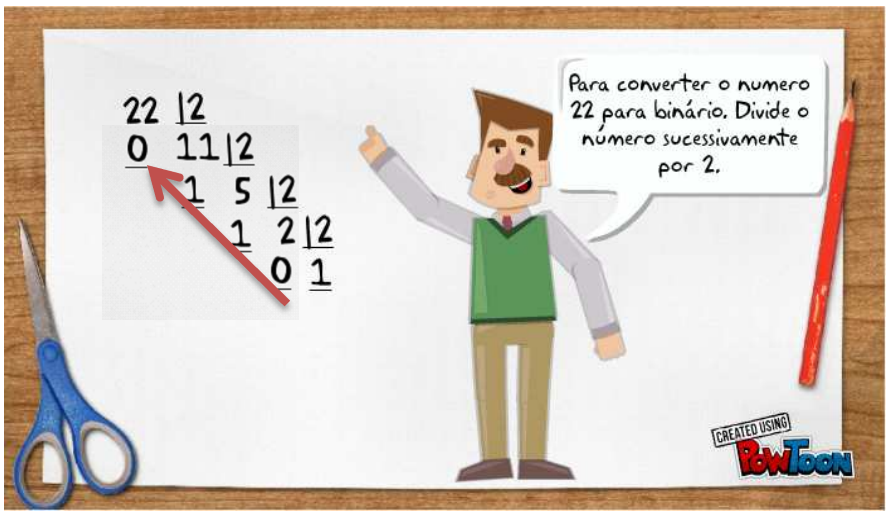


Figure 32 – Binary - Aural Explanation

For the students that preferred a read/write learning process is given a readable explanation of the subject with a sample picture how to solve the problem at hand as exemplified in the next figure.

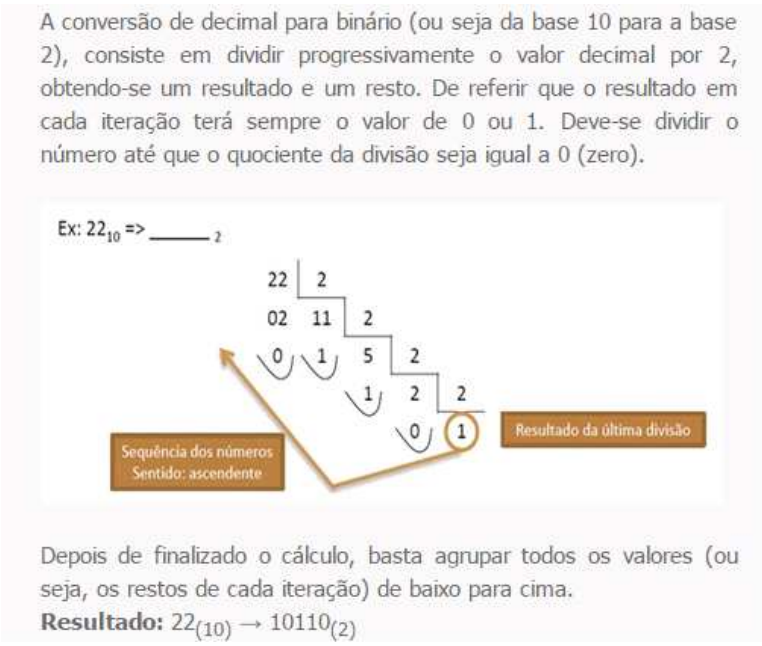


Figure 33 – Binary - Read and Write Explanation

For the students that preferred a kinetic learning process, given a readable explanation followed by a small widget in which the student can interact. By turning the light bulbs, on and off the student can form any given number in binary using the same principle explained for the dots cards. This is demonstrated in the next figure.

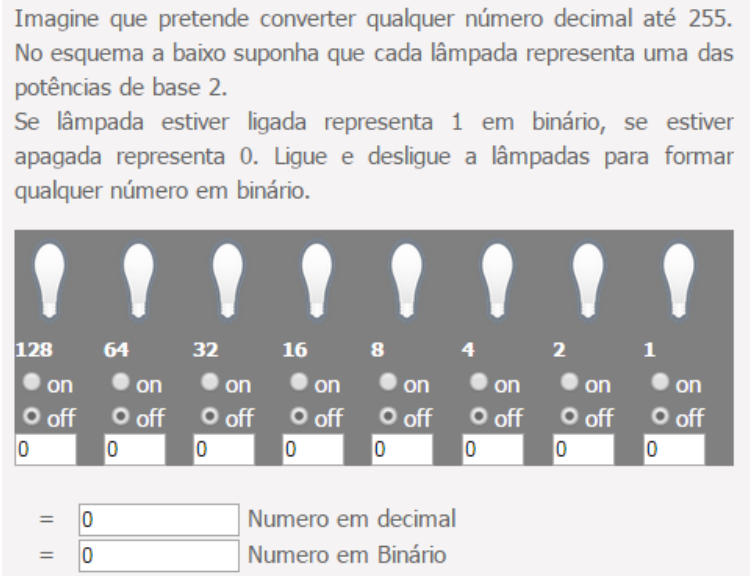


Figure 34 – Binary - Read and Write Explanation

After the completion of the explanation about the conversion from decimal to binary this is followed by the subject exercises (B2). If the students are able to complete the exercises a new subject is presented. First, it is introduced the conversion from decimal to octal (C1) and after that the conversion from decimal to hexadecimal (D1). The octal numeral system uses the digits 0 to 7 and the hexadecimal numeral system that uses sixteen distinct symbols, the numeric 0 to 9 and A, B, C, D, E, F to represent the remaining symbols. Both explanations provided were presented considering the learning preference of each student, like the explanation given for the conversion to binary system. Also both explanations were followed by the subject exercises (C2) and (D2). If the student completes all the subject's explanations and exercises he has to perform the subject test (E1).

If the student completes the subject without any failures his path will be represented by the following directed acyclic graph G1(V,E). In which V: is the set of vertices (or nodes) and E: is the set of ordered pairs of vertices, called paths.

V = {A1, B1, B2, C1, C2, D1, D2, E1}

E = {(A1,B1), (B1, B2), (B2, C1), (C1, C2), (C2, D1), (D2, E1)}

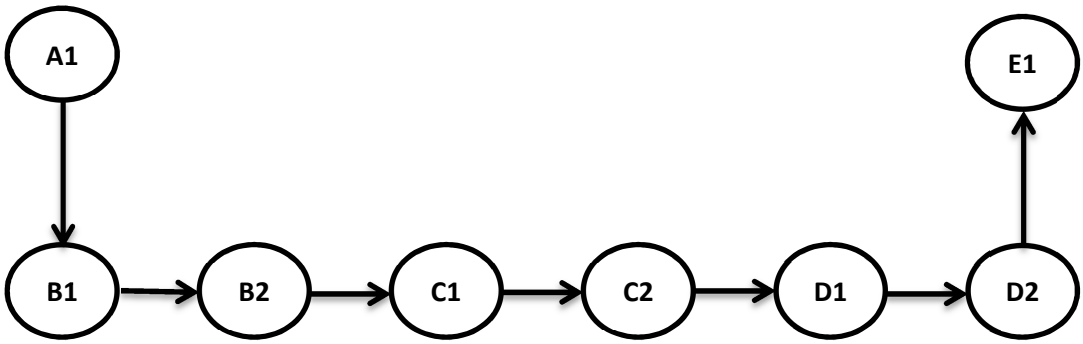


Figure 35 – Concept Graph G1(V,E)

3.2.4. Emotive Pedagogical Model

The Emotive Pedagogical Model is composed by three sub models: Rules of Emotion Adaptability, Emotional Interaction Mechanisms and Graph of Concepts in case of failure. In each step of a subject the emotional profile is updated by facial expression recognition software. The emotional expression allows establishing an emotional profile and with this information it is possible to make some adjustments to the content of the application or trigger an emotional motivation action or emotional interaction.

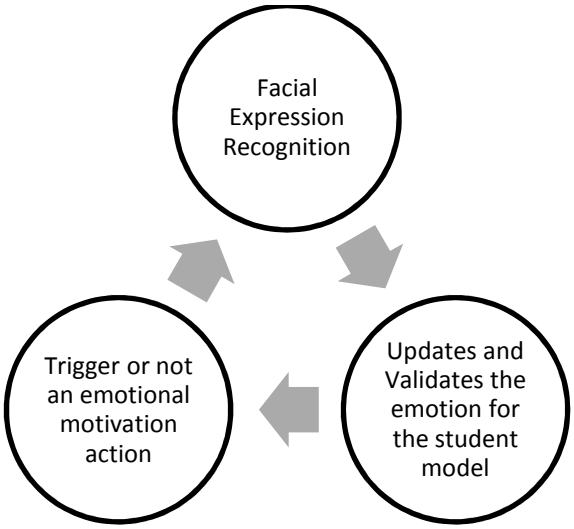


Figure 36 – Emotional cycle

3.2.4.1. Rules of emotion adaptability

The Rules of Emotion Adaptability manage the way the subject content is presented. The subject content is presented according the student's learning preference and personality. This way information and exercises are presented in a manner more agreeable to the student helping him to comprehend the subject at hand. For example if a student has visual preference the information and exercises will be presented in a graphic way, like the example show in the figure on the right.

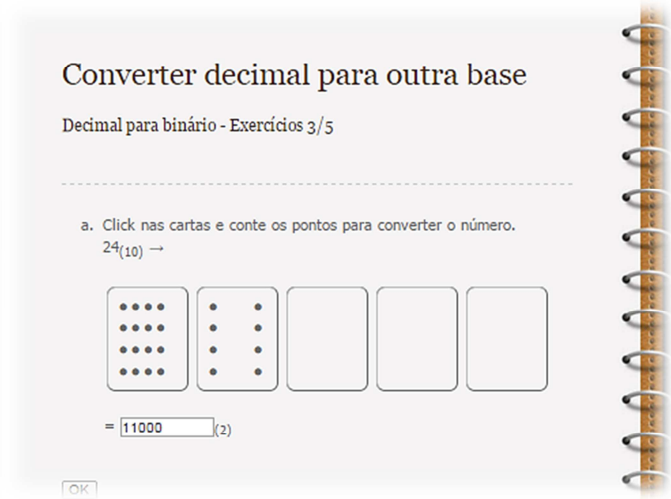


Figure 37 – Emotion Test – Exercises

For each stereotype the information is presented in a different way as summarised in the next table.

Stereotype	How information is presented	How it is formulated	Tests
SVO	Explanation and exercises with images.	The question formulated for this type of student should try to make him/her think open. For instance, "In general, imagine X, what can you say?"	Test? and Placement test equal to all stereotype They are presented in plain text
SAO	Explanation and exercises with images and sound.		
SRO	Read and write explanation and exercises		
SKO	Explanation with images, and interactive exercises		
SVC	Explanation and exercises with images.	The question formulated for this type of student will ask him/her to help other people. For instance, "If you have to explain X to a friend, what would you say to him/her?".	
SAC	Explanation and exercises with images and sound.		
SRC	Read and write explanation and exercises		
SKC	Explanation with images, and interactive exercises		
SVE	Explanation and exercises with images.	The question formulated for this type of student will allow him/her to think that s/he is talking to a lot of people. For instance, "What would you say or a lot of people about X?".	
SAE	Explanation and exercises with images and sound.		
SRE	Read and write explanation and exercises		
SKE	Explanation with images, and interactive exercises		
SVA	Explanation and exercises with images.	The question formulated for this type of student will allow him/her to talk to him/herself. For instance, "Could you help with X?".	
SAA	Explanation and exercises with images and sound.		
SRA	Read and write explanation and exercises		
SKA	Explanation with images, and interactive exercises		
SVN	Explanation and exercises with images.	"If you are asked about X, although you are not forced to answer, what would you say?"	
SAN	Explanation and exercises with images and sound.		
SRN	Read and write explanation and exercises		
SKN	Explanation with images, and interactive exercises		

Table 9 - Stereotypes adaptability

3.2.4.1. Emotional Interaction Mechanisms

For all the stereotypes there is an emotion or group of emotions that is expected to be found due to the student's personality (Shiota, Keltner, & John, 2006). These emotions can have a positive or negative influence in the learning process. The Emotional Interaction Mechanism aims to bring the students back to the emotions that influence the learning process in a positive way, when a trigger situation arises. In the following table, it can be observed the relation between stereotypes, the expected emotion(s), the emotions that can positively influence learning, and the emotions that can trigger an interaction by the application.

<table>
<tr><th>Stereotype</th><th>Expected emotion</th><th>Emotions that can positively influence learning</th><th>Emotions that can trigger an interaction</th></tr>
<tr><td>SVO</td><td rowspan="4">Anticipation
Interests
Optimism</td><td rowspan="4">Calm/Serenity
Happy
Surprised</td><td rowspan="16">Anger
Sad
Confused
Disgusted</td></tr>
<tr><td>SAO</td></tr>
<tr><td>SRO</td></tr>
<tr><td>SKO</td></tr>
<tr><td>SVC</td><td rowspan="4">Calm/Serenity</td><td rowspan="4">Calm/Serenity</td></tr>
<tr><td>SAC</td></tr>
<tr><td>SRC</td></tr>
<tr><td>SKC</td></tr>
<tr><td>SVE</td><td rowspan="4">Joy/happy
ecstasy</td><td rowspan="4">Calm/Serenity
Happy</td></tr>
<tr><td>SAE</td></tr>
<tr><td>SRE</td></tr>
<tr><td>SKE</td></tr>
<tr><td>SVA</td><td rowspan="4">Trust
Submission
Happy</td><td rowspan="4">Calm/Serenity
Happy</td></tr>
<tr><td>SAA</td></tr>
<tr><td>SRA</td></tr>
<tr><td>SKA</td></tr>
<tr><td>SVN</td><td rowspan="4">Anger
Contempt
Anxiety</td><td rowspan="4">Calm/Serenity</td></tr>
<tr><td>SAN</td></tr>
<tr><td>SRN</td></tr>
<tr><td>SKN</td></tr>
</table>

Table 10- Stereotypes emotions

The emotions to be contradicted are: anger, sadness, confusion and disgust. The interaction can depend on the personality and on the learning preference of the student. In the next table is shown which emotions can trigger an interaction and which could be a possible interaction, for each stereotype, to change an emotion.

Stereotype	Emotions that can trigger an interaction				Emotions required
	Anger	**Sad**	**Confused**	**Disgusted**	
SVO	Happiness can be trigger by show images or playing sounds that can remind of happy things like comedies or up-beat music.				Calm/ Serenity Happy Surprised
SAO	Happiness can be trigger by playing sounds that can remind of happy things like comedies or up-beat music.				
SRO	Another trigger for happiness is the written word. To read phases that contain words such as 'new', 'exciting' and 'wonderful' it will trigger a feel good sensation.				
SKO	Happiness can also be trigger by a positive experience such as receiving good news or achieving a goal.				
SVC	Happiness can be trigger by show images or playing sounds that can remind of happy things like comedies or up-beat music.				
SAC	Happiness can be trigger by playing sounds that can remind of happy things like comedies or up-beat music.				
SRC	Another trigger for happiness is the written word. To read phases that contain words such as 'new', 'exciting' and 'wonderful' it will trigger a feel good sensation.				
SKC	Happiness can also be trigger by a positive experience such as receiving good news or achieving a goal.				
SVE	Happiness can be trigger by show images or playing sounds that can remind of happy things like comedies or up-beat music.				
SAE	Happiness can be trigger by playing sounds that can remind of happy things like comedies or up-beat music.				
SRE	Another trigger for happiness is the written word. To read phases that contain words such as 'new', 'exciting' and 'wonderful' it will trigger a feel good sensation.				
SKE	Happiness can also be trigger by a positive experience such as receiving good news or achieving a goal.				
SVA	Happiness can be trigger by show images or playing sounds that can remind of happy things like comedies or up-beat music.				
SAA	Happiness can be trigger by playing sounds that can remind of happy things like comedies or up-beat music.				
SRA	Another trigger for happiness is the written word. To read phases that contain words such as 'new', 'exciting' and 'wonderful' it will trigger a feel good sensation.				
SKA	Happiness can also be trigger by a positive experience such as receiving good news or achieving a goal.				
SVN	Happiness can be trigger by show images or playing sounds that can remind of happy things like comedies or up-beat music. Also calm image of landscapes to calm.				
SAN	Happiness can be trigger by playing sounds that can remind of happy things like comedies or up-beat music.				
SRN	Another trigger for happiness is the written word. To read phases that contain words such as 'new', 'exciting' and 'wonderful' it will trigger a feel good sensation. Also using words that cam calm, repeat sodding phrases like "relax", "calm down" or "take it easy".				
SKN	Happiness can also be trigger by a positive experience such as receiving good news or achieving a goal.				

Table 11- Emotions that can trigger an interaction

To interact with the students a virtual character was created. The virtual character was generated using Voki[4], it was named Yoshi and is one of the free avatars provided by Voki. Voki is a free service that allows the creation of customized speaking characters. The character created, performs all the emotional interactions carried out on the prototype. The

[4] http://www.voki.com/

same character is used in all the emotional interactions for all the stereotypes. The chosen avatar (Yoshi) is shown in the next figure.

Figure 38 – Emotion Test – Interaction

If there is no need for an emotional interaction or the same emotion is repeatedly captured, in order to prevent a repeated emotional interaction that with time can prove to be annoying, an animated world globe is presented. Next figure shows the animation presented.

Figure 39 – Emotion Test – Interaction

3.2.4.2. Graph of Concepts in Case of Failure

The graph of concepts in case of failure represents the steps to be taken when fail to surpass a subject. To be approved in a subject the whole the tasks must be completed, and only with a subject completed it is possible to pass to the next. Inside of a subject the student has to complete the placement test, the subject content plus exercises with a grade equal or higher than 80% and the subject test with approval with a grade higher than 50% to complete the subject. In case of failure it has to go back to the subject content and repeat all the steps. The following directed acyclic graph G2(V,E) represents the complete graph of

paths in case of failure. In which V: is the set of vertices (or nodes) and E: is the set of ordered pairs of vertices, called paths.

$V = \{B1, B2, C1, C2, D1, D2, E1\}$

$E_{sucess} = \{(A1,B1), (B1, B2), (B2, C1), (C1, C2), (C2, D1), (D2, E1)\}$

$E_{failure} = \{(B2,B1), (C2, C1), (D2, D1), (E1, B1)\}$

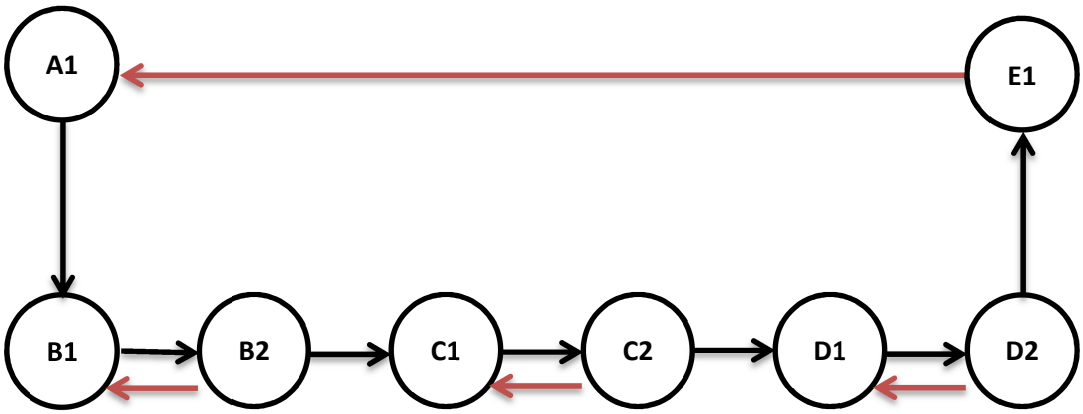


Figure 40 – Graph of concepts path and failure

3.3. Additional Tool

An additional tool was created to monitor the pre-test and final test. This tool is merely statistic. It produces in real-time, charts with some of the most important platform variables. This was important to observe if the API was working properly, to observe if any errors would occur or if any changes were necessary during the tests. The variables are divided into six categories: Users, Personality & VARK, Emotions, Emotion tests, Rating and Quota.

Users	In the Users category can be observed the pie charts of gender, age, stereotypes, and the use of glasses.
Personality & VARK	In the Personality & VARK category can be observed the result of the questionnaires. In the personality category it can be observed a line chart for each dimension of personality. In the VARK category it can be observed a pie chart with the percentages of each learning preference.
Emotions	In the Emotion category can be observe the emotions captured during the pre-test and final test.
Emotion tests	In the Emotion test category can be observe the grades achieved by the students during the pre-tests and final test.
Rating	In the Rating category can be observe the subject rating assigned by the students at the end of the pre-tests and final test.
Quota	In the quota category can be observe the quota of the API responsible for the facial emotion recognition. The API quota was of 5000 requests a month for each registration on the API site.

Table 12- Additional tool categories

This tool was built with HTML5, and JavaScript Cascading Style Sheets (CSS). The Database Management System (DBMS) used was MySQL, the same as used by the platform. To design the real-time charts it was used Google Charts API[5]

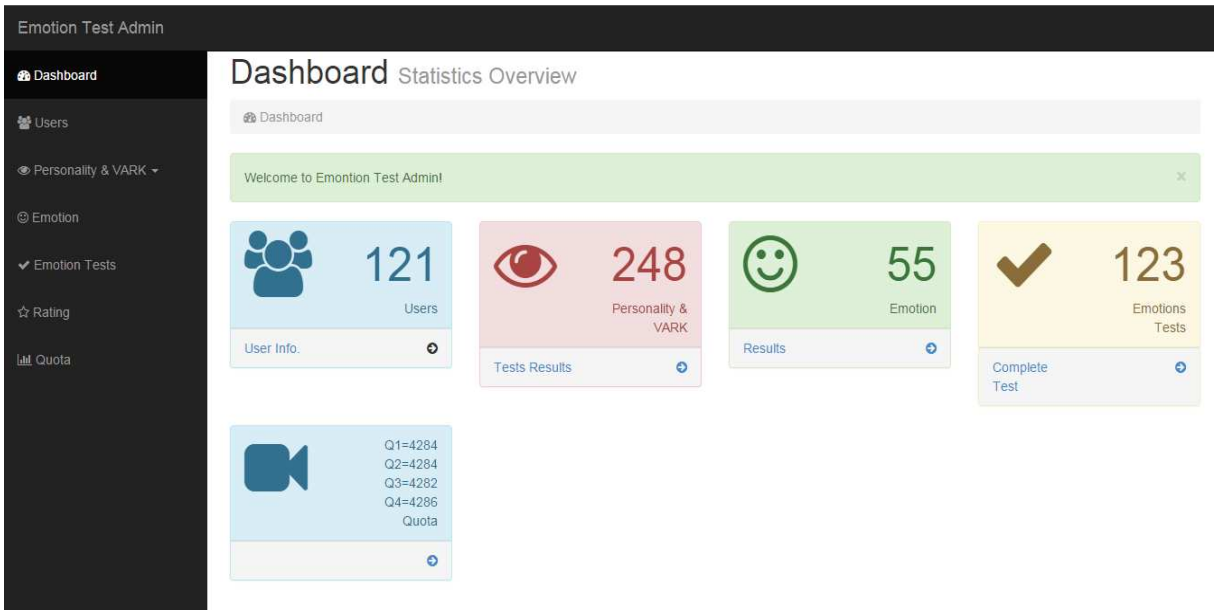


Figure 41 – Additional tool

3.4. Conclusions

This chapter describes the design and development step of the adopted research methodology. This consists in the architecture developed and the prototype constructed based on the architecture. The prototype was entitled Emotion Test implemented to be an engaged learning environment with multimedia interactions, to be used in a web environment. The Emotion Test simulates the entire learning process, from the subject's explanation to exercises and assessment tests. Through the entire process the student emotional state and the personality traits were taken into account.

[5] https://developers.google.com/chart/

The architecture proposed for this prototype is composed of 4 main models: Student Model, Emotional Model, Application Model and Emotive Pedagogical Model.

The student model represents student information and characteristics. This includes personal information (name, email, telephone, etc.), demographic data (gender, race, age, etc.), knowledge, deficiencies, learning styles, emotion profile, personality traits, etc. This information is useful to better adapt the prototype to the student.

The emotion model gathers all the information of facial recognition software and feedback of the students.

The application model is composed by a series of modules contain different subjects. The subject consist in a number steps that the student has to pass in order to complete the learning program. Usually each subject is composed by a diagnostic test in order to access the student level of knowledge. Followed by the subject content in which the subject is explained and followed by the subject exercises and final evaluation test.

The last model is the emotive pedagogical model which is composed by three sub-models: the rules of emotion adaptability, the emotional interaction mechanisms and the graph of concepts in case of failure. The rules of emotion adaptability comprise the ways the subject content is presented. The subject content and subject exercises are presented according the student's learning style and personality. The emotional interaction mechanisms consist in the trigger of an emotion interaction, when is captured an emotion that need to be contradicted in order to facilitate the learning process. The emotions to be contradicted are: anger, sadness, confusion and disgusted. The interaction can depend on the student's learning preference and personality. Finally the graph of concepts in case of failure this indicates the steps to be taken when a student fails to surpass a subject.

In addition to the platform prototype development, it was also built a statistic tool that allows the monitoring the pre-tests and the final evaluation test.

4

4. Results and discussion

This chapter describes two steps of the adopted methodology, the demonstration step and the evaluation step. This consists in describing the two pre-tests developed for demonstration step, including the test procedure, data analysis, results and any corrective action taken for the evaluation step. The evaluation step consists in describing the final test performed, including the test procedure, data analysis and results. The conclusions from these two steps were vital to comprehend if the design and development steps were accurate and if there is the need to go back and make any changes to the design.

4.1. Research Objectives

The research work was held based on the principle that emotion can influence several aspects of people's lives. Emotions can affect the decision process and knowledge acquisition of an individual because they directly influence the perception, the learning process, the way people communicate and the way rational decisions are made. Given the fact in a learning platform there isn't any mechanism that can perceive any changes in the emotional behavior and intervene to recapture the student attention and motivation, similar to the role of the teacher in a traditional classroom. So a question is asked, what if a learning platform could have a mechanism that could detect the emotional behavior of a student and interact with him accordingly and considering his profile. Could this influence or even improve the student's learning results? Considering all of the above, the research goal is to find out if a learning platform taking into account the emotional profile of a student can produce better learning results, than a learning platform with no emotional interaction. A prototype was developed to test the assumption made. This prototype takes into account the student personality, learning style and the emotional profile.

4.2. Participants

To test the performance of the developed prototype some experiences were carried out with students from two ISEP Engineering courses: Informatics Engineering and Systems Engineering. The total number of students involved in these tests was 115 with ages between 17 and 42 years old. This group of students was composed of 20% female (n=23) and 80% male (n=92), the participants were mainly from the districts of Oporto, Aveiro and Braga. These students were chosen because during their course it is address the subject of decimal conversions to other bases and it is an important knowledge foundation for other subjects in their course. It was also attempted to conduct these experiences before this subject was address in their classes, so the student did not have any prior knowledge of the subject.

4.3. Method

To evaluate the prototype, two pre-tests and a final test were conducted. For the first pre-test the students were grouped randomly in 2 groups as shown in the table below.

Groups	Description
Group v1	Test the prototype with the emotional interaction and learning style with a high level of difficulty
Group v2	Test the prototype without the emotional interaction and learning style with a high level of difficulty

Table 13- Groups for the first pre-test

Group v1 had to accomplish a diagnostic test (in paper) to help grade the student initial knowledge level, followed by the evaluation of the prototype with the emotional interaction and learning style. This would include, the login into the prototype, at this moment is when the initial data is begins to be collected for the student model. By accessing the school's Lightweight Directory Access Protocol (LDAP) one was able to gather the generic information of the students (like name, email and other). After login the students were required to answer two questionnaires (TIPI, VARK) build into the prototype. This allows the prototype to known the student's personality traits and learning preferences. Afterward the student could assess the learning materials and exercises. From the moment the student login his emotion state has been monitor and saved and every time that is detected an emotion that triggers an intervention it would appear on the screen.

After this evaluation the students had to complete a final test (in paper) to help grade the student final knowledge level. The evaluation by this group ended with the answer of the Acceptability questionnaire (annex E) to determine the prototype acceptability.

Group v2 had to accomplish diagnostic test (in paper) to help grade the student initial knowledge level, followed by the prototype evaluation without any emotional interaction. This evaluation is in all similar to group v1, but with one big difference. Even though the emotional state is monitor, when is detected an emotion that triggers an intervention it would not appear on the screen. After this test the students had to complete a final test (in paper) to help grade the student final knowledge level. The evaluation by this group also ended with the answer of the Acceptability questionnaire (annex E) to determine the prototype acceptability.

Due to restrictions of the students schedule, each group only had one hour to conduct the pre-test, this proved to be inefficient because the students didn't have enough time to complete the required tasks. Also, it was observed that due to the high level of difficulty of the application (80% to pass to the next task), some students didn't get that grade and had to start again, this proved to led the students to frustration and to give up the completion of the group task. Another problem was the capture of emotion that sometimes did not work properly. For these reasons was conducted a second pre-test. The same evaluation protocol was used for Groups v1 and v2, but with a time increase, roughly 1 and half hours. Also, the prototype level of difficulty was cut by half. This second pre-test was not performed by the same students. These changes originated Groups v3 and v4, as showed in table 14, below.

Groups	Description
Group v3	Test the prototype <u>with</u> the emotional interaction and learning style with a low level of difficulty
Group v4	Test the prototype <u>without</u> the emotional interaction and learning style with a low level of difficulty

Table 14- Groups for the second pre-test

The first and second pre-test were made by the students of Informatics Engineering. For the final test, the experience was repeated with the students of Systems Engineering course, but only were tested groups v3 and v4 with a time increase, two hours to conduct the test. The following tables show the division of students between the groups of the two courses.

Groups	Number of participants	Average Age	Gender		Average entry note
			Female	Male	
Group v1	31	18,3	10	20	144
Group v2	31	18,4	9	22	146
Group v3	14	21,29	2	12	148
Group v4	11	18	0	11	144

Table 15- Groups and participants course of Informatics Engineering

Groups	Number of participants	Average Age	Gender		Average entry note
			Female	Male	
Group v4	14	19,2	1	13	139,7
Group v5	14	19.4	1	13	137,6

Table 16- Groups and participants course of Systems Engineering

All data gathered was stored on a Microsoft Excel file, which was then imported into a statistical processing application data, Statistical Package for Social Sciences (SPSS) in order to statistically analyze the data.

An evaluation of the normality of data is a precondition for many statistical tests since normal data is a fundamental hypothesis in parametric testing. So to test the normality of the data Kolmogorov-Smirnov Test was used. For this test two hypotheses were made ***H0***: The distribution of the data is normal and ***H1***: The distribution of the data is not normal. For each test if the ***P*** value is less the 0,05 that leads to reject the ***H0*** hypothesis, concluding that the data is not normal. On the other hand if the ***P*** value is great than 0,05 the ***H0*** hypothesis can be accepted concluding that the data is normal.

After discovering the normality, there could be two types of test data and therefore different types of analysis. Parametric data has a normal distribution which can be mathematically defined. Anything else is non-parametric. It will be shown that most of the data gather does not have a normal distribution, so non-parametric tests will be used to analyze the data. In particular Mann-Whitney test, this test is used to compare differences between two independent groups. For that a ***Null Hypothesis*** is created that states that the medians of the two samples are identical. For each test if the ***P*** value is less the 0,05 that leads to reject the ***H0*** hypothesis, concluding that there are statistical differences between the two samples. Moreover, if the ***P*** value is great than 0,05 the ***H0*** hypothesis can be accepted concluding that the two samples are identical.

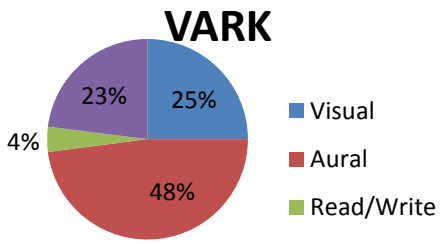
Also used, was the two-way analysis of variance (ANOVA) that observes the effect of two different categorical independent variables on one continuous dependent variable. The two-way ANOVA not only aims at assessing the main effect of each independent variable but also if there is any relation between them.

4.4. Data Analysis and Pre-tests Results

This section describes the two pre-tests performed for demonstration step, including data analysis, results and any corrective action taken for the evaluation step. It starts by describing the analysis accomplished for learning preferences and personality. This was followed by the analysis of the student's grades in all the test groups.

4.4.1. VARK

In order to assess the learning preferences of each student, the VARK questionnaire was answered by the students. The analysis of the data showed that the preferred preference was aural with 48% of the students, followed by visual preference with 25%, kinetic preference with the 23% and read/write with 4%.



VARK	Global	
	N	%
Visual	22	25%
Aural	42	48%
Read/Write	3	4%
Kinetic	20	23%

Figure 42 – Global Distribution of Participants according to their answers of VARK questionnaire

In the test groups the distribution of participants according to their answer of the VARK questionnaire is showed in the table 17. The aural preference is the most preferred with the highest percentage in almost all the groups and read/write preference is the less preferred with the lowest percentage of all.

VARK	Group v1		Group v2		Group v3		Group v4	
	N	%	N	%	N	%	N	%
Visual	5	16,1%	12	38,7%	1	7,1%	4	36,4%
Aural	13	41,9%	11	35,5%	12	85,7%	6	54,5%
Read/Write	3	9,7%	0	0,0%	0	0,0%	0	0,0%
Kinetic	10	32,3%	8	25,8%	1	7,1%	1	9,1%

Table 17- Distribution of Participants according to their answers of VARK questionnaire

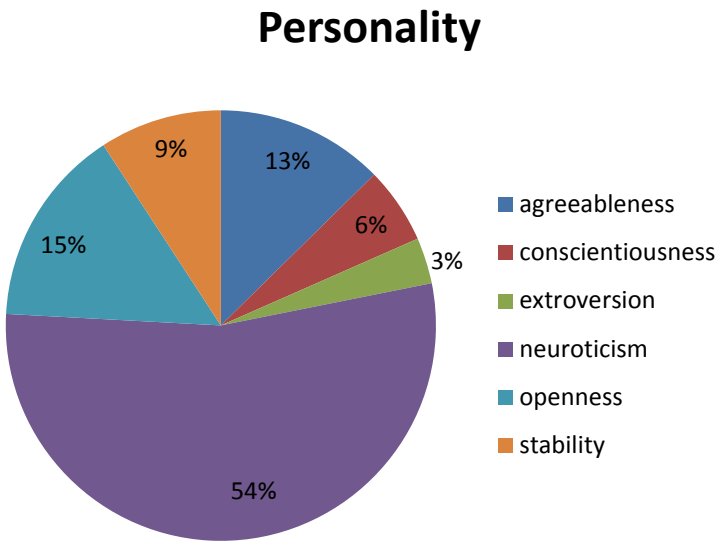
The next table shows the average grade of the diagnostic test and the final test according to student's learning preference across all the test groups.

VARK	Group v1		Group v2		Group v3		Group v4	
	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test
Visual	32%	33,3%	9,1%	31,3%	0,0%	100,0%	46,7%	60,0%
Aural	8,3%	48,3%	15,8%	38,3%	33,3%	63,3%	46,7%	63,3%
Read/Write	13,3%	46,7%	-	-	-	-	-	-
Kinetic	8,0%	26,0%	15,0%	42,5%	0,0%	80,0%	20,0%	60,0%

Table 18- Average grade of the diagnostic test and final test by learning preference

4.4.2. Personality

To determine student's personality their responses to the TIPI questionnaire were analyzed. The data showed that 54% of students fell into neuroticism personality followed by openness (15%), agreeableness (13%), stability (9%), conscientiousness (6%) and extroversion (3%).



Personality	Global	
	N	%
Openness	13	15%
Conscientiousness	5	6%
Extroversion	3	3%
Agreeableness	11	13%
Neuroticism	47	54%
Stability	8	9%

Figure 43 – Global Distribution of Participants according to their answers of TIPI questionnaire

In the test groups the distribution of participants according to their answer of the TIPI questionnaire is showed in the following table. Neuroticism was the personality with the highest percentage in all the groups and the extroversion was the personality with the lowest percentage.

Personality	Group v1		Group v2		Group v3		Group v4	
	N	%	N	%	N	%	N	%
Openness	2	6,5%	5	16,1%	2	14,3%	4	36,4%
Conscientiousness	0	0,0%	2	6,5%	2	14,3%	1	9,1%
Extroversion	1	3,2%	1	3,2%	1	7,1%	0	0,0%
Agreeableness	4	12,9%	3	9,7%	2	14,3%	2	18,2%
Neuroticism	19	61,3%	19	61,3%	6	42,9%	3	27,35
Stability	5	16,1%	1	3,2%	1	7,1%	1	9,1%

Table 19- Distribution of Participants according to their answers of TIPI questionnaire

The next table shows the average grade of the diagnostic test and final test according to student's personality across all the group tests.

Personality	Group v1		Group v2		Group v3		Group v4	
	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test
Openness	10,0%	30,0%	20,0%	28,0%	0,0%	50,0%	55,0%	35,0%
Conscientiousness	-	-	0,0%	0,0%	40,0%	90,0%	60,0%	100,0%
Extroversion	0,0%	80,0%	0,0%	0,0%	80,0%	100,0%	-	-
Agreeableness	30,0%	70,0%	46,7%	66,7%	30,0%	70,0%	50,0%	50,0%
Neuroticism	10,5%	33,7%	6,3%	37,9%	26,7%	63,3%	46,7%	73,3%
Stability	20,0%	53,3%	0,0%	0,0%	20,0%	40,0%	20,0%	60,0%

Table 20- Average grade of the diagnostic test and final test by personality

4.4.1. Tests Results

From the gathered data it was concluded that the distributions are not normal. After having applied the Kolmogorov-Smirnov test shown in the following table.

	Groups	Kolmogorov-Smirnov[a]		
		Statistic	df	P
Diagnostic Test in paper	**Group v1**	0,416	30	0,000
	Group v2	0,424	31	0,000
	Group v3	0,349	14	0,000
	Group v4	0,164	11	0,200*
Final Test in paper	**Group v1**	0,238	30	0,000
	Group v2	0,257	31	0,000
	Group v3	0,219	14	0,046
	Group v4	0,227	11	0,118

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 21- Tests of Normality

Analyzing the results shown in Table 21, it can be observed that group v4 for the diagnostic test has a ***P*** value with low bound but of true significance, the final test also have ***P*** value with some significance. All the other groups for ***P*** values are not statistically significant. So it can be concluded that all the groups, with the exception of group v4, do not have normal distributions. The next table shows the descriptive statistics of the diagnostic test and final test across the test groups.

Groups		N	Minimum	Maximum	Mean	Std. Deviation
Group v1	**Diagnostic Test in paper**	31	0	100	12.26%	22,9
	Final Test in paper	31	0	100	36,00%	36,5
Group v2	**Diagnostic Test in paper**	31	0	60	11,61%	20,5
	Final Test in paper	31	0	100	34,19%	34,7
Group v3	**Diagnostic Test in paper**	14	0	80	28,57%	37,4
	Final Test in paper	14	0	100	67,14%	33,8
Group v4	**Diagnostic Test in paper**	11	0	100	49,09%	36,2
	Final Test in paper	11	0	100	56,36%	39,8

Table 22- Descriptive statistics of the diagnostic test and final test by group

As data does not have a normal distribution, the two pairs of groups were compared using a non-parametric test Mann-Whitney. For group v1, diagnostic test has a mean of 12,26% (Standard Deviation (SD) = 22,9) and the final test a mean of 36,00% (SD=36,5). For group v2 diagnostic test has a mean of 11,61% (SD = 20,5) and the final test a mean of 34,19% (SD=34,7). The observed differences between these two groups are not statistically significant, not only for the diagnostic test but also for the final test. The diagnostic test has a ***Mann–Whitney U*** = 472,5 for the same sample size in both groups of 31 students with ***P*** = 0,890. The final test has a ***Mann–Whitney U*** = 452,5 for the same sample size in both groups of 31 students with ***P*** = 0,851. As the ***P*** value is in both analyses is higher than 0,050 it can be concluded that the differences between the groups are not statistically significant.

For group v3 diagnostic test has a mean of 28,57% (SD = 37,4) and the final test a mean of 67,14% (SD=36,2). For group v4 diagnostic test has a mean of 49,09% (SD = 36,2) and the final test a mean of 56,36% (SD=39,8). The observed differences between these two groups also are not statistically significant. The diagnostic test has a ***Mann–Whitney U*** = 51,5 and for a sample size for group v3 of 14 students and for group v4 of 11 student. For this analysis it was found a ***P*** value of 0,146. The final test has a ***Mann–Whitney U*** = 66,5 and for an equal sample size of the diagnostic test. For this analysis it was found a ***P*** value of 0,554. As the

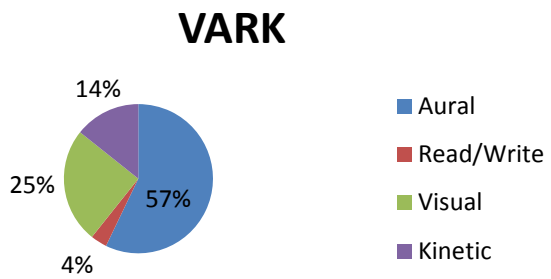
previous test it has a ***P*** value higher than 0,050 this indicates that the differences between the groups are not statistically significant.

4.5. Data Analysis and Final Test Results

This section describes the final tests performed for evaluation step, including data analysis and results. It starts by describing the analysis carried out for learning preferences and personality. This was followed by the analysis of the student's grades and emotions in all the test groups.

4.5.1. VARK

Also, in this final test it was tried to assess each student learning preferences, so the VARK questionnaire was answered by the students. The analyses of the data showed that the preferred preference was aural with 57% of the students, followed by visual preference with 25%, kinetic preference with 14% and finally read/write with 4%.



VARK	Global	
	N	%
Visual	7	25%
Aural	16	57%
Read/Write	1	4%
Kinetic	4	14%

Figure 44 – Global Distribution of Participants according to their answers of VARK questionnaire

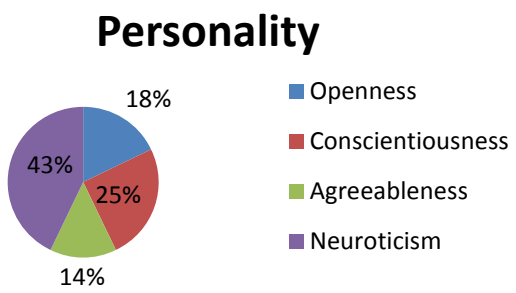
In the test groups the distribution of participants according to their answers of the VARK questionnaire is showed in the fowling table. The aural preference is the preference with the highest percentage in group v3 while visual preference is the highest in group v4. The read/write preference has the lowest percentage in all the groups. The next table shows the average grade of the diagnostic test and final test according to participants learning preferences across all the test groups.

VARK	Group v3		Group v4	
	N	%	N	%
Visual	1	7,1%	6	42,9%
Aural	11	78,6%	5	35,7%
Read/Write	-	-	1	7,1%
Kinetic	2	14,3%	2	14,3%

Table 23- Distribution of Participants according to their answers of VARK questionnaire

4.5.2. Personality

To determine student's personality, the responses to the TIPI questionnaire were also analyzed. The data showed that 43% of students fell into neuroticism personality followed by conscientiousness with 25%, openness with 18% and agreeableness and stability with 14%. No students were found with extroversion personality.



Personality	Global	
	N	%
Openness	4	18%
Conscientiousness	6	25%
Extroversion	-	-
Agreeableness	3	14%
Neuroticism	12	43%

Figure 45 – Global Distribution of Participants according to their answers of TIPI questionnaire

For all the test groups the distribution of participants according to their answers of the TIPI questionnaire is showed in the following table. The Neuroticism personality was the one with the highest percentage in all the groups and the agreeableness personality was the one with the lowest percentage.

Personality	Group v3		Group v4	
	N	%	N	%
Openness	1	7,1%	4	28,6
Conscientiousness	2	14,3%	5	35,7
Extroversion	-	-	-	-
Agreeableness	2	14,3%	2	14,3
Neuroticism	9	64,3%	3	21,4

Table 24- Distribution of Participants according to their answers of TIPI questionnaire

The next table shows the average grade of the diagnostic test and final test according to student's personality across all the group tests.

Personality	Group v3		Group v4	
	Average Grade of the Diagnostic Test	Average Grade of the Final Test	Average Grade of the Diagnostic Test	Average Grade of the Final Test
Openness	30%	45%	60%	60%
Conscientiousness	0%	80%	24%	60%
Extroversion	-	-	-	-
Agreeableness	10%	80%	50%	70%
Neuroticism	62%	91%	60%	80%

Table 25- Average grade of the diagnostic test and final test by personality

4.5.1. Final Test Results

From the gathered data from the final test it was concluded that the distributions are not normal after having applied the Kolmogorov-Smirnov test as shown in the following table.

	Groups	Kolmogorov-Smirnov[a]		
		Statistic	df	P
Diagnostic Test in paper	**Group v3**	0,229	14	0,046
	Group v4	0,184	14	0,200*
Final Test in paper	**Group v3**	0,323	14	0,000
	Group v4	0,281	14	0,004

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 26- Tests of Normality

Analyzing the results shown in Table 26, only group v4, for the diagnostic test has a ***P*** value with low bound but of true significance. All the other groups, for the ***P*** values are not statistically significant. So, it can be concluded that all the groups, with the exception of group v4 in the diagnostic test, do not have normal distributions. The next table shows the descriptive statistics of the diagnostic test and final test across the groups.

Groups		N	Minimum	Maximum	Mean	Std. Deviation
Group v3	**Diagnostic Test in paper**	14	0	100	45,7%	40,3
	Final Test in paper	14	60	100	85,7%	12,2
Group v4	**Diagnostic Test in paper**	14	0	80	37,1%	29,2
	Final Test in paper	14	0	100	61,4%	33,7

Table 27- Descriptive statistics of the diagnostic test and final test by group

As for the pre-tests, this data does not have a normal distribution so the two pairs of groups were compared using a non-parametric test Mann-Whitney. For group v3, the diagnostic test has a mean of 45,7% (SD =40,3) and the final test a mean of 85,7% (SD=12,2). For group v4, the diagnostic test has a mean of 37,1% (SD = 29,2) and the final test a mean of 61,4% (SD=33,7). The diagnostic test has a ***Mann–Whitney U*** = 83,0 and for a sample size of 14 students. For this analysis it was found a ***P*** value of 0,479 which indicates that it doesn't have any statistical difference which is understandable because it was assumed that all students had more or less the same level of knowledge. The final test it has a ***Mann–Whitney U*** =54,0 and for an equal sample size of the diagnostic test. For this analysis it was found a ***P*** value of 0,029 in this case the differences observed are statistical different.

Beside of the overall analyses of the student's performance, a similar analysis was performed to the gathered data in each subject that the students had to learn. This include three subjects conversion from decimal to binary (Binary), conversion from decimal to octal (Octal) and conversion from decimal to hexadecimal (Hexadecimal). The first analysis consisted in finding out its distribution, so it was applied the test Kolmogorov-Smirnov as showed in the following table.

	Group	Kolmogorov-Smirnov[a]		
		Statistic	df	P
Binary	**Group v3**	0,218	14	0,069
	Group v4	0,181	14	0,200*
Octal	**Group v3**	0,290	14	0,002
	Group v4	0,319	14	0,000
Hexadecimal	**Group v3**	0,357	14	0,000
	Group v4	0,326	14	0,000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 28- Tests of Normality

Analyzing the data for the binary system subject, group v4 it has a ***P*** value with low bound but of true significance and group v3 also has a ***P*** value with some significance. For all the other groups the ***P*** values are not statistically significant. So it can be concluded that all the groups, with the exception of groups v3 and v4 in binary system subject, do not have normal distributions. The next table shows the descriptive statistics of the subject results across each test group.

Group		N	Minimum	Maximum	Mean	Std. Deviation
Group v3	Binary	14	40	100	75,7	19,5
	Octal	14	40	100	75,7	22,4
	Hexadecimal	14	0	100	82,9	30,2
Group v4	Binary	14	0	100	62,9	34,1
	Octal	14	0	100	62,9	37,5
	Hexadecimal	14	0	100	42,9	45,7

Table 29- Descriptive statistics of the subjects

For group v3 the binary system subject has a mean of 75,7% (SD =19,5), the octal system subject has a mean of 75,7% (SD =22,4) and the hexadecimal system subject has a mean of 82,9% (SD =30,2). For group v4 the binary system subject has a mean of 62,9% (SD =34,1), the octal system subject has a mean of 62,9% (SD =37,5) and the hexadecimal system has a

mean of 42,9% (SD =45,7). As the data does not have a normal distribution, the two pairs of groups were compared using a non-parametric test Mann-Whitney.

Subject	Group	N	Mean	Mean Rank	Mann–Whitney U	P
Binary	**Group v3**	14	75,7	15,86	79,0	0,336
	Group v4	14	62,9	13,14		
Octal	**Group v3**	14	75,7	15,57	83,0	0,468
	Group v4	14	62,9	13,43		
Hexadecimal	**Group v3**	14	82,9	18,18	46,5	0,012
	Group v4	14	42,9	10,82		

Table 30- Statistical comparison using Mann-Whitney test

Analyzing the results for the binary system subject, the results showed a ***P*** value of 0,336 in this case the result is not significant at $p \leq 0.05$. The same occurs for the octal system subject with a ***P*** value of 0.468. Analyzing the means of these two subjects they were both positive which leads to conclude that these two topics were fairly easy for the students to comprehend for both group tests. The same does not happened for the hexadecimal system subject. In this case the ***P*** value is 0,012, which is significant at $p \leq 0.05$. Analyzing the means for group v4 (application without emotional integration) it showed that they struggled with this topic achieving a negative mean. Although the group v3 had no problem with this topic achieving an above average positive mean.

Using the two-way ANOVA it was tried to run a series of test to compare the means of the students by group and by learning preference and by group and personality. The objective of running these tests it is to see if learning preference, personality and emotional state had any influence on the outcome of the final test. First, it was tested by group and by learning preference however, no statistically significant differences in the results were obtained (***P***=0,614). Therefore it cannot be concluded that the learning preference in each group had any influence in the final test outcome. Next figure illustrate the results obtained.

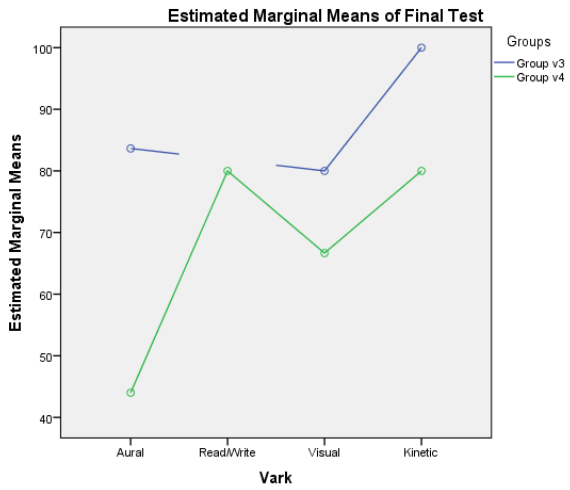


Figure 46 – Estimated Marginal Means of the Final Test -VARK

Second, it was tested by group and by personality however, no statistically significant differences in the results were obtained (P=0,988). Therefore it cannot be concluded that the personality had any influence in the final test result. To prove this assumption it was needed a larger sample size. Next figure shows the results gathered.

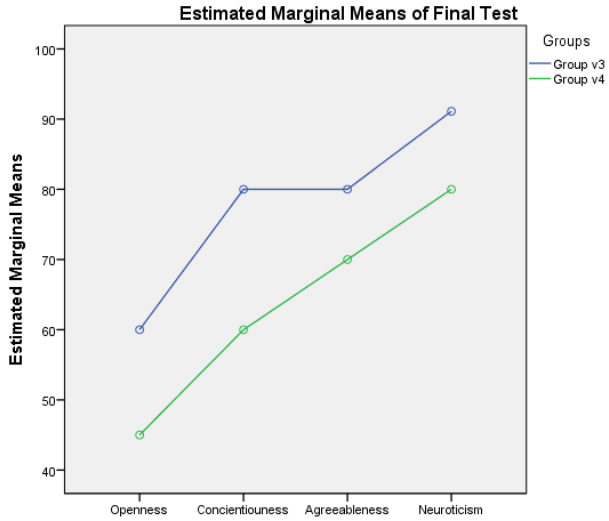


Figure 47 – Estimated Marginal Means of the Final Test – Personality

Another test was made regarding the emotional state of the student during this experiment. The assumption was that the student in a negative state throughout the experiment had lower results. The differences found were statistically significant (P=0,011). Consequently, it can be concluded that the emotional state had influence in the final test results of the students. Next figure presents the results collected.

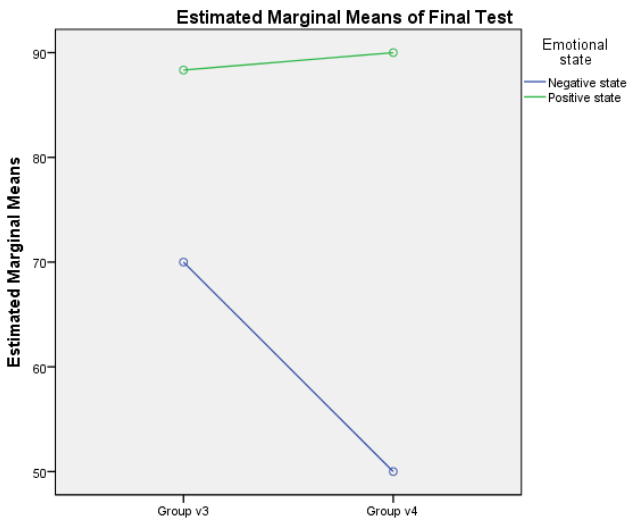


Figure 48 – Estimated Marginal Means of the Final Test – Emotional State

4.6. Results of Acceptability Survey

This survey was important for understand interest acceptability of the application. A sample of the survey used can be found in Annex E. Understand the interest and usefulness of an application. It examines the student's core needs that may lead to acceptance of the application, for purposes of understanding if actual concept of the application is relevant to the group of students used.

After the students explored the application and completed the tasks they answered to a questionnaire to determine the acceptance of the prototype and the degree of difficulty and the usefulness of each feature. Finlay, the resulting data on the frequency of use of the prototype, as well should it be used in other disciplines. Here are presented the obtained results.

4.6.1. Acceptance of the Application

Using a scale of 1 to 4 (1 - Fully Disagree, 2 - Disagree, 3 - Agree, 4 - Fully Agree) with an additional option for the students with no opinion on the question.

	Fully Disagree		Disagree		Agree		Fully Agree		No opinion		Disagree		Agree	
Tests	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**
1. The application would facilitate the study of the discipline outside the classroom.	1,2%	3,2%	4,7%	3,2%	40,7%	54,8%	46,5%	29,0%	7,0%	9,7%	5,8%	6,5%	87,2%	83,9%
2. The application would facilitate the study of the discipline in the classroom.	3,5%	3,2%	12,8%	9,7%	47,7%	54,8%	27,9%	29,0%	8,1%	3,2%	16,3%	12,9%	75,6%	83,9%
3. The application information is well organized.	3,5%	0,0%	8,2%	16,1%	45,9%	45,2%	38,8%	38,7%	3,5%	0,0%	11,8%	16,1%	84,7%	83,9%
4. The application has a good graphics / design.	1,2%	0,0%	10,5%	9,7%	43,0%	58,1%	38,4%	32,3%	7,0%	0,0%	11,6%	9,7%	81,4%	90,3%
5. Can you easily access the content in the application of discipline.	3,5%	0,0%	5,8%	6,5%	41,9%	61,3%	36,0%	29,0%	12,8%	3,2%	9,3%	6,5%	77,9%	90,3%
6. The application may be useful is to improve their results in discipline	1,2%	0,0%	5,8%	3,2%	38,4%	58,1%	41,9%	35,5%	12,8%	3,2%	7,0%	3,2%	80,2%	93,5%
7. He recommended the use of the application.	2,4%	0,0%	3,5%	9,7%	36,5%	41,9%	45,9%	38,7%	11,8%	9,7%	5,9%	9,7%	82,4%	80,6%
8. I wish all teachers would use the application in their respective classes.	2,35%	0,0%	17,4%	25,8%	39,5%	19,4%	18,6%	29,0%	22,1%	25,8%	19,8%	25,8%	58,1%	48,4%
9. Can you easily access the activities of the application.	1,2%	0,0%	3,5%	6,5%	48,8%	61,3%	40,7%	32,3%	5,8%	0,0%	4,7%	6,5%	89,5%	93,5%
10. The interaction is given by the application useful.	1,2%	3,2%	5,8%	12,9%	39,5%	35,5%	47,7%	45,2%	5,8%	3,2%	7,0%	16,1%	87,2%	80,6%

PT - Pre-tests; FT - Final test.

Table 31- Survey

4.6.2. Usefulness and difficulty in using application features

To assess the usefulness of the application features was use a scale of 0 to 4 (0 - Do not know, 1- Useless, 2 - Somewhat Useful, 3 – Useful, 4 - Very Useful). To the students was asked how they rate the degree of usefulness of each of the tools of the application. The tools of the application were divided in questionnaires, contents, activities, videos and interaction. The next table shows the percentages obtained in the different categories. More than 80% of the students found that every tools of the application were useful.

How would you rate the degree of usefulness of each of the tools of the application?	Useless		Somewhat useful		Useful		Very useful		Do not know		Useless		Useful	
Test	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**
Questionnaires	3,2%	0,0%	12,9%	0,0%	50,0%	71,4%	33,9%	28,6%	0,0%	0,0%	16,1%	0,0%	83,9%	100,0%
Contents	0,0%	0,0%	5,0%	4,8%	56,7%	66,7%	35,0%	28,6%	3,3%	0,0%	5,0%	4,8%	91,7%	95,2%
Activities	0,0%	0,0%	3,3%	4,8%	57,4%	57,1%	34,4%	33,3%	4,9%	4,8%	3,3%	4,8%	91,8%	90,5%
Videos	1,7%	0,0%	5,0%	10,0%	28,3%	35,0%	53,3%	45,0%	11,7%	10,0%	6,7%	10,0%	81,7%	80,0%
Interaction	1,7%	15,0%	6,7%	0,0%	50,0%	50,0%	40,0%	35,0%	1,7%	0,0%	8,3%	15,0%	90,0%	85,0%

PT - Pre-tests; FT - Final test.

Table 32- Survey Usefulness

To assess the difficulty of the application features was use a scale of 0 to 4 (0 - Do not know, 1- Difficult, 2 - A bit Difficult, 3 – Easy, 4 - Very Easy). To the students was asked how they rate the degree of difficulty of each of the tools of the application. The tools of the application were divided in questionnaires, contents, activities and videos. The next table shows the percentages obtained in the different categories. More than 70% of the students found that every tools of the application were easy. Also, there was an increase of the percentage of students that find difficulty the application tools, in the pre-tests. This was to be expected because one of the pre-test ran with higher level of difficulty.

How would you rate the degree of difficulty in using each of the tools of the application?	Difficult		A bit Difficult		Easy		Very Easy		Do not know		Difficult		Easy	
Test	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**	**PT**	**FT**
Questionnaires	0,0%	0,0%	17,7%	4,8%	48,4%	81,0%	33,9%	14,3%	0,0%	0,0%	17,7%	4,8%	82,3%	95,2%
Contents	1,7%	0,0%	18,3%	4,8%	53,3%	85,7%	23,3%	9,5%	3,3%	0,0%	20,0%	4,8%	76,7%	95,2%
Activities	3,3%	0,0%	18,3%	0,0%	48,3%	85,7%	23,3%	9,5%	6,7%	4,8%	21,7%	0,0%	71,7%	95,2%
Videos	1,7%	0,0%	6,7%	5,0%	41,7%	40,0%	38,3%	40,0%	11,7%	15,0%	8,3%	5,0%	80,0%	80,0%

PT - Pre-tests; FT - Final test

Table 33- Survey Difficulty

4.7. Conclusions

This chapter describes the demonstration and evaluation steps of the adopted research methodology, which are essential to prove the validity of the architecture. This includes all the tests performed with the prototype and analysis of the gathered data. The research began based on the principal that emotion can influence several aspects of people's lives. In a traditional learning environment the teacher can detect changes in the student emotional behavior and adjust his teaching accordingly. In a learning platform this interaction does not exist or, if exists it does not occur in real time. So a question was placed, "what if a learning platform could detect the emotional behavior of a student and interact with him accordingly and considering his profile. Could this influence or even improve the student's learning results?" Hence the research goal was to find out if a learning platform that take into account the emotional profile of a student can improve the learning results, in opposition to a learning platform with no emotional interaction. Also observe if student's emotional state would influence the learning process.

To test the performance of the developed prototype some experiences were carried out with students from two ISEP Engineering courses: Informatics Engineering and Systems Engineering. The total number of students involved in these tests was 115 with ages between 17 and 42 years old. This group of students was composed of 20% female (n=23) and 80% male (n=92), the participants were mainly from the districts of Oporto, Aveiro and Braga.

To assess validity of the prototype were conducted 2 pre-tests and a final test. For the first pre-test the students were divided in two groups, v1 and v2. Group v1 tested the prototype with emotional interaction and group v2 without any emotional interaction. In this first pre-test it were encountered several problems. The first problem was the amount of time required to complete the test, the tests were conducted in roughly an hour which proved to be insufficient because the students didn't have enough time to complete the required tasks. The second problem was the difficulty of the application (80% to pass to the next task), the students that didn't get that grade had to start and go through all over again. This proved to lead the students to frustration and to give up the completion of group tasks. The third problem was the capture of emotion, which, in some cases, did not work properly.

For this problems was conducted a second pre-test for groups v1 and groups v2 with the same evaluation protocol but with more available time (roughly 1½ hours) and the application level of difficulty cut by half. This second pre-test was not conducted with the same students. These changes originated two groups, v3 and v4. For the final test, the experience was repeated with different students, but only were tested groups v3 and v4 with a time increase, two hours to conduct the test.

Analyzing the gathered data it was found for the first pre-test due to its high level of difficulty and reduced time available to perform the tasks relatively low mean scores. In respect to group v1 diagnostic test has a mean of 12,26% (SD = 22,9) and final test, a mean of 36,00% (SD=36,5). For group v2 diagnostic test has a mean of 11,61% (SD = 20,5) and final test a mean of 34,19% (SD=34,7). The observed differences between these two groups are not statistically significant not only for the diagnostic test but also for the final test. For the second pre-test, means values were a little higher than for the previous test. For group v3 diagnostic test has a mean of 28,57% (SD = 37,4) and final test a mean of 67,14% (SD=36,2) and for group v4 diagnostic test has a mean of 49,09% (SD = 36,2) and final test a mean of 56,36% (SD=39,8). The observed differences between these two groups are also not statistically significant.

Analyzing the data for the final evaluation test, for group v3 for diagnostic test it has a mean of 45,7% (SD =40,3) and for the final test a mean of 85,7% (SD=12,2) and for group v4 for diagnostic test it has a mean of 37,1% (SD = 29,2) and for the final test a mean of 61,4% (SD=33,7). For the diagnostic test it was not found any statistical differences between the two groups, which is understandable because it was assumed that all students had more or less the same level of knowledge. For the final test, however, the differences observed are statistical significant. In addition, a series of tests were made to compare the means values of the students by group and by learning preference, by group and personality and by group and emotional state. The objective of running these tests was to find out if learning preference, personality and emotional state had any influence on the outcome of the final test. In relation to the first two tests, by learning preference and by personality, no statistically significant differences were found in the data. Therefore it cannot be concluded that learning preference and personality in each group had any influence in the final test

outcome. To prove this assumption it is needed a larger sample size. For the question “if the emotional state had any influence in the in the final test”, the differences observed were statistical significant. Also in the pre-test and in the final test an acceptability questionnaire was made to determine the acceptance of the application, the degree of use difficulty and the usefulness of each feature. Overall the responses to this questionnaire were very positive.

5

5. Conclusion

The research was carried out based on the assumption that emotion can influence several aspects of human life, knowledge acquisition, perception, learning process to the way people communicate and the way rational decisions are made. The main research goal was to find out if the consideration of student's emotional state influences their learning process. Also, if learning results can be improved through the utilization of a learning platform that takes into account the referred student's emotional state.

This document starts by highlight background research, methodology and research approaches, used on the subject of this work. The Design Science Research methodology was used in order to address the research problem under consideration.

With the purpose of identify the problem and clarify the motivation and objectives, it was conducted a background research on the basic concepts that support this work. This concepts include: Learning, e-learning and the different theories and branches of psychology that were used in related studies; emotions and emotion theories that throughout the years tried to explain the world of emotion; affective learning and the models proposed by the different researchers, and finally affective computing and the several research lines and techniques such as facial and speech recognition among others and their role in the discovery of human emotion. Emotion shapes almost all modes of human communication, namely facial expression, gestures, posture, tone of voice, choice of words, respiration, and skin temperature, among others. Today advances in recognition allow creation of new ways of human-computer interaction, making this interaction more usable and intuitive. This research resulted in a survey published in the International Symposium on Computational Intelligence for Engineering systems – ISCIES 2011 (R. Faria & Almeida, 2013).

To design and develop a solution to the problem at hand (if a learning platform that takes into account the emotional profile of a student can improve the learning results) a new architecture was proposed. Subsequently, based on this architecture a new prototype, to be used in web environment, was developed. The development of the architecture and prototype had several iterations some of which were published in International Conference of Artificial Intelligence – EPIA 2013 (R. Faria, Almeida, Martins, & Figueiredo, 2013).

The final prototype was entitled "Emotion Test", it was implemented to be an engaged learning environment with some multimedia interactions. Emotion Test simulates the entire learning process, from the subject explanation to exercises and assessment. Through the entire process, student's emotional state, personality traits and learning preferences was taken into account. The architecture proposed for this prototype is composed of 4 main models: Student Model, Emotional Model, Application Model and Emotive Pedagogical Model.

The Student Model represents student's information and characteristics. This includes personal information (name, email, telephone, etc.), demographic data (gender, race, age, etc.), knowledge, deficiencies, learning styles, emotion profile, personality traits, etc. This information is useful to better adapt the prototype to the student.

The Emotion Model gathers all the information of facial recognition software and students feedback.

The Application Model is composed by a set of modules contain different subjects. The subject consist in a number steps that the student has to pass in order to complete the learning program. Usually, each subject is composed by a diagnostic test in order to access the student level of knowledge, followed by the subject content in which the subject is explained and the subject exercises and final evaluation test.

The last model is the Emotive Pedagogical Model that is composed by three sub-models: Rules of Emotion Adaptability, Emotional Interaction Mechanisms and Graph of Concepts in Case of Failure. The Rules of Emotion Adaptability consist in the manner the subject content is presented. The subject content and exercises are presented according the learning style and personality of the student. The Emotional Interaction Mechanisms are the triggering of

an emotion interaction when is captured an emotion that needs to be contradicted in order to facilitate the learning process. Emotions to be contradicted are: anger, sadness, confusion and disgust. The interaction depends on student personality and learning style. Finally the Graph of Concepts in Case of Failure indicates the steps to be taken when a student fails to pass a subject. This architecture was published in the 9th International Technology, Education and Development Conference – INTED2015 (A. Faria, Almeida, Martins, Lobo, & Gonçalves, 2015). To the proposed architecture, was added a new approach in user modelling process that uses learning and cognitive styles and student emotional state to adapt the user interface, learning content and context. This work was published and in the Methodologies and intelligent Systems for Technology Enhance Learning - MIS4TEL 2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015b).

In order to demonstrate and evaluate the final prototype developed some tests were carried out with some of 1st year students of Instituto Superior de Engenharia do Porto (ISEP) from two programs: Informatics Engineering and Systems Engineering. The total number of students involved in these tests was 115 with ages between 17 and 42 years old. This group of students was composed of 20% female (n=23) and 80% male (n=92) participants mainly from the districts of Oporto, Aveiro and Braga. To demonstrate and evaluate the new prototype were conducted two pre-tests for demonstration step and one final test for the evaluation step. This final stage of the developed work generated four papers for conferences and one for a journal. One paper accepted to be published on the 10th Iberian Conference on Information Systems and Technologies - CISTI 2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015e), another accepted to be published on the 17th Portuguese conference on Artificial Intelligence – EPIA 2015 (R. Faria, Almeida, Martins, Gonçalves, & Figueiredo, 2015) and the others submitted to the Eighth International C* Conference on Computer Science & Software Engineering – C3S2E 2015 (yet to be accepted) and to Cognitive Models and Emotions detection for Ambient Intelligence (COMEDAI 2015) Special Session of the 9th International Symposium on Intelligent Distributed Computing - IDC'2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015a) (yet to be accepted). The fourth paper was submitted to the Computers & Education journal also yet to be acepted.

A brief description of publications of this work:

1º “Affect Recognition” in the International Symposium on Computational Intelligence for Engineering Systems – ISCIES 2011 (R. Faria & Almeida, 2013). This paper consisted in a survey of all the theories and techniques of emotion recognition.

2º “Emotional Adaptive Model for Learning” in the International Conference of Artificial Intelligence – EPIA 2013 (R. Faria et al., 2013). This paper consisted in an early architecture proposal that was the step in stone to the finish architecture.

3º “Emotional Interaction Model For Learning” in the 9th International Technology, Education and Development Conference – INTED2015 (A. Faria et al., 2015). This paper consisted in the final architecture with a full description of its components.

4º “Emotional Adaptive Platform for Learning” in the Methodologies and intelligent Systems for Technology Enhance Learning - MIS4TEL 2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015b). This paper presented a new approach in user modelling process that uses learning and cognitive styles and student emotional state to adapt the user interface, learning content and context.

5º “Learning Platform - Emotional Learning” in the 10th Iberian Conference on Information Systems and Technologies - CISTI 2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015e). This paper gives a full overview of the work developed. Introducing the final architecture and prototype as well the tests performed and results achieved.

6º “Including Emotion in Learning Process” in the 17th Portuguese conference on Artificial Intelligence – EPIA 2015 (R. Faria, Almeida, Martins, Gonçalves, et al., 2015). Describing how the use of emotions in the learning process can influence the learning results.

7º “Personality traits, Learning Preferences and Emotions” in the Eighth International C* Conference on Computer Science & Software Engineering – C3S2E 2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015f). This paper gives an outline learning platform developed, emphasising the use of the student’s learning preferences, personality and emotions to prompt better learning results. Revealing the tests performed and results obtained.

8º “Emotion Effects on Online Learning” in the Cognitive Models and Emotions detection for Ambient Intelligence (COMEDAI 2015) Special Session of the 9th International Symposium on Intelligent Distributed Computing - IDC'2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015a). This paper gives an outline of the study of emotions and its effects on online learning.

9º “Emotions in online Learning” in the 6th International Conference on Security-enriched Urban Computing and Smart Grids-SUComS 2015 (R. Faria, Almeida, Martins, & Gonçalves, 2015d). This paper gives an overview how emotions can effect online learning.

10º “Emotional Learning Model” in the Computers & Education journal (R. Faria, Almeida, Martins, & Gonçalves, 2015c). This paper gives detail overview work developed.

5.1. Critical Overview

The central question that guided this work was as follows:

“*Does a learning platform that takes into account the student’s emotions, learning preferences and personality improve the student’s learning results?”*

During the course of this work it was attempted to find an answer to this question. The gathered data from the performed tests showed that there is a statistical difference between students’ learning results while using two learning platforms: one learning platform that takes into account the student’s emotional state and the other platform that does not have that in consideration. This gives an indication that by introducing the emotional component, the students’ learning results can possibly be improved.

In the development of this work and in the attempt to answer the central question other issues became apparent, ones that were beneficial to the research others harmful. The beneficial issue was the use of a new approach in user modelling process that uses learning and cognitive styles and student emotional state to adapt the user interface, learning content and context. This was observed to be very advantageous because the user interface, learning content and context was presented according the student’s learning preference and

personality and associated with an emotional component enhancing their learning outcomes. Noting that this user modelling process was used in both learning platforms but only one platform used the emotional component.

Two harmful issues were: the time given for testing and the initial difficulty level set in the prototype. Due to participants schedule restrictions, the initial tests had little time to be conducted, this was observed to be damaging to the research because the students didn't have enough time to complete the test causing frustration and nervousness among them. This issue was corrected in the following tests by giving the students more time to conduct the tests. Another harmful issue was the difficulty level initial set in the prototype. The high level of difficulty triggered some of the students not to complete some of the tasks required to pass to the next level in the prototype causing them to start again, this also led the students to frustration and to give up the conclusion of the test. This was corrected by reducing the level of difficulty in the subsequent tests performed.

Other question that was initially established was:

"Is it possible to identify and quantify correctly and accurately student's emotions during a session in an online learning environment?"

This question could not be fully proved. Although it was able to gather students emotions in a given instant, the capture accuracy could only be verified by observation or based on the students opinions. According to this verification the emotional data gathered was in generally accurate, but not one hundred percent accurate. Also, the system used to gather emotions only captured a limited number of 7 emotions, which narrowed the field of analyses.

Another question was:

"Does Affective computing technology help improving a student learning process?"

In answering positively to the central question, this question is partly answered. As results showed, the students' learning results can be improved by adding an emotional component to a learning platform; also the use of Affective Computing technology to capture emotion can enhance this improvement. The use Affective Computing allows the

capture of the student's emotion by using techniques that don't inhibit the student's actions. Also, it can be used one or more techniques simultaneously to help verify the accuracy of the emotional capture.

The last question was:

"What are the stimuli that can be used to induce or change the student state of mind in order to improve the learning process?"

First, the results indicate that the platform with an emotional component had an overall set of more positive emotions than the platform without this component. Showing that, the stimuli produced in the platform with an emotional component was able to keep the students in a positive emotional state and motivated to do the tasks at hand, this did not happen in the platform without this component.

Second the results demonstrated that the platform with an emotional component not only got the set of more positive emotions among the students, but also obtained an improvement in the students learning results.

5.2. Limitations and Problems of the Research

In the course of this work some obstacles were encountered which weren't fully overcome. One of them was the emotion capture and mainly emotion capture online. It was used a simple working webcam thru the web which raise security and privacy problems. This security issues were partially solved by using Hypertext Transfer Protocol Secure (HTTPS) which is a communications protocol for secure communication over the internet. The use of this protocol also solved an issue of privacy. The browser continually requesting access to webcam prove to be increasing annoying, therefore with the use of this protocol the user only need to grant access once and the browser would remember the user choice. Although this seemed to solve one problem it created another. If the user failed to grant access to the webcam in the beginning of the prototype use, the capturing of the user emotion would not work properly and entailing that the prototype would not adapt the course to the student's emotions.

Another major problem if not the biggest problem faced, was the used technique to capture the student's emotions. Initially, was thought that a multimodal system with facial emotion recognition, speech emotion recognition and text emotion recognition would be an ideal scenario, but soon that idea would be abandoned. Speech emotion recognition and text emotion recognition brought innumerous problems. For speech emotion recognition it was used the microphone. This brought the same problems that arise with the use of the webcam, with the addition of the microphone sensitivity, but this were not the only problems, the language barrier also was a problem, most of the existent systems are developed for English not for Portuguese and this also occurred for text emotion recognition. Another problem was the accent of the student, which leads to misinterpretation of the words. For text emotion recognition besides the language barrier, another problem was the misspelling and the unknown abbreviations and emoticons. Finally, the decision was to capture the emotion considering only the facial emotion recognition.

To capture student emotion it was used an API that detects human emotion, but has two limitations, first one, it only detect 7 emotions (happy, sad, surprised, calm, disgust, confused and anger). Second, was observed that in most cases the emotion of fear was confused with surprised.

5.3. Recommendations for Future Work

Due to the limitations that arise from the use of the chosen API it is recommended a modification on the emotion capture system to obtain a more exact form of emotion recognition or even combined forms of emotion recognition like: facial emotion recognition, speech emotion recognition, text emotion recognition or even the analysis of body posture. Trying to solve the some of the limitations related in the previous section.

The experiment repetition with a larger sample of students in order to answer that remained unanswered, questions like: "if learning preference and personality has any influence in the student's results". Another option could be to test the platform over a larger period of time and to test with different groups of people with dissimilar background, knowledge, skills and age. This would allow comparing results and analyzing if they differ in each group or even if the results differ from the presented tests.

Finally, in order to enrich and to make the platform more efficient and user friendly, some others functionalities could be added. Theses functionalities could be possible entry points for capture emotion or even to make an emotion interaction in order to help the student to complete his task. Some examples of potential functionalities that could be added are:

- The introduction of a new feedback system able to respond in real time to the student's doubts in order to improve the student's learning results. The system could be programed in order to respect student learning preference, personality and emotional state. This system can have a double objective. It could allow the capture of emotion or to be an emotion interaction when the system detects the student in trouble. The capture of emotion could be performed by text messages or by speaking character depending on the feedback system implemented.
- The introductions of new content, allowing access to external repositories, help links and help videos. This could be a new form of emotion interaction every time system detect the student as a difficulty a series of links and help videos can be offered to the student.

5.1.Final Remarks

With this work contributed to a new approach for an emotional adaptive architecture for online learning that uses the student's emotional state, personality traits and learning preferences to adapt the user interface, learning content and context to the student needs. Also, the contribution of a working prototype that uses the referred architecture that can be adapted to be used in others domains. Furthermore one expects to have made a contribution in the form of the several published papers in the course of this work.

In conclusion to this work, it was referred the conclusions achieved, the contributions and originality that underlay the work carried out. Also, were highlighted the limitations as well as the more immediate problems and suggested to some possibilities to overcome them. As well, future developments that may significantly increase prototype performance and at the same time could make this work the seed for future projects.

Bi

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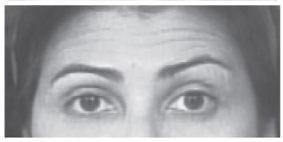
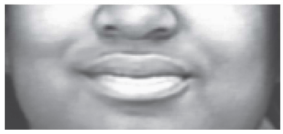
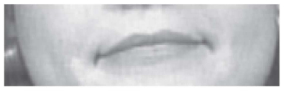
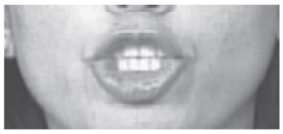
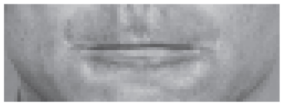
An

Annexes

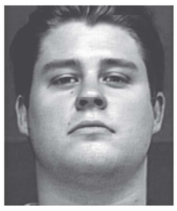
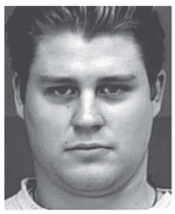
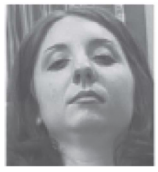
Annex A – List of Action Units and Action Descriptors

The next tables (J. F. Cohn et al., 2007) list Action Units and Action Descriptors (with underlying facial muscles)

AU	Description	Facial muscle	Example image	Interrater agreement (Kappa coefficient) (tolerance window in seconds)			
				1/30th	1/6th	1/3rd	1/2
1	Inner Brow Raiser	*Frontalis, pars medialis*		.73	.79	.81	.83
2	Outer Brow Raiser	*Frontalis, pars lateralis*		.66	.71	.74	.76
4	Brow Lowerer	*Corrugator supercilii, Depressor supercilii*		.58	.64	.67	.70
5	Upper Lid Raiser	*Levator palpebrae superioris*		.68	.76	.79	.82
6	Cheek Raiser	*Orbicularis oculi, pars orbitalis*		.72	.78	.82	.85
7	Lid Tightener	*Orbicularis oculi, pars palpebralis*		.44	.49	.53	.56
9	Nose Wrinkler	*Levator labii superioris alaquae nasi*		.67	.76	.81	.83
10	Upper Lip Raiser	*Levator labii superioris*		.69	.76	.79	.81
11	Nasolabial Deepener	*Zygomaticus minor*		-	-	-	.97
12	Lip Corner Puller	*Zygomaticus major*		.67	.71	.74	.76

AU	Description	Facial muscle	Example image	Interrater agreement (Kappa coefficient) (tolerance window in seconds)			
13	Cheek Puffer	*Levator anguli oris (*a.k.a. *Caninus)*		-	-	-	-
14	Dimpler	*Buccinator*		.59	.67	.72	.75
15	Lip Corner Depressor	*Depressor anguli oris (*a.k.a. *Triangularis)*		.54	.65	.69	.72
16	Lower Lip Depressor	*Depressor labii inferioris*		-	-	-	-
17	Chin Raiser	*Mentalis*		.55	.63	.66	.68
18	Lip Puckerer	*Incisivii labii superioris* and *Incisivii labii inferioris*		.65	.71	.74	.75
20	Lip stretcher	*Risorius* with *platysma*		.38	.47	.54	.60
22	Lip Funneler	*Orbicularis oris*		-	-	-	-
23	Lip Tightener	*Orbicularis oris*		.32	.41	.47	.53
24	Lip Pressor	*Orbicularis oris*		.50	.58	.62	.64
25	Lips parted	*Depressor labii inferioris* or relaxation of *Mentalis,* or		.57	.62	.65	.67

AU	Description	Facial muscle	Example image	Interrater agreement (Kappa coefficient) (tolerance window in seconds)			
		Orbicularis oris					
26	Jaw Drop	*Masseter,* relaxed *Temporalis* and *internal Pterygoid*		.65	.72	.76	.79
27	Mouth Stretch	*Pterygoids, Digastric*		-	-	-	.96
28	Lip Suck	*Orbicularis oris*		.61	.70	.76	.79
41	Lid droop	Relaxation of *Levator palpebrae superioris*		-	-	-	-
42	Slit	*Orbicularis oculi*		-	-	-	-
43	Eyes Closed	Relaxation of *Levator palpebrae superioris; Orbicularis oculi, pars palpebralis*		-	-	-	-
44	Squint	*Orbicularis oculi, pars palpebralis*		-	-	-	.87
45	Blink	Relaxation of *Levator palpebrae superioris; Orbicularis oculi, pars palpebralis*		-	-	-	.98
46	Wink	Relaxation of *Levator palpebrae superioris; Orbicularis oculi, pars palpebralis*		-	-	-	-
51	Head turn left	---		-	-	-	-

AU	Description	Facial muscle	Example image	Interrater agreement (Kappa coefficient) (tolerance window in seconds)			
52	Head turn right	---		-	-	-	-
53	Head up	---		-	-	-	-
54	Head down	---		-	-	-	-
55	Head tilt left	---		-	-	-	-
56	Head tilt right	---		-	-	-	-
57	Head forward	---		-	-	-	-
58	Head back	---		-	-	-	-
61	Eyes turn left	---		-	-	-	-

Annex B – TIPI

Here are a number of personality traits that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

Disagree Strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	2	3	4	5	6	7

I see myself as:

1. _____ Extraverted, enthusiastic.
2. _____ Critical, quarrelsome.
3. _____ Dependable, self-disciplined.
4. _____ Anxious, easily upset.
5. _____ Open to new experiences, complex.
6. _____ Reserved, quiet.
7. _____ Sympathetic, warm.
8. _____ Disorganized, careless.
9. _____ Calm, emotionally stable.
10. ____ Conventional, uncreative.

TIPI scale scoring (“R” denotes reverse-scored items):

Extraversion: 1, 6R; Agreeableness: 2R, 7; Conscientiousness; 3, 8R; Emotional Stability: 4R, 9; Openness to Experiences: 5, 10R.

Annex C – VARK

The VARK Questionnaire (Version 7.8)
How Do I Learn Best?
Choose the answer which best explains your preference and circle the letter(s) next to it.
Please circle more than one if a single answer does not match your perception.
Leave blank any question that does not apply.

1. You are helping someone who wants to go to your airport, the center of town or railway station. You would:
    a. go with her.
    b. tell her the directions.
    c. write down the directions.
    d. draw, or show her a map, or give her a map.
2. A website has a video showing how to make a special graph. There is a person speaking, some lists and words describing what to do and some diagrams. You would learn most from:
    a. seeing the diagrams.
    b. listening.
    c. reading the words.
    d. watching the actions.
3. You are planning a vacation for a group. You want some feedback from them about the plan. You would:
    a. describe some of the highlights they will experience.
    b. use a map to show them the places.
    c. give them a copy of the printed itinerary.
    d. phone, text or email them.
4. You are going to cook something as a special treat. You would:
    a. cook something you know without the need for instructions.
    b. ask friends for suggestions.
    c. look on the Internet or in some cookbooks for ideas from the pictures.
    d. use a good recipe.
5. A group of tourists want to learn about the parks or wildlife reserves in your area. You would:
    a. talk about, or arrange a talk for them about parks or wildlife reserves.
    b. show them maps and internet pictures.
    c. take them to a park or wildlife reserve and walk with them.
    d. give them a book or pamphlets about the parks or wildlife reserves.
6. You are about to purchase a digital camera or mobile phone. Other than price, what would most influence your decision?
    a. Trying or testing it.
    b. Reading the details or checking its features online.

c. It is a modern design and looks good.
d. The salesperson telling me about its features.

7. Remember a time when you learned how to do something new. Avoid choosing a physical skill, eg. riding a bike. You learned best by:
    a. watching a demonstration.
    b. listening to somebody explaining it and asking questions.
    c. diagrams, maps, and charts - visual clues.
    d. written instructions – e.g. a manual or book.
8. You have a problem with your heart. You would prefer that the doctor:
    a. gave you a something to read to explain what was wrong.
    b. used a plastic model to show what was wrong.
    c. described what was wrong.
    d. showed you a diagram of what was wrong.
9. You want to learn a new program, skill or game on a computer. You would:
    a. read the written instructions that came with the program.
    b. talk with people who know about the program.
    c. use the controls or keyboard.
    d. follow the diagrams in the book that came with it.
10. I like websites that have:
    a. things I can click on, shift or try.
    b. interesting design and visual features.
    c. interesting written descriptions, lists and explanations.
    d. audio channels where I can hear music, radio programs or interviews.
11. Other than price, what would most influence your decision to buy a new non-fiction book?
    a. The way it looks is appealing.
    b. Quickly reading parts of it.
    c. A friend talks about it and recommends it.
    d. It has real-life stories, experiences and examples.
12. You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have:
    a. a chance to ask questions and talk about the camera and its features.
    b. clear written instructions with lists and bullet points about what to do.
    c. diagrams showing the camera and what each part does.
    d. many examples of good and poor photos and how to improve them.
13. Do you prefer a teacher or a presenter who uses:
    a. demonstrations, models or practical sessions.
    b. question and answer, talk, group discussion, or guest speakers.
    c. handouts, books, or readings.
    d. diagrams, charts or graphs.
14. You have finished a competition or test and would like some feedback. You would like to have feedback:
    a. using examples from what you have done.
    b. using a written description of your results.
    c. from somebody who talks it through with you.

d. using graphs showing what you had achieved.

15. You are going to choose food at a restaurant or cafe. You would:
    a. choose something that you have had there before.
    b. listen to the waiter or ask friends to recommend choices.
    c. choose from the descriptions in the menu.
    d. look at what others are eating or look at pictures of each dish.
16. You have to make an important speech at a conference or special occasion. You would:
    a. make diagrams or get graphs to help explain things.
    b. write a few key words and practice saying your speech over and over.
    c. write out your speech and learn from reading it over several times.
    d. gather many examples and stories to make the talk real and practical.

The VARK Questionnaire Scoring Chart

Use the following scoring chart to find the VARK category that each of your answers corresponds to. Circle the letters that correspond to your answers e.g. If you answered b and c for question 3, circle V and R in the question 3 row.

Calculating your scores

Count the number of each of the VARK letters you have circled to get your score for each VARK category.

Total number of Vs circled =

Total number of As circled =

Total number of Rs circled =

Total number of Ks circled =

Annex D – Emotion Diagrams

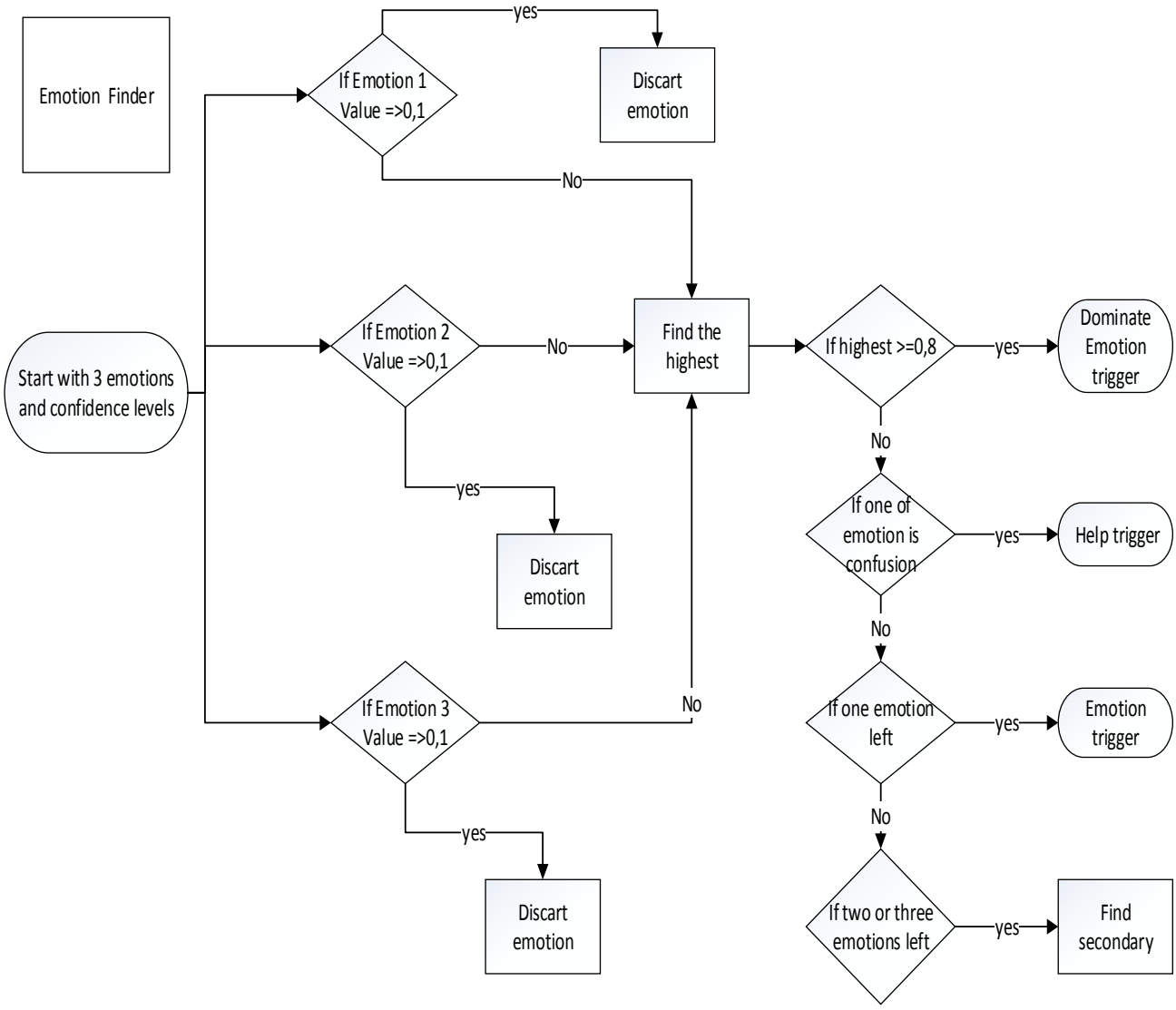


Figure 49 – Emotion finder

Secondary Emotion Finder

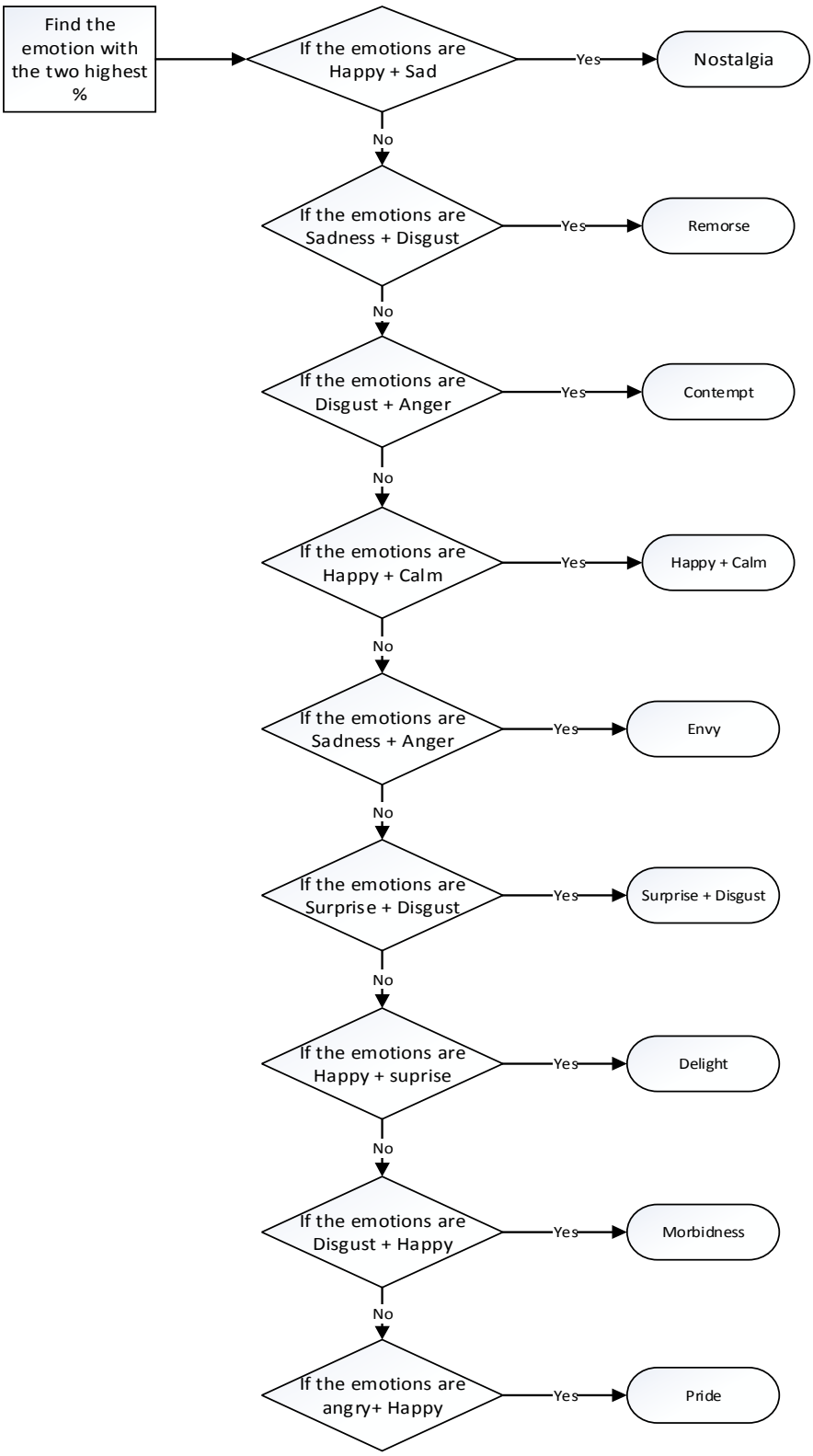


Figure 50 – Secondary Emotion finder

Annex E – Acceptability Survey

Caro(a) Aluno(a)
Assunto: Avaliação do EmotionTest
Pensamos ser altura de fazer um balanço, e último; acerca da aceitabilidade e interesse do EmotionTest por parte dos alunos. Esta avaliação é muito importante para podermos saber como o melhorar e, claro está, identificando problemas ou obstáculos à sua utilização! Neste âmbito, pedíamos-lhe que respondesse anonimamente ao seguinte inquérito.
Muito grato pela sua colaboração.

A. Assinale o seu grau de concordância relativamente às seguintes afirmações sobre o EmotionTest:

	Discordo totalmente	Discordo maioritariamente	Concordo maioritariamente	Concordo totalmente	Sem opinião
1. A aplicação facilitaria o estudo da disciplina fora das aulas.	☐	☐	☐	☐	☐
2. A aplicação facilitaria o estudo da disciplina durante as aulas.	☐	☐	☐	☐	☐
3. A informação da aplicação está bem organizada.	☐	☐	☐	☐	☐
4. A aplicação tem um bom grafismo / design.	☐	☐	☐	☐	☐
5. Consegue aceder facilmente aos conteúdos da Disciplina na aplicação.	☐	☐	☐	☐	☐
6. A aplicação poderá ser é útil para melhorar os seus resultados na disciplina	☐	☐	☐	☐	☐
7. Recomendava o uso da aplicação.	☐	☐	☐	☐	☐
8. Gostava que todos os professores usassem a aplicação nas respectivas aulas.	☐	☐	☐	☐	☐
9. Consegue aceder facilmente as actividades da aplicação.	☐	☐	☐	☐	☐
10. A interacção dada pela aplicação é útil.	☐	☐	☐	☐	☐

B. Como classificaria o grau de utilidade de cada uma das ferramentas do EmotionTest?					
	Inútil	Pouco útil	Útil	Muito útil	Não conheço
1. Questionários	☐	☐	☐	☐	☐
2. Conteúdos	☐	☐	☐	☐	☐
3. Actividades	☐	☐	☐	☐	☐
4. Videos	☐	☐	☐	☐	☐
5. Interacção	☐	☐	☐	☐	☐

C. Como classificaria o grau de dificuldade na utilização de cada uma das ferramentas do EmotionTest?					
	Difícil	Pouco Fácil	Fácil	Muito Fácil	Não conheço
1. Questionários	☐	☐	☐	☐	☐
2. Conteúdos	☐	☐	☐	☐	☐
3. Actividades	☐	☐	☐	☐	☐
4. Videos	☐	☐	☐	☐	☐

D. Sugestões/Comentários