A proposed method for adapting and integrating student learning style, teaching strategies and electronic media

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Al fin, contra viento y marea!

Dans le cadre de l'Ecole Doctorale SSTO
Sciences des Systèmes Technologiques et Organisationnels
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RESUME

Thèse de Doctorat: Proposition d'une méthodologie pour adapter et intégrer les styles d'apprentissage, les stratégies d'enseignement et les medias électroniques

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Short Abstract

Les études récentes dans le processus d'apprentissage ont constatées que les élèves ont tendance à apprendre de différentes façons et à travers divers moyens et qu'ils préfèrent utiliser des ressources d'apprentissage multiples. Les chercheurs dans le champ de l'éducation sont d'accord sur le fait que les supports d'enseignement ne doivent pas uniquement refléter le style d'enseignement des professeurs, mais doivent aussi être conçus et adaptés à chaque personnalité et à chaque profil psychologique. L'évolution des technologies d'information (TI) et les formes multiples de medias électroniques ouvrent de nouvelles perspectives pour adapter et personnaliser le processus d'apprentissage.

Dans le cadre de cette recherche, nous nous sommes intéressées à la pédagogie adaptive et aux méthodes personnalisées d'apprentissage. Notre objectif est de combiner les medias électroniques et les stratégies d'enseignement selon les profils de chaque étudiant. Les problématiques sous-jacentes sont : Comment prendre en compte la personnalité de l'étudiant et son profil psychologique pour développer une pédagogie adaptée ? Comment utiliser et tirer profit des nouveaux e-media et des outils disponibles basés sur les TI? Comment combiner dans un cours ou dans système d'apprentissage une pédagogie adaptée avec les e-media adéquats ?

Notre recherche prend s'appuie sur l'instrument de mesure des styles d'apprentissage de Felder et Soloman (1993). Dans un premier temps, nous explorons des idées fondamentales sur la correspondance entre e-medias et les styles d'apprentissage dans le contexte d'un système de e-learning expérimental. Dans un second temps, nous présentons un cadre général pour combiner et adapter les stratégies d'enseignement avec les styles d'apprentissage et les medias électroniques. Ce cadre a été construit avec l'aide d'un panel d'experts en utilisant l'approche Delphi. Finalement, deux études de cas qui incluent des questionnaires et des analyses statistiques ont été conduites pour valider ce cadre et généraliser son applicabilité. Ce travail contribue à une meilleure compréhension de l'utilisation des e-media dans l'éducation et augmente notre connaissance de l'interaction entre les profils psychologiques des étudiants et les pratiques et systèmes d'enseignement.

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RESUME

PhD thesis: A proposed method for adapting and integrating student learning style, teaching strategies and electronic media

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Short Abstract

Recent research on the learning process has shown that students tend to learn in different ways and manners, and that they prefer to use different teaching resources. Researchers in the education field agree on the fact that learning materials shouldn't just reflect the teacher's teaching style, but should be designed and adapted to all kind of personalities and psychological profiles. The availability of information technology and multiple forms of electronic media open new perspectives for adapting and personalizing the learning process.

In this research, we are interested in adaptive pedagogy and personalized teaching methods. Our goal is combining electronic media and teaching strategies according to student profiles. The underlying problems are: How to take into account the student personality and psychological profile to develop an adapted pedagogy? How to use and take advantage of new available e-media and IT based tools? How to combine in a course or in a learning system adapted pedagogy with adequate e-media? We have based our work on the Felder and Soloman's learning styles instrument. First, we explore some basic ideas concerning the matching of e-media and learning styles in the context of an experimental e-learning system. Second, we present a general framework for combining and adapting teaching strategies, learning styles and electronic media. This framework has been constructed with the help of an expert panel and using the Delphi approach. Finally, two case studies including surveys and statistical analysis have been conducted to validate the framework and generalize its applicability. This works contributes to a better understanding of e-media usage in education, and increases our knowledge concerning the interaction between students psychological profile and learning systems.

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Chapter 1

"Instruction begins when you, the teacher, learn from the learner. Put yourself in his place so that you may understand what he learns and the way he understands it“

[Kierkegaard]

1 Introduction

Along with the innovations in Information Technologies (IT), large perspectives for developing new educational scenarios are emerging. These scenarios allow us to profoundly modify the traditional pedagogic models by using flexible and adaptable IT tutors as teaching resources and as teaching tools. The use of electronic media (e-media) in education can significantly enhance and support the learning process. A person can acquire new knowledge in a more flexible and adaptable way than with traditional methods. Innovative elements can be introduced to help students consolidate the subjects studied in class and efficiently improve their learning process.

The problem lies in the IT tutor's ability to adapt himself to the prior knowledge and to the psychosocial characteristics of a particular student. We must picture this change in terms of integration and complementarities between the vast resources offered by IT and the student. We need to create environments which support the development of individuals with different skills by using these powerful tools provided by IT. Certainly not all of these things are possible in the real world (at this time). But we can imagine a form of personalization that aims to provide to everyone the right information at the right time in the right place. And, of course, if the student's preferences and interests change, the IT tutor adapts to suit them.

Regarding learning, not everyone learns in the same way as each person has a particular set of learning abilities. Educational research tells us that 'one size does not fit all' (Reigeluth, 1996) and that the learning characteristics of students differ (Honey & Mumford, 1986). It suggests that students learn differently, they process and represent knowledge in different ways, and they prefer to use different types of resources. However, most educational systems have ignored individual differences that exist between learners, such as the learning ability, background knowledge, learning goals and learning style (Ford & Chen, 2001). Educational systems generally provide a unique and standardized teaching material to all students which tend to benefit those whose learning style and background knowledge fits well with the teaching material.

This dissertation deals with the topic of adaptive pedagogy and personalized teaching methods. It is based on the fact that students learn more effectively when instruction is adapted to the way they learn (Rasmussen& Davidson-Shivers, 1998). Our goal is combining electronic media and teaching strategies according to student psychological profiles. In this dissertation, we describe the design of a personalized teaching method

that is based on an adaptive framework for matching e-media and teaching strategies with Felder and Silverman's learning styles.

In this introductory chapter we present the general research agenda. Section 1.1 describes the motivation of our research. Section 1.2 defines the research questions and approaches. Section 1.3 presents an outline of this dissertation.

1.1 Motivation, background and history

This research brings together two disciplines: e-learning tools (electronic media), as a research topic in **computer science,** and learning and teaching styles an **educational psychology** topic. We will start by showing why our choice for understanding of learning styles can be used to identify and implement better teaching and learning strategies (Felder & Soloman, 1993; Coffield et al., 2004). Learning styles have also been shown to have an impact on the effectiveness of online learning (Allert, 2003; Carver et al., 1999).

1.1.1 Learning styles

The nature of learning styles (LS) is studied by educational psychology and especially cognitive psychology. Learning style is seen as a broader construct, which includes cognitive along with affective and psychological styles (Keefe, 1979). Learning styles have been studied mostly together with practical applications (Liu & Ginther, 1999).

The definition of learning styles accepted by the leading theorists is “relatively stable indicators of how a learner perceives, interacts with and responds to the learning environment" (Keefe, 1979). In this dissertation, we will refer to the learning styles definition proposed by Felder and Silverman as “the characteristics, strengths and preferences in the way people receive and process information” (Felder & Silverman 1988). It refers to the fact that every person has his/her own method or set of strategies when learning.

Experiments in educational settings show that matching/mismatching a user's learning styles with the design of an instruction can be an important factor with regard to learning outcome. A number of studies indicate that the user's performance is much better if the teaching methods are matched to the user's learning styles (Chen & Macredie, 2002). And recent research on the learning process has shown that students tend to learn in different ways and that they prefer to use different teaching resources as well (Felder & Silverman, 1988). Many researchers agree on the fact that learning materials shouldn’t just reflect the teacher’s style, but should be designed for all kinds of students and all kinds of learning styles (Dagger, Wade & Conlan 2003; Felder &

Silverman, 1988; Paredes & Rodriguez, 2002). Even though they agree on the importance of applying these learning styles to different learning systems, various problems still need to be solved, such as matching teaching contents with the student's learning style.

1.1.2 Teaching strategies

Teaching strategies (TS) are the elements given to the students by the teachers to facilitate a deeper understanding of the knowledge. The emphasis relies on the design, programming, elaboration and accomplishment of the learning content. Teaching strategies must be designed in a way that students are encouraged to observe, analyze, express an opinion, create a hypothesis, look for a solution and discover knowledge by themselves. Teaching strategy can refer for example to an organized and systematized sequence of activities and resources that teachers use while teaching. The main objective is to facilitate the students´ learning.

One crucial aspect of our research is the integration of electronic media with teaching strategies, due to the informational technology breakthroughs that allow us to use a variety of them. On the other hand, we need to link such teaching strategies with the concept of learning styles, something that hasn't been exploited to the extent that is intended here. The teaching strategies used in this dissertation are: games and simulations, learning based on problem solving, role playing, presentation, discussion panel, brainstorming and case study.

1.1.3 Electronic media (e-learning tools)

Electronic media (e-media) deals with the topic of electronic and the topic of media. In communication, media (singular medium) are the storage and transmission tools used to store and deliver information or data. It is often referred to as synonymous with mass media or news media, but may refer to a single medium used to communicate any data for any purpose. Electronic media is media that use electronics or electromechanical energy for the end user (audience) to access the content. This is in contrast to static media (mainly print media), which are most often created electronically, but don't require electronics to be accessed by the end user in the printed form. The primary electronic media sources familiar to the general public are better known as video recordings, audio recordings, multimedia presentations, slide presentations, CD-ROM and Online Content. Throughout this dissertation, we will use the term "electronic media" to cover "Web 2.0" platforms which are characterized as facilitating communication, information sharing, interoperability, user-centered design and collaboration on the World Wide Web (O'Reilly, 2009). Examples include social-networking sites, video-sharing sites, wikis, blogs, mashups and folksonomies.

In every teaching process, the tools used play an important role. In traditional classrooms, blackboards and books are generally used. The importance in this matter is that the tools regulate and condition the rest of the curricular components, such as: objectives, content, strategy, activities. At the same time, these components allow the selection of the right tools that make possible the definition of the course and the realization of the goal.

Throughout this dissertation we will use the terms “means” and “media” interchangeably. We concentrate on our definition of media, which is “any material made with the intention to support, transmit and/or facilitate teaching – learning processes, whether or not it has a teaching purpose”, thus we won’t make a difference between mean and resource. In order to give a solution for the raised challenges of personalizing the learning process according to the student learning style, we will only take care of electronic media. Therefore, the definition of electronic media in the learning context is “any electronic device that supports, transmits and/or facilitates teaching – learning processes with a teaching purpose”.

1.2 Connection between learning styles, teaching styles and electronic media

In the context of Information Technology evolution and the availability of large number of electronic media, the idea of matching e-media with appropriate teaching and learning styles has been explored since the late 90's. It means deploying resources to support the learning process in a way that not only suits the characteristics of a few, but that adapts to the characteristics of each student. There are many studies on the effectiveness of combining e-learning tools with learning styles in educational systems (Najjar, 1996; Liao, 1999). They attempt to associate specific e-media characteristics to different categories of learners and propose instruments and methods for assessing learning style (Riding & Rayner, 1998). Most of these studies rely on Kolb's Learning Styles Inventory (LSI) (Kolb 1984) and Soloman-Felder Index of Learning Styles (ILS) (Soloman, & Felder, 1993).

However, very few researchers give an idea of which appropriate combinations of electronic media and learning styles are more effective than others. Electronic media can be used in different ways to implement different teaching strategies which can be matched with different learning styles. For example, a discussion forum can be used in different ways. It can be used to assign a practical task to students in such a way that students solve the assigned problem in a collective way. This fits well with a sensitive learning style. The discussion forum can also be used to give a sequential series of theoretical presentations to students who can interact with the teacher. The sequence

of presentations associated with the corresponding discussion is an adequate teaching material for sequential style students.

The introduction of e-media in formal educational systems provides a number of possibilities for curriculum development. It also implies difficulties that cannot be ignored. Among them we have: the knowledge or ignorance of means, how to consistently incorporate the e-media in the educative and learning processes, which must be the educator's role and which strategies are to be used in the selection and design of materials in order to develop the learning capabilities based on these electronic media.

In our opinion it would be useful to give an answer to these difficulties by providing the teacher with a guide for the selection of suitable electronic means for the teaching strategy according to the student's learning style. Based on that, for each learning style there is one or many appropriate teaching strategies which may be combined by one or many electronic means.

This dissertation analyzes the possibilities of providing support for the creation of teaching methods and environments that use the vast resources offered by IT in such a way to adapt teaching material and strategies to the learner's skills and learning style.

1.3 Research questions and approaches

This dissertation addresses the following research questions:

Research question 1: Is it helpful for a student in a course to learn and acquire knowledge using his/her particular learning style and e-media combined in a learning system? We explored some basic ideas concerning the matching of e-media and learning styles in the context of an experimental e-learning system. In order to suggest that, we indeed created a system that evaluated the learning style(s) of a student (called his/her 'profile'), matched course content with the corresponding student profile (stored in a database), created specific teaching material (e-media material) for the student and use the system to validate the approach with engineering students.

To address this question we invited Computer Science, Business Engineering, Industrial Engineering, and Telematics Engineering Students in the 2006 introductory programming course at ITAM in México City to participate in our study. Twenty six students had three hours of lectures each week. The course was based on teaching the C Programming Language. At the beginning the Felder – Solomon Index of Learning Styles Instrument was applied to determine the students individual learning styles. The course took place during the students' first semester. The learning style Instrument was integrated into the system, and all of the students answered the test. The student

used the system with the selected material depends of his/her learning style during the course and at the end of the semester we analyzed the results. The student used the system, with selected material according to his/her learning style, during the course and at the end of the semester we analyzed the results.

This experiment showed the feasibility of our approach and we concluded that it is possible to introduce personalization techniques based on learning styles and electronic media. The system was well accepted by students, even if the matching was limited to only two learning styles and one teaching strategy, so we found several problems: which is the correct e-media material for each learning styles? Are the teaching strategies important to that selection? Therefore, we have continued with a different approach and decided to concentrate on generating a framework for matching the learning styles and electronic media together with the teaching strategies. Consequently, we considered two more research questions regarding this:

Research question 2: Can we create a framework for integrating teaching strategies, learning styles and electronic media? The answer to research question 2 will make a connection between the learning styles and their representation in adaptive media. We analyzed and connected the recommendations from psychological and computer science research. We investigated how other researchers tried to incorporate the learning styles. Thus we presented a general framework for combining and adapting teaching strategies, learning styles and electronic media. It also suggests the suitable electronic media as a channel for the material representation, hence personalizing it to every student. This framework has been constructed based on literature review, previous findings and our own experiences with Soloman – Felder learning style theory and usage of e-media. It has been confirmed approved through an expert panel using the Delphi method which was held during the "III Congreso de Estilos de Aprendizaje" at Cáceres (Spain) in July 2008.

This framework has been tested on an undergraduate computer science course in 2008 with 30 Computer Science, Business Engineering, Industrial Engineering, and Telematics Engineering students. First results showed that a majority of students had a better assimilation of knowledge and that students positively appreciated the personalized pedagogical material proposed in the course.

Next, we wanted to generalize the usage of this framework to other student's programs not only for engineering students. Therefore the next question is:

Research question 3: to which extent is it possible to validate and to generalize this framework? This research question addressed the following objectives in a comparative mode:

- Identification of learning styles for undergraduate engineering, economic, business, mathematics, law, accounting students and their correlation with teaching strategies, with electronic media, and with individual and course performance;
- Identification of electronic media and their correlation with teaching strategies;
- Examination of the association between teaching style and learning style.

To answer question 3, we conducted a series of questionnaires to 726 students in Computer Science, Business Engineering, Industrial Engineering, Telematics Engineering, Business Administration, Economics, Public Accounting and Financial Strategy, Actuarial Science and Applied Mathematics, International Relation and Law programs in order to generalize and validate the matching framework using statistical methods.

We found similar correlations with the comparison of teaching strategies and learning styles and also between electronic media and learning styles that we obtained from the Delphi expert panel.

1.4 Outline of the dissertation

This dissertation consists of six chapters. In **chapter 1** we introduced the topic and context of our research and outlined the main research questions. **Chapter 2** presents, first, general information about learning styles and emphasizes those learning style that, according to psychological researchers, have possible implications for pedagogy; second, the chapter presents definitions of teaching strategies; to end with an overview of e-media and adaptive hypermedia systems. **Chapter 3** starts by addressing research question 1, providing a list of design-requirements for an experimental system; it provides an answer by presenting the design and implementation of such a tool, furthermore, the chapter pays attention to the results and to the complications found. **Chapter 4** answers research question 2. To make a connection between the learning styles and their representation in adaptive media we analyze the recommendations from psychological and computer science research. We present a general framework for combining and adapting teaching strategies, learning styles and electronic media and the results of approach validation performed by Delphi expert panel. **Chapter 5** answers research question 3. The chapter describes the statistical methods used to validate the matching framework and generalize it. And finally, **chapter 6** gives a summary of the main results and indicates some directions for future research.

Chapter 2

2 Learning styles, teaching strategies and e-media theory

In this chapter we introduce the field of learning styles, teaching strategies and e-media. We focus on those learning styles that (according to psychological research) can potentially apply to adaptive Web-based settings, the general teaching strategies and e-media.

Section 2.1 discusses the introduction to these topics. Section 2.2 discusses the origins of the learning styles theory. Section 2.2.1 provides definitions of the terms cognitive and learning styles. Section 2.2.2 reviews a number of learning style models, involving their potential implications on adaptation purposes. Section 2.2.3 presents the Kolb's learning styles inventory. Section 2.2.4 presents Honey and Mumford's learning styles questionnaire. Section 2.2.5 presents Felder and Silverman's index of learning styles. Section 2.3 discusses the definitions of the teaching strategies and discusses the problems connected with assessing the teaching styles of users. Section 2.4 discusses the definitions of the e-media and e-learning tools. Section 2.4 summarizes the chapter.

2.1 Introduction

How can we teach students if we do not know how they learn? Are the learning difficulties of so many students better understood than the teaching problems of tutors? The electronic media is a tool for the learner or for the teacher?

University students enormously vary concerning to velocity, the way of gathering new information, and knowledge application on new events. Students learn in very different ways. For instance, let's analyze some students' particular preference in learning C language. Some rather listen to a recording that explains the starts of C language programming (verbal learners), some read a C programming tutorial (visual learners), some start with direct practice right away (active learners) while others need to see a number of examples before writing any code (reflective learners).

Surely there are so many ways to teach as there are to learn. Some teachers only dictate their traditional lesson as in conference, others give some examples to apply their knowledge, others incite the students to participate in discussions, and some focus on the material memorizing (Felder & Henriques, 1995).

It has been widely documented and recognized that success in the classroom depends not only on the intellectual abilities, skills, and talents of the student, but also on the

student's learning style (Kolb, 1984). Learning styles are an important variable in processing cognitive information (Davidson, 1990; Kolb, 1984; Rasmussen & Davidson-Shivers, 1998). More specifically, learning styles refers to how individuals learn in terms of their perceptions, processes, and preferences (Kolb, 1984).

Over the years, educators have recognized the importance of learning styles for students as well as teachers and have incorporated a variety of teaching and learning methods and strategies in their pedagogy (Ronchetto, et al., 1992; Wynd & Bozman, 1996). Moreover, the 21st Century brings to the classroom a vast array of technologies including CD-ROM, videotapes, multimedia presentation software, World Wide Web (www) discussion forums, and the Internet. The main role of instructional technologies in higher education is to further effective learning methods and teaching pedagogies in ways that are not possible by using traditional classroom methodologies.

With this increasing interest in instructional technologies and it is integration into the curriculum, there has been a growing concern among educators regarding the effectiveness of these tools to meet the needs of the students (Brouwer, 1996; Grasha, 1996; Jonassen, 2000; Rintala, 1998).

At the same time, other experiments show that for more able users mismatching learning materials to learning styles may be advantageous as it encourages users to develop learning strategies that could cope with a wider range of materials and experiences in the future (Holodnaya, 2002). There are also a number of studies that do not show any significant difference between the learning outcomes while matching or mismatching design of an instruction with learning styles (Hayes & Allison, 1993; Coffield et al., 2004).

Other issues that are often discussed in relation to instructional technology integration are whether or not these technologies are using some pedagogical and/or learning theory principles (Ahola-Sidaway & McKinnon, 1999; Grasha & Yangarber-Hicks, 2000).

In the following section we look at existing definitions of learning styles provided by different theorists.

2.2 Learning styles

People perceive and acquire knowledge in different ways, have ideas and think in different ways and act differently. Moreover, people have preferences to certain cognitive strategies that help them give meaning to new information. The term learning style refers to those who preferred strategies are, more specifically, ways to collect, interpret, organize and think about new information (Gentry & Helgesen, 1999).

2.2.1 Definitions of learning styles

One of the oldest learning styles definitions according to Keefe (1979) is a composition of cognitive characteristics, affection and psychological factors that serve as standard indicators of how a student perceives, interacts and responses to the learning environment. At the same time, Gregorc (1979) proposes them as distinctive behaviours that serve as indicators of how a person learns and adjusts to his/her environment; immediately, Kolb (1981) defines them as preferences of an adjustment method above others, but this preference do not exclude the other methods, and can vary from one situation to another; a bit later, Honey and Mumford (1992) exhibit the definition as a description of behaviors and attitudes that determine individual learning preferences; Vermunt (1996) explains that they are a consistent group of learning activities that students tend to employ, in the orientation and mental learning model (See Table 2.1).

In most cases the cognitive terms styles and learning styles are used indifferently by some theorists but there is still a difference between them, cognitive styles mostly refer to cognitive activities (talk, think, perceive and remember), not its content. In general cognitive styles are more theoretical, in relation to academic investigation meanwhile learning styles are more related to practical applications (Liu & Ginther, 1999). According to Riding and Cheema (1991) the learning styles are better known as an extension of cognitive styles to distinguish the act of learning from the simply treatment of information.

However, there is a distinction missing between the styles and the capacities. According to Sternberg (1999) capacity refers to how good someone can do something. Style refers to how someone likes something. Therefore, a style is the preferred way of using one's abilities; we do not have a style, but a profile of styles.

In this dissertation the definition of learning style we take as a base is, according to Felder y Silverman (1988), the characteristics, strengths, and preferences in the way people takes and process information, that is to say, it refers to the fact that each person has its own method and group of strategies while learning.

Year	Author	Learning Style Definition
1979	Keefe	Is a composition of cognitive characteristics, affection and psychological factors that serve as standard indicators of how a student perceives, interacts and responses to the learning environment.
1979	Gregorc	Distinctive behaviors that serve as indicators of how a person learns and adjusts to his/her environment.
1981	Kolb	Preferences of an adjustment method above others, but this preference do not exclude the other methods, and can vary from one situation to another.
1988	Felder & Slverman	The characteristics, strengths, and preferences in the way people takes and process information, that is to say, it refers to the fact that each person has its own method and group of strategies at the time of learning.
1991	Riding & Cheema	An extension of cognitive styles for distinguishing the act of learning from the simply treatment of information.
1992	Honey & Mumford	A description of behaviors and attitudes that determine individual learning preferences.
1992	Dunn	The way each learner begins to concentrate, process, and retain new and difficult information
1996	Vermunt	They are a consistent group of learning activities that students tend to employ, in the orientation and mental learning model.
1999	Sternberg	Style is the preferred way of using one's abilities; we do not have a style, but a profile of styles.

Table 2-1 Learning styles definitions

2.2.2 Overview of learning styles models

As a basis for our review we took the latest major report on learning styles theory provided by a team from Newcastle University, UK in 2004 (Coffield et al., 2004). The report states that Mitchell (Mitchell, 1994) claimed there were over 100 learning style models. However Coffield et al. found only 71 of them worth consideration. This report reviews the most influential and potentially influential models and instruments of learning styles and their accompanying literatures with a particular focus on validity, reliability and practical application. The main models chosen for detailed study are as follows:

- Allinson and Hayes' Cognitive Styles Index (CSI)
- Apter's Motivational Style Profile (MSP)
- Dunn and Dunn model and instruments of learning styles
- Entwistle's Approaches and Study Skills Inventory for Students (ASSIST)
- Gregorc's Mind Styles Model and Style Delineator (GSD)
- Herrmann's Brain Dominance Instrument (HBDI)
- Honey and Mumford's Learning Styles Questionnaire (LSQ)
- Jackson's Learning Styles Profiler (LSP)
- Kolb's Learning Style Inventory (LSI)
- Myers-Briggs Type Indicator (MBTI)
- Riding's Cognitive Styles Analysis (CSA)
- Sternberg's Thinking Styles Inventory (TSI)
- Vermunt's Inventory of Learning Styles (ILS).

Coffield organizes them in learning style families (see Figure 2-1), the one we will address in this article is the learning styles flexibly stable learning preferences, and for our specific purpose we will only explain the ones that have been underlined (see Figure 2-1), (Quoted from (Coffield et al., 2004)):

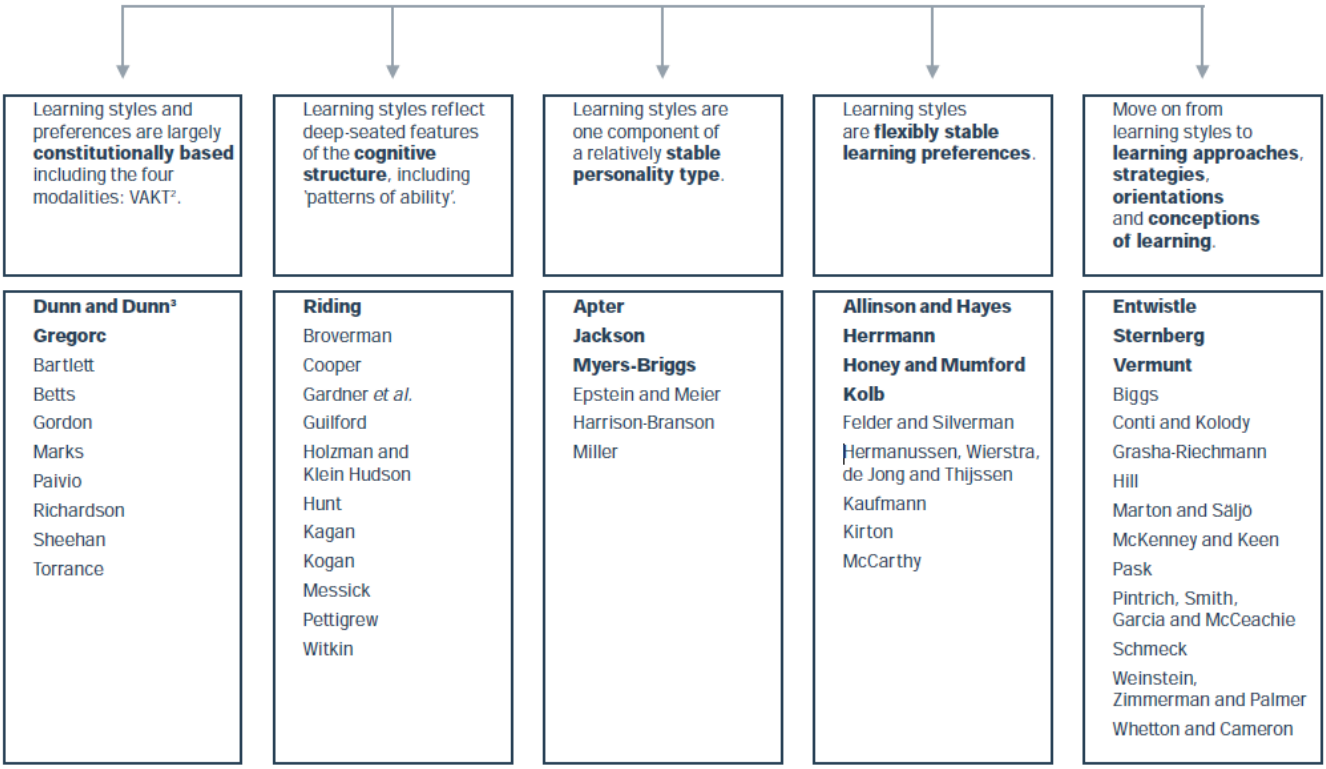


Figure 2-1 Learning style family according to Coffield et al.

Figure 2-2 Learning style family used

In this group, Coffield's report places the models where authors consider that learning style is not a fixed trait, but "a differential preference for learning, which changes slightly from situation to situation. At the same time, there is some long-term stability

in learning style" (Kolb, 2000). This model of learning styles classifies students according to a scale that reflects the way they receive and process information. While there is a number of learning style assessment tools and methodologies (Coffield et al., 2004), two similar assessment instruments are predominant in science and engineering education Kolb's Learning Styles Inventory (LSI) (Kolb, 1984) and the Soloman – Felder Index of Learning Styles (ILS) (Felder & Soloman, 1993).

We present here Kolb's Learning Style Inventory (LSI), Honey and Mumford's Learning Styles Questionnaire (LSQ) and the Felder-Silverman model.

2.2.3 Kolb's learning style inventory

Kolb´s model is one of the most influential learning style models. It was developed by David Kolb at the early 70s. The Kolb's model supposes that in order to learn something we must work or process the information that we receive. Kolb says that, on the one hand, we can start: a) of a direct experience and it makes specific: active student or b) of an abstract experience, that is the one that we have when we read about something or when somebody tell us: theoretical student.

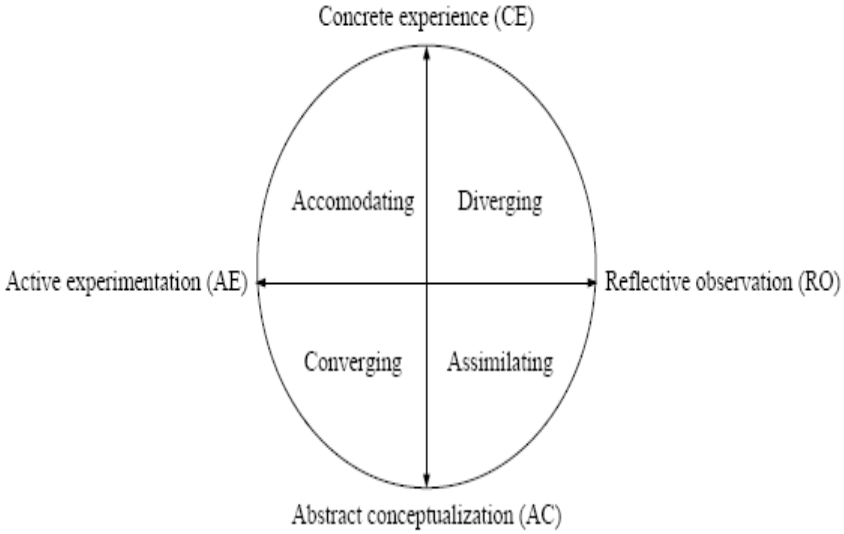
The experiences that we have, concrete or abstract, are transformed into knowledge when we elaborated them by some of these two forms: a) reflecting and thinking about them: reflective student or b) experimenting of active form with the received information: pragmatic student. (see Figure 2-3)

According to Kolb (1984) "learning is the process by which knowledge is created through experience transformation. Knowledge derives from the combination of getting experience and transforming it". He proposes that experiential learning has six characteristical features:

1. Learning is best conceived as a process, not in terms of outcomes.
2. Learning is a continuous process grounded in experience.
3. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. For Kolb, learning is, by its very nature, full of tension, because new knowledge is constructed by learners choosing the particular type of abilities they need. Effective learners need four kinds of abilities to learn: from concrete experiences (CE); from reflective observations (RO); from abstract conceptualizations (AC); and from active experimentations (AE). These four capacities are structures along two independent axes as shown in Figure 2-3, with the concrete experiencing of events at one end of the first axis and abstract conceptualization at the other. The second axis has active experimentation at one end and reflective observation at the other. Conflicts

are solved by choosing one of these adaptive modes, and over time, we develop preferred ways of choosing.

4. Learning is a holistic process of adaptation to the world.
5. Learning involves transactions between the person and the environment.
6. Learning is the process of creating knowledge: '(which) is the result of the transaction between social knowledge and personal knowledge' (Coffield et al., 2004).



The basic principle of his theory of experimental learning is the learning cycle that includes the following forms of learning:

- Concrete experience
- (EC | feeling),
- Abstract Conceptualization
- (AC | thinking),
- Active experimentation
- (AE | making)
- Reflective observation
- (RO | observing).

Figure 2-3 Learning style model according to Kolb

Kolb (1984) describes the four learning modes as follows:

Concrete experience (EC) is real life experiences that are external to the learner.

Abstract conceptualization (AC) is the process whereby an individual internalizes new ideas in the process of creating new theories.

Active experimentation (AE) is external to an individual as he/she puts the theories and ideas into practice.

Reflective observation (RO) is an individual's internal reflection of the relevance of an actual event and how it is important and applies to their lives.

Kolb (1984) posits that in different learning situations, individuals often use different combinations of learning modes; hence, no one learning mode clearly identifies an individual's learning style. The combination of learning modes are used to establish four quadrants reflecting four learning styles: Accommodator, Diverger, Assimilator, and Converger. Kolb describes the association between the learning modes and the learning styles as follows:

Convergent learning style moves in cycles in which theory is moved into practice and back again.

Divergent learning style focuses on action and reflection whereby the individual ponders the relevance of real life experiences.

Assimilative learning style uses theorization and logic to convert observations into knowledge constructs.

Accommodation learning style relies on practicality whereby an individual focuses on moving into action.

During the learning process the student goes through every phase. For instance, first the student gets familiar with the concrete situation, accumulates experience (CE), this leads to observation and reflection (RO), later on he tries to build abstract concepts (AC), with which the person can actively experiment (AE), finally this result allows the creation of new experiences and the cycle repeats itself.

The learning style inventory (LSI)

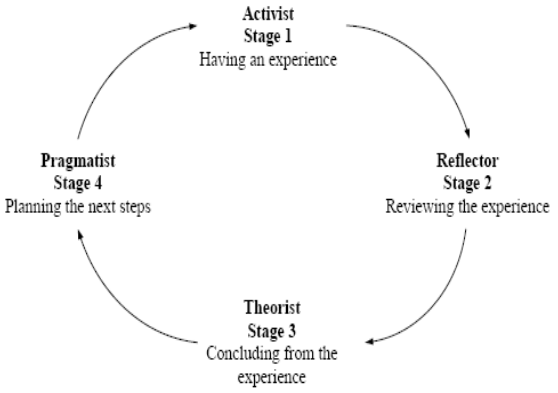
The first version of the LSI appeared in 1976, the second in 1985, and the third in 1999 (following an experimental version in 1993). The 1999 inventory uses a forced-choice ranking method to assess an individual's preferred modes of learning (AC, CE, AE and RO) and is described by Mainemelis, Boyatzis and Kolb (2000) in the following way (Quoted from (Coffield et al., 2004)): Individuals are asked to complete 12 sentences that describe learning. Each sentence (e.g. 'I learn best from') has four endings (e.g. AC = 'rational theories', CE = 'personal relationships', AE = 'a chance to try out and practice', and RO = 'observation'). Individuals rank the endings for each sentence according to what best describes the way they learn (i.e. '4 = most like you', '1 = least like you'). Four scores, AC, CE, AE and RO, measure an individual's preference for the four modes, and two dimensional scores indicate an individual's relative preference for one pole or the other of the two dialectics, conceptualizing/experiencing (AC–CE) and acting/reflecting (AE-RO).

Within each pair, individuals tend to prefer one mode more than the other, and they tend to use that mode most often since it typically comes more easily to them.

Further support is provided by Sein and Robey (1991) who administered Kolb's LSI to 80 undergraduate computer students in the US and then assigned them randomly to one of two different training methods. The results appear to indicate that 'performance can be enhanced by tailoring instructional methods to accommodate individual preferences in learning style'.

2.2.4 Honey and Mumford's learning styles questionnaire

Peter Honey and Alan Mumford developed their model of learning styles in 1982 based on Kolb´s theory (Honey & Mumford, 2000). The links with Kolb's work remain strong, however, because the four learning styles are connected to a revised version of Kolb's experiential learning cycle. So, for example, activists are said to have a predilection for experiencing; reflectors for reviewing experiences or mulling over data; theorists for drawing conclusions; and pragmatists for planning the next steps (see Figure 2-4). Honey and Mumford's intention is that learners should become proficient in all four stages of the learning cycle. Honey and Mumford (1992) define a learning style as being 'a description of the attitudes and behavior which determine an individual's preferred way of learning'. Honey and Mumford use different terms for the learning styles classification and refer to them with four stages. (See Figure 2-4)



Learning Style Stages:

- Stage 1: Active style

While having and experience, I like doing something and want what happens.

- Stage 2: Reflective style

Experience examination, I like to gather information and reflect about things.

- Stage 3: Theoretical style.

Concluding an experience, I like to order and achieve some conclusions.

- Stage 4: Pragmatic style.

Planning of the next steps, I like to try and proof theories that are important for my questions.

Figure 2-4 Learning style model according to Honey and Mumford

The four learning styles are described as those of activists, reflectors, theorists and pragmatists and the following lists in Table 2-2 give a brief summary of the strengths of each style.

Activists	Reflectors	Theorists	Pragmatists
•Flexible and open-minded •Ready to take action •Like to be exposed to new situations •Optimistic about anything new and •therefore unlikely to resist change	•Careful •Thorough and methodical •Thoughtful •Good at listening to others and •assimilating information •Rarely jump to conclusions	•Logical, 'vertical' thinkers •Rational and objective •Good at asking probing questions •Disciplined approach •Grasp of the 'big picture'	•Eager to test things out in practice •Practical, down to earth, realistic •Businesslike – get straight to the point •Technique-oriented

Table 2-2 Strengths Source: Honey and Mumford (2000)

When it comes to matching learning activities with learning style preferences, Honey and Mumford claim (2000) that: 'Our research into a number of different training methods showed the following positive correlations'. Unfortunately, what follows is not a set of correlations, but a list of activities which match each of the four learning styles, a list which is reproduced above(Quoted from (Coffield et al., 2004)) in Figure 2-3.

Activists react positively to:	■ Action learning ■ Business game simulations	■ Job rotation ■ Discussion in small groups	■ Role playing ■ Training others ■ Outdoor activities
Reflectors react positively to:	■ E-learning ■ Learning reviews	■ Listening to lectures or presentations ■ Observing role plays	■ Reading ■ Self-study/self-directed learning
Theorists react positively to:	■ Analytical reviewing ■ Exercises with a right answer	■ Listening to lectures ■ Self-study/self-directed learning	■ Solo exercises ■ Watching 'talking head' videos
Pragmatists react positively to:	■ Action learning ■ Discussion about work problems in the organisation	■ Discussion in small groups ■ Problem-solving workshops	■ Group work with tasks where learning is applied ■ Project work

Table 2-3 Activities and preferences Source: Honey and Mumford (2000)

Honey and Mumford (Honey & Mumford, 2000) mention that "no single style has an overwhelming advantage over any other. Each has strengths and weaknesses but the strengths may be especially important in one situation, but not in another". They make it clear that they produced their own Learning Styles Questionnaire (LSQ) because they found that Kolb's LSI was not efficient for the managers with whom they worked. Instead of asking people directly how they learn, as Kolb's LSI does - something which most people have never consciously considered - Honey and Mumford give them a questionnaire which probes general behavioral tendencies rather than learning (Coffield et al., 2004). Both Kolb and Honey and Mumford models are widely known in the LS field and are used extensively in the UK (Coffield et al., 2004).

2.2.5 Felder and Silverman's index of learning styles

Felder and Silverman first introduced their model in 1988 (Felder & Silverman, 1988), but it has been upgraded since that date.

This model classifies a student learning style with a five-grade scale. Each learning style can be defined if the next five questions are answered.

What kind of information the student most favorably perceives: sensitive (external) places, sounds, physical sensations or intuition (internal) possibilities, ideas, hunches?

Through which sensitive channel do students perceive information a more effective way: visual (images, diagrams, graphs) or verbal (words, sounds)?

With what kind of information structure does the student rather work with: inductive, deductive?

How does the student process information: an active way as through physical activity or discussions, or a reflective way as through introspection?

How does the student enhance his/her learning: sequentially through continuous steps or globally with big leaps and an integrated vision?

Tables 2-4, 2-5, 2-6, 2-7, 2-8 shows the dimensions of the learning styles obtained through the previous questions.

Dimension	Types	Description
What type of information does the student prefer in order to perceive: Sensitive / external (sights, sounds, physical sensations), or intuitive/internal (possibilities, insights, hunches)?		
Perception	**Sensitive**	Sensitive students prefer empirical facts, data, practical procedures and experimentation. They are patient with details, but don't like complications.
	Intuitive	Intuitive students prefer conceptual meanings, principles and theories; they get bored with details and accept complications.

Table 2-4 Felder and Silverman's perception dimension

Dimension	Types	Description
Through which sensory channel is external information most effectively perceived: visual (pictures, diagrams, graphs, demonstrations), or Verbal (words, sounds)?		
Input	**Visual**	For the visual learners it is easy to remember the things they see: diagrams, timelines, films, demonstrations and usually prefer multimedia and simulations.
	Verbal	Verbal learners remember what they have heard, read or said. They prefer lecture or textbook learning resources.

Table 2-5 Felder and Silverman's input dimension

Dimension	Types	Description
With which information structure is the student more comfortable: inductive (facts and observations are given, underlying principles are inferred), or deductive (principles are given, consequences and applications are deduced)?		
Organization	**Inductive**	Inductive learners prefer information that proceeds from particularities to generalities (Garcia et al., 2005:1-15).
	Deductive	Deductive learners' information that proceeds from generalities to particularities.

Table 2-6 Felder and Silverman's organization dimension

Dimension	Types	Description
How does the student prefer to process information: actively (through engagement in physical activity or discussion), or reflectively (through introspection)?		
Processing	**Active**	Active learners learn better when they work in groups and manipulate things, first-hand experimentation and social interaction.
	Reflective	Reflective learners learn better when they can think and reflect about the information that is presented to them and they work better alone, a predisposition for learning by thinking through the process and examining ideas mentally.

Table 2-7 Felder and Silverman's processing dimension

Dimension	Types	Description
How does the student progress towards understanding: sequentially (in continual steps), or globally (in large jumps, holistically)?		
Understanding	**Sequential**	Sequential learners follow a linear reasoning process when they solve problems. They can work with a certain material once they have understood it partially or superficially. They prefer learning in a series of steps leading to broader understanding.
	Global	Global learners make intuitive leaps with the information. They can have difficulties when they try to explain how they got a solution, and they need an integral vision. They prefer o work from larger frameworks and fill in gaps; they learn by starting with broad trends and patterns and fitting individual pieces of knowledge into the structure.

Table 2-8 Felder and Silverman's understanding dimensions

On 2002 the author, Felder, introduced the following changes in his model: disappearance of inductive/deductive dimension, because of pedagogical reasons and the change of the visual/auditory dimension to visual/verbal, because verbal dimension can comprise the written and spoken words, which was confusing in the previous name.

For this dissertation the changes will be taken into account, and we will only use four of the five dimensions. Perception (Sensitive, Intuitive), Input (Visual, Verbal), Processing (Active, Reflective), Understanding (Sequential, Global).

The Index of Learning Styles (ILS) is the tool that Felder and Soloman (1993) uses to evaluate a student's learning style. It consists of 44 questions with two possible answers ('a' or 'b'). The intensity of a dimension can vary from 1 to 11. This is because each dimension has 11 questions. The organization dimension cannot be measured through this type of question. Therefore the test has 44 questions in total (Felder & Soloman, 1993). What follows is a set of strategies for helping students that answer ILS, a list which is reproduced below (Quoted from (Felder & Soloman, 1993)).

Active and reflective learners

Active learners tend to retain and understand information best by doing something active with it, discussing it, applying it or explaining it to others. Reflective learners prefer to think about it quietly first. "Let's try it out and see how it works" is an active learner's phrase; "Let's think it through first" is the reflective learner's response. Active learners tend to like group work more than reflective learners, who prefer working alone. Sitting through lectures without getting to do anything physical but take notes is hard for both learning types, but particularly hard for active learners.

Everybody is active sometimes and reflective sometimes. Your preference for one category or the other may be strong, moderate, or mild. A balance of the two is desirable. If you always act before reflecting you can jump into things prematurely and get into trouble, while if you spend too much time reflecting you may never get anything done.

How can active learners help themselves? If you are an active learner in a class that allows little or no class time for discussion or problem-solving activities, you should try to compensate for these lacks when you study. Study in a group in which the members take turns explaining different topics to each other. Work with others to guess what you will be asked on the next test and figure out how you will answer. You will always retain information better if you find ways to do something with it.

How can reflective learners help themselves? If you are a reflective learner in a class that allows little or no class time for thinking about new information, you should try to compensate for this lack when you study. Don't simply read or memorize the material;

stop periodically to review what you have read and to think of possible questions or applications. You might find it helpful to write short summaries of readings or class notes in your own words. Doing so may take extra time but will enable you to retain the material more effectively.

Sensing and intuitive learners

Sensing learners tend to like learning facts; intuitive learners often prefer discovering possibilities and relationships. Sensors often like solving problems by well-established methods and dislike complications and surprises; intuitors like innovation and dislike repetition. Sensors are more likely than intuitors to resent being tested on material that has not been explicitly covered in class.

Sensors tend to be patient with details and good at memorizing facts and doing hands-on (laboratory) work; intuitors may be better at grasping new concepts and are often more comfortable than sensors with abstractions and mathematical formulations. Sensors tend to be more practical and careful than intuitors; intuitors tend to work faster and to be more innovative than sensors. Sensors don't like courses that have no apparent connection to the real world; intuitors don't like "plug-and-chug" courses that involve a lot of memorization and routine calculations.

Everybody is sensing sometimes and intuitive sometimes. Your preference for one or the other may be strong, moderate, or mild. To be effective as a learner and problem solver, you need to be able to function both ways. If you overemphasize intuition, you may miss important details or make careless mistakes in calculations or hands-on work; if you overemphasize sensing, you may rely too much on memorization and familiar methods and not concentrate enough on understanding and innovative thinking.

How can sensing learners help themselves? Sensors remember and understand information best if they can see how it connects to the real world. If you are in a class where most of the material is abstract and theoretical, you may have difficulty. Ask your instructor for specific examples of concepts and procedures, and find out how the concepts apply in practice. If the teacher does not provide enough specifics, try to find some in your course text or other references or by brainstorming with friends or classmates.

How can intuitive learners help themselves? Many college lecture classes are aimed at intuitors. However, if you are an intuitor and you happen to be in a class that deals primarily with memorization and rote substitution in formulas, you may have trouble with boredom. Ask your instructor for interpretations or theories that link the facts, or try to find the connections yourself. You may also be prone to careless mistakes on test because you are impatient with details and don't like repetition (as in checking

your completed solutions). Take time to read the entire question before you start answering and be sure to check your results

Visual and verbal learners

Visual learners remember best what they see - pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words - written and spoken explanations. Everyone learns more when information is presented both visually and verbally.

In most college classes very little visual information is presented: students mainly listen to lectures and read material written on chalkboards and in textbooks and handouts. Unfortunately, most people are visual learners, which mean that most students do not get nearly as much as they would if more visual presentation were used in class. Good learners are capable of processing information presented either visually or verbally.

How can visual learners help themselves? If you are a visual learner, try to find diagrams, sketches, schematics, photographs, flow charts, or any other visual representation of course material that is predominantly verbal. Ask your instructor, consult reference books, and see if any videotapes or CD-ROM displays of the course material are available. Prepare a concept map by listing key points, enclosing them in boxes or circles, and drawing lines with arrows between concepts to show connections. Color-code your notes with a highlighter so that everything relating to one topic is the same color.

How can verbal learners help themselves? Write summaries or outlines of course material in your own words. Working in groups can be particularly effective: you gain understanding of material by hearing classmates' explanations and you learn even more when you do the explaining.

Sequential and global learners

Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it." Sequential learners tend to follow logical stepwise paths in finding solutions; global learners may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture, but they may have difficulty explaining how they did it.

Many people who read this description may conclude incorrectly that they are global, since everyone has experienced bewilderment followed by a sudden flash of understanding. What makes you global or not is what happens before the light bulb

goes on. Sequential learners may not fully understand the material but they can nevertheless do something with it (like solve the homework problems or pass the test) since the pieces they have absorbed are logically connected. Strongly global learners who lack good sequential thinking abilities, on the other hand, may have serious difficulties until they have the big picture. Even after they have it, they may be fuzzy about the details of the subject, while sequential learners may know a lot about specific aspects of a subject but may have trouble relating them to different aspects of the same subject or to different subjects.

How can sequential learners help themselves? Most college courses are taught in a sequential manner. However, if you are a sequential learner and you have an instructor who jumps around from topic to topic or skips steps, you may have difficulty following and remembering. Ask the instructor to fill in the skipped steps, or fill them in yourself by consulting references. When you are studying, take the time to outline the lecture material for yourself in logical order. In the long run doing so will save you time. You might also try to strengthen your global thinking skills by relating each new topic you study to things you already know. The more you can do so, the deeper your understanding of the topic is likely to be.

How can global learners help themselves? If you are a global learner, it can be helpful for you to realize that you need the big picture of a subject before you can master details. If your instructor plunges directly into new topics without bothering to explain how they relate to what you already know, it can cause problems for you. Fortunately, there are steps you can take that may help you get the big picture more rapidly. Before you begin to study the first section of a chapter in a text, skim through the entire chapter to get an overview. Doing so may be time-consuming initially but it may save you from going over and over individual parts later. Instead of spending a short time on every subject every night, you might find it more productive to immerse yourself in individual subjects for large blocks. Try to relate the subject to things you already know, either by asking the instructor to help you see connections or by consulting references. Above all, don't lose faith in yourself; you will eventually understand the new material and, once you do, your understanding of how it connects to other topics and disciplines may enable you to apply it in ways that most sequential thinkers would never dream of.

2.3 Teaching strategies and teaching styles

Institutions of higher learning across the nation are responding to political, economic, social and technological pressures to be more responsive to students' needs and more concerned about how well students are prepared to assume future societal roles.

Faculty are already feeling the pressure to lecture less, to make learning environments more interactive, to integrate technology into the learning experience, and to use collaborative learning strategies when appropriate.

One of the most popular recommendations from psychologists is that the learning styles of the students should be linked to the teaching style of the tutor, the so-called “matching hypothesis". From the first glance it seems logical that this would increase the learner's performance. Felder (1993) mentions that mismatching can lead to serious consequences. Students can feel “as though they are being addressed in an unfamiliar foreign language” (Felder, 1993). They tend to get lower grades than students whose learning styles are better matched to the instructor's teaching style and are less likely to develop an interest in the course material". This is especially worrying if the mismatches are extreme. Felder complains about the negative outcomes of unintentional mismatching where, for instance, teachers are unaware of their own learning style and may, as a result teach only in that style, thus favoring certain students and disadvantaging others (Coffield et al., 2004).

Considering that pedagogy includes teaching and learning strategies, I will provide a definition of both: Learning strategies are the strategies used to remember, learn and use information. In this case, responsibility relies on the student (comprehension and text writing, problem solving, etc.). Students go through a process where they recognize the new knowledge, review previous concepts, organize and restore that previous knowledge, match it with the new one, assimilate it and interpret everything that was seen on the subject.

Teaching strategy refers to an organized and systematized sequence of activities and resources that teachers use while teaching. The main objective is to facilitate students´ learning (Rose, 1998). Teaching strategies are the elements given to the students by the teachers to facilitate a deeper understanding of the information. The emphasis relies on the design, programming, elaboration and accomplishment of the learning content. Teaching strategies must be designed in a way that students are encouraged to observe, analyze, express an opinion, create a hypothesis, look for a solution and discover knowledge by themselves. Among the different activities, we can mention the method, which is the way of developing the learning process, and among the resources, we can find the means or characteristics. One crucial component of our research is the integration of electronic media, because of the informational technology breakthroughs that allow us to use a variety of them. On the other hand, we need to link such teaching strategies with the concept of learning styles, something that hasn’t been exploited to the extent that is intended here. In this sense, some of the previous studies worth mentioning are for example those of Dunn (Dunn, 1988), whom insists on the importance of teaching the students by using methods that adapt

to their conceptual preferences. Or Cabrero et al. (2006), whom also points out how the applied teaching strategies will take effect on the teaching quality, not only from an individual point of view, but also on the collaboration of the group as a whole.

This study used Teaching Styles Inventory (TSI) an instrument created by the Texas Higher Education Coordinating Board from 2002 to 2007 and it was designed by Center for Occupational Research and Development (CORD) to gauge the teaching preferences and styles, the Collaborative was created to support faculty at two-year colleges across Texas through a collegial, cooperative approach to professional development. The TSI instrument is conveniently available on internet. The scores will provide insight into your affective learning goals for students and the teaching methods that you use to support your goals. The instrument has been constructed using a forced choice technique similar to that used in the Meyers-Briggs Type Indicator and in Kolb's Learning Style Inventory and uses four scales for measuring your preferred teaching styles:

Learning—varies from Rote to Understanding
Concept Representation—varies from Abstract to Applied
Cognitive Processing—varies from Enactive to Symbolic
Interaction—varies from Individual to Cooperative Groups

The scores should provide food for thought regarding the type of students you may be best suited to teach based upon your style of teaching, or ways in which you may want to alter your style of teaching based upon the kinds of students you have in your classroom. There is no right or wrong answer; there are 12 items, each of which contains four statements about ways you might respond in your teaching, through the way you might behave, think, or feel. The answer has to be ranked at 4(Maximum) to 1 to reflect how well they describe the way you teach.

There are nine teaching strategies analyzed in this dissertation, the description for each one are:

Games and simulations: A learning event in which an educator and/or learner models or simulates a natural or physical phenomenon.

Learning based on problem solving: Occurs when learners work to determine the solution to a question raised for inquiry.

Role playing: The deliberate acting out of a role (possibly a role that one would not normally occupy), as part of group therapy or of a learning session directed towards understanding that role or the situations with which this occupants have to cope.

Presentation: Typically refers to when a student explains or shows some content to a learning audience; similar to a lecture.

Discussion panel: Oral, and sometimes written, exchange of opinions—usually to analyze, clarify, or reach conclusions about issues, questions, or problems.

Brainstorming: A learning event in which a group of learners spontaneously contribute ideas.

Case study: An intensive analysis of an individual unit stressing developmental factors in relation to environment.

Question and answer method: A learning event in which learners interview or survey others about a particular topic.

Project design method: A learning event in which learners solve a real problem step by step.

2.4 e-learning tools

In every teaching process the means play an important role, in traditional classrooms' we find teachers using the blackboard and books. The importance in this matter is that the means regulate and condition the rest of the curricular components establishment, as in objectives, content, strategy, activities, etc., and at the same time this components allow the selection of the right means that make possible its definition and reach.

The midpoint can be seen in different ways. The most common interpretation of means is as an information transmitter, thus for Rossi and Biddle (1970) a mean is "any device and equipment that is formally used to transmit information between people", another perspective according to Area (2003) is the distinction of the means as communication channels trough which different curricular agents are related (designers-teachers, teachers-students, students-students, teachers-teachers) conditioning the pattern of communicative flows in the classroom. Sometimes the term "mean" is confused with the term "resource". It is considered that teaching means have their own use technique; however, the use of a teaching resource depends on the originality of the user, thus for example, the text book is a mean and the Internet is an educative resource because it was not created with a teaching intention, Marqués (2002) makes a distinction between both concepts "Teaching mean is any material made with the intention to facilitate the educative and learning processes. For example a text book or a multimedia program that allows making chemical formulation. Educative refers to any material that, in a determined educational context, is used with a teaching purpose or to facilitate the formative activities development". In actual classrooms we find diverse objects used like educative resources that enhance the learning potential, for example, computers, recording machines, DVD players, among others, are used by many educators to design

activities where, for instance, students watch a movie and then discuss its main and secondary ideas, what makes us agree with González (1999) to whom mean or resource is the instrument of representation, facilitation or approach to reality". With the passing of time, these definitions have varied subtly in spite of being written based on their elements. From Salomón (1979) to Escudero (1983) the context in which they are elaborated or used with instructive intentions, is taken into account, Alonso and Gallego (1993) and Cabero (1999) explicitly consider them curricular elements (but they do not differentiate them from the rest of the curricular elements: contents, objectives, activities, etc.), they take the context into account and also their usage gold: Contributing to the improvement of the educative and learning processes, concept that González (1999), Marqués (2002) and Area (2003) reinforce as supports, transmitting information materials that facilitate those processes. (See Table 2-9).

Year	Author	Mean definition	Purpose – (perspective)
1970	Rossi & Biddle	"Any device and equipment that is used formally to transmit information between people".	Instrumental, communicative or informative. As supports, transmitting information materials
1979	Salomón	"The result of the interaction of three elements: the symbolic system, the message and the transmission technology".	Relation with its constituent elements
1983	Escudero	"Any object or technological resource that articulates in certain symbol systems, messages according to their operation in educative contexts"	Mean = Technological resource Relation to its constituent elements (symbols, messages) Correspondence with educative contexts (teaching purposes)
1993	Alonso & Gallego	"The instruments, equipment or materials, conceived as mediating curricular elements of the direct expression, that articulate certain messages in a determined symbol system and pursue the optimization of the teaching-learning process".	Mediator Curricular dependence Relation to its constituent elements (symbols, messages) Correspondence with the teaching-learning process
1999	Cabero	"Curricular elements that , due to their symbolic systems and usage	Instrumental, communicative or informative. As support,

		strategies cause the development of cognitive abilities on subjects, in a precise context, helping and stimulating the mediated intervention on reality, the comprehension of the information on behalf of the student and the creation of differentiated environments that facilitate learning"	transmitting information materials Curricular dependence Relation to its constituent elements (symbols, usage strategies) Cognitive abilities development Specific atmosphere that facilitates learning.
1999	González	"A resource or mean is the instrument of representation, assistance or approach to reality".	Mean = Resource Instrumental, communicative or informative. As support, transmitting information materials
2002	Marqués	"Teaching mean is any material made with the intention to facilitate the educative and learning processes. For example a text book or a multimedia program that allows making chemical formulation. Educative refers to any material that, in a determined educational context, is used with a teaching purpose or to facilitate the formative activities development. The educative resources that can be used in a teaching and learning situation can be or not teaching means."	Mean ≠ Resource Teaching - learning process facilitator.
2003	Area	"Communication channels through which the different curricular agents are related (designers-teachers, teachers-students, students-students, teachers-teachers) conditioning the communicative flow pattern in the classroom".	Instrumental, communicative or informative. As support, transmitting information materials Curricular dependence

Table 2-9 Mean and Purpose definitions

In this dissertation our definition of mean is “any material made with the intention to support, transmit and/or facilitate teaching – learning processes having or not a teaching purpose, for it we won’t make a difference between mean and resource, in addition, in order to give a solution for the raised challenges we will only take care of electronic means, therefore, the definition of electronic mean in the learning context is “any electronic device that supports, transmits and/or facilitates teaching – learning processes with a teaching purpose”.

Emerging e-learning tools have the potential to enrich academic environments. The adoption level of emerging e-learning tools is on the rise in educational settings (Long, 2006). These tools include instant messengers (IM), social bookmarks, podcasts, vodcasts, blogs, wikis, etc. Several examples can be sighted for incorporating these tools into courses (Farmer & Bartelett-Bragg, 2005; Augar et al. 2004). A review of learning theory suggests that learning styles and preferences influence the effectiveness with which individual learners learn. Therefore, this can help lecturers choose the right methods of instruction for the right audience (Smith & Dalton, 2005; Saeed & Yang, 2008) The web is transforming into a fully interactive space and the control of the content has been decentralized in order to allow everyone to collaborate, create, publish, subscribe and share information (Asmus et al, 2008; Saeed & Yang, 2008). In academic settings, students and teachers alike are achieving many of the benefits of these interactions (Baird & Fisher, 2005). For example, blogs facilitate publication of knowledge, opportunities for subsequent reflection and analysis, and help teachers understand the relational and contextual basis of knowledge (Ferding & Trammell, 2008; Saeed & Yang, 2008). Similarly, wikis facilitate the creation of shared knowledge, dissemination of information, and group interaction (Augar et al. 2004); social bookmarks allow quick and easy access online resources (Asmus et al, 2008); and podcasts provide an innovative way for people to improve communication, collaboration and social networking (Ratchman & Zhang, 2006). All these features are key learning elements and make emerging tools appropriated for educational settings.

Whereas in the students´ daily life the role of technology increases significantly, we, the teachers, hesitate about the integration of electronic media in our classes, therefore, the knowledge of the teachers in relation to means, its design and pedagogical use is very important, as teachers “are essential at the time of initiating any change. Their knowledge and skills are fundamental for the correct operation of a program” (Salinas, 1997). This enrichment of teaching knowledge will allow the teacher to include technological means in his/her planning, which will end up on the practical grounding of that teaching element, and in its time, they will give it

preference above another mean (Barroso & Cabero, 2002), according to the role that it takes in his/her practice and to the bonds he/she establishes with these means.

The e-media analyzed in this dissertation are grouped into eight sections:

Section 1 presents audio media:

***Audio*:** Sound that is capable of being heard

Audioconference: audioconferencing uses audio telecommunications to bring people at different sites together for a meeting. This can be as simple, as a conversation between two people in private offices (point-to-point) or involve several sites (multi-point), with more than one person in large rooms at different sites.

Lectures: a lecture is an oral presentation intended to present information or teach people about a particular subject, for example by a university or college teacher.

Section 2 presents read media:

Digital magazines: digital Magazine is an online magazine intended for professional web designers, web developers and those who practice Information architecture.

Digital newspapers: digital Magazine is an online newspaper intended for professional web designers, web developers and those who practice Information architecture.

eBooks: an e-book (for electronic book: also eBook) is the digital media equivalent of a conventional printed book. Such documents are either read on personal computers, or on dedicated hardware devices known as e-book readers or e-book devices.

Hypertext (web pages): hypertext most often refers to text on a computer that will lead the user to other, related information on demand. Hypertext represents a relatively recent innovation to user interfaces, which overcomes some of the limitations of written text. Rather than remaining static like traditional text, hypertext makes possible a dynamic organization of information through links and connections (called hyperlinks). Hypertext can be designed to perform various tasks; for instance when a user "clicks" on it or "hovers" over it, a bubble with a word definition may appear, a web page on a related subject may load, a video clip may run, or an application may open.

Readings: reading is the cognitive process of deriving meaning from written or printed text

Written text (Documents): a document (noun) is a bounded physical representation of information designed with the capacity (and usually intent) to communicate.

Slideshows: slideshow is a modern concatenation of "Slide Show". A slideshow is a display of a series of chosen images, which is done for artistic or instructional purposes. Slideshows are conducted by a presenter using an apparatus, such as a

carousel slide projector, an overhead projector or in more recent years, a computer running presentation software.

Section 3 presents video media:

Podcast: a podcast is a collection of digital media files which is distributed over the Internet, often using syndication feeds, for playback on portable media players and personal computers. The term, like "radio", can refer either to the content itself or to the method by which it is syndicated; the latter is also termed podcasting. The host or author of a podcast is often called a podcaster. The term "podcast" is a portmanteau of the acronym "Pod" – standing for "Portable on Demand" – and "broadcast". The iPod name was coined with Pod, prefixed with the "i" commonly used by Apple for its products and services. The first podcasting scripts were developed for the iPod (see history of podcasting). These scripts allow podcasts to be automatically transferred to a mobile device after they are downloaded.

Recorded live events: Record live events is a type of video recording system that works by using a digital rather than an analog video signal and recording daily events with a camera, video camera, and camcorder.

Videoconference: videoconferencing uses telecommunications of audio and video to bring people at different sites together for a meeting. This can be as simple as a conversation between two people in private offices (point-to-point) or involve several sites (multi-point) with more than one person in large rooms at different sites. Besides the audio and visual transmission of people, videoconferencing can be used to share documents, computer-displayed information, and whiteboards.

Videos : Video is the technology of electronically capturing, recording, processing, storing, transmitting, and reconstructing a sequence of still images representing scenes in motion. Video technology was first developed for television systems, but has been further developed in many formats to allow for consumer video recording. Video can also be viewed through the Internet as video clips or streaming media clips on computer monitors.

Web seminars (broadcasts): broadcasting is the distribution of audio and/or video signals which transmit programs to an audience. The audience may be the general public or a relatively large sub-audience, such as children or young adults

Section 4 presents diagrams media:

Animations: animation is the rapid display of a sequence of images of 2-D artwork or model positions in order to create an illusion of movement

Graphics: graphics (from Greek γραφικός; see -graphy) are visual presentations on some surface, such as a wall, canvas, computer screen, paper, or stone to brand,

inform, illustrate, or entertain. Examples are photographs, drawings, Line Art, graphs, diagrams, typography, numbers, symbols, geometric designs, maps, engineering drawings, or other images. Graphics often combine text, illustration, and color

Movies: film is a term that encompasses individual motion pictures, the field of film as an art form, and the motion picture industry. Films are produced by recording images from the world with cameras, or by creating images using animation techniques or special effects.

Pictures: in common usage, an image (from Latin imago) or picture is an artifact, usually two-dimensional, that has a similar appearance to some subject—usually a physical object or a person. Images may be two-dimensional, such as a photograph, screen display, and as well as a three-dimensional, such as a statue.

Simulations: a simulation is an imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviors of a selected physical or abstract system.

Section 5 presents search media:

Internet research: internet research is the practice of using the Internet, especially the World Wide Web, for research

Section 6 presents collaboration media:

Forums: an Internet forum is a web application for holding discussions and posting user generated content. Internet forums are also commonly referred to as Web forums, message boards, discussion boards, (electronic) discussion groups, discussion forums, bulletin boards, fora (the Latin plural) or simply forums. The terms "forum" and "board" may refer to the entire community or to a specific sub-forum dealing with a distinct topic. Messages within these sub-forums are then displayed either in chronological order or as threaded discussions

Online learning communities: an online learning community is a common place on the Internet that addresses the learning needs of its members through proactive and collaborative partnerships. Through social networking and computer-mediated communication, people work as a community to achieve a shared learning objective. Learning objectives may be proposed by an instructor or may arise out of discussions between participants that reflect personal interests. In an online community, people communicate via textual discussion (synchronous or asynchronous), audio, video, or other Internet-supported devices.

Webblog or blog: a blog (a portmanteau of web log) is a website where entries are commonly displayed in reverse chronological order. "Blog" can also be used as a verb, meaning to maintain or add content to a blog. Many blogs provide commentary or

news on a particular subject; others function as more personal online diaries. A typical blog combines text, images, and links to other blogs, web pages, and other media related to its topic. The ability for readers to leave comments in an interactive format is an important part of many blogs. Most blogs are primarily textual, although some focus on art (artlog), photographs (photoblog), sketchblog, videos (vlog), music (MP3 blog), audio (podcasting) are part of a wider network of social media. Micro-blogging is another type of blogging which consists of blogs with very short posts.

Wikis: wiki is software that allows users to create, edit, and link web pages easily. Wikis are often used to create collaborative websites and to power community websites. They are being installed by businesses to provide affordable and effective Intranets and for Knowledge Management. Ward Cunningham, developer of the first wiki, WikiWikiWeb, originally described it as "the simplest online database that could possibly work". One of the best known wikis is Wikipedia.

Section 7 presents communication media:

Chat (Messenger): online chat can refer to any kind of communication over Internet, but is primarily meant to refer to direct one-on-one chat or text-based group chat (formally also known as synchronous conferencing), using tools such as instant messaging applications—computer programs, Internet Relay Chat and talkers. Instant messaging (IM) is a form of real-time communication between two or more people based on typed text. The text is conveyed via computers connected over a network such as the Internet

e-mail: e-mail, short for electronic mail and often abbreviated to e-mail, email or simply mail, is a store and forward method of composing, sending, storing, and receiving messages over electronic communication systems

Section 8 presents tutoring media:

Student Response System: a Student Response System (SRS) is a tool used to promote active learning in the classroom. Students respond to questions posed by the instructor using a small handheld keypad that looks like a TV remote control.

Tutorial systems: a tutorial systems is a document, software, or other media created for the purpose of instruction for any of a wide variety of tasks

WebQuest: a WebQuest is a learning activity used by educators. During this activity learners read, analyze, and synthesize information using the World Wide Web.

Course Legacy System: a legacy system is an old computer system or application program which continues to be used because the user (typically an organization) does not want to replace or redesign it

2.5 Summary

In this chapter we provided a review of the learning styles theory. We discussed the most popular and influential LS models:

- Kolb's Learning Style Inventory;
- Honey and Mumford's Learning Style Questionnaire;
- Felder and Silverman's Index of Learning Styles;

We can see from the descriptions of these models that there is much overlap between them. Currently there is no general consensus whether it is reasonable or not to apply learning styles in pedagogy in order to improve the learner's outcome.

However, we consider that first, it is good for the learner to be aware of his/her learning style and to know what his/her strengths and weaknesses are. Second, it is important to provide the learner with a variety of instructional strategies and let him/her choose the one he/she prefers. Third, intentional mismatch may help more advanced learners develop new skills. Coffield's report raises some concerns about the reliability and validity of some of the learning styles instruments (see section 2.2.2). The theory and practice of learning styles provides us with new interesting ideas for our research. It concerns providing a new type of adaptive behavior that can be based on the recommendations from the theory of teaching styles (see section 2.3). We also consider that use e-learning tools can contribute to the psychological research by providing a new media for teach and learn (see section 2.4). We can see from the descriptions of these theories that there is much overlap between them. We consider these similarities to discuss possible implications in educational settings in the following chapters.

Chapter 3

3 Using learning styles to enhance an e-learning system

This chapter[1] investigates the possible ways of representing learning styles in an e-learning system. The questions being addressed in this chapter are: Can the learning material be presented in a way that suits the preferred students' approach of learning? What should the format of learning materials be in order to fit a certain learning style? Is there a relationship between the students' learning styles and the different ways of using the e-learning system? Is it helpful for a student in a course to learn and acquire knowledge using his or her particular learning style? Is there a single way to represent a particular learning style in an e-learning system? Section 3.1 provides the connections between learning styles and e-learning systems. In section 3.2 we investigate how other researchers have incorporated LS into their e-learning systems. It gives examples of existing e-learning systems providing adaptation to learning styles. It also compares our approach with the ones adopted in the presented systems. In section 3.3 we describe the design, design database, implementation of our e-learning system using learning styles. Section 3.4 the evaluation of approach with an experiment with students. Section 3.5 summarizes the chapter and provides an answer to research question 1 of this dissertation.

3.1 Connections between learning styles and e-learning systems

Learning styles have been intensively studied in the classical educational (classroom) settings. In such an environment a teacher is able to identify learners' individual differences in regard to learning styles and thus provide them with individually selected and structured learning material. However, it is much more difficult to provide such interaction with individual learners in an e-learning environment. One of the problems consists of identifying the learner's preferences or learning styles.

Though application of learning styles to an e-learning course design still seems to be problematic, for (some) learning styles outlined in chapter 2 we found several resources with recommendations from psychologists for a possible format of the learning material and the instructional design. We present an overview of learning

[1] *The content of this chapter was presented in 6th European Conference on e-Learning (ECEL 2007)*

styles with their corresponding implications for pedagogy in table 3.1 and provide a more detailed description of instructional strategies here.

A learning style is defined as the characteristics, strengths and preferences in the way people receive and process information (Felder & Silverman, 1988). It refers to the fact that every person has its own method or set of strategies when learning. According to Sewall, there are several theories about learning styles (Sewall, 1986). He did a detailed study of four evaluation instruments: Myers-Briggs Type Indicator, Kolb Learning Style, Inventory, Coffield's Learning Style Inventory and Gregorc's Type Indicator.

The Felder and Silverman model was selected as the base of our e-learning system (Felder & Silverman, 1988) because it has been successfully implemented in previous work when individually adapting the electronic learning material (Carver, et al., 1999; Hong & Kinshuk, 2004;Paredes & Rodriguez, 2002), because it has been approved by its author and other specialists (Zywno 2003; Felder & Spurlin 2005), because it is user friendly and the results are easy to interpret, and because the number of dimensions is controlled and can actually be implemented (Paredes & Rodriguez 2002).

This model rates the student's learning style in a scale of five dimensions. Each learning style can be defined by answering these five questions:

What kind of information does the student tend to receive: sensitive (external agents), places, sounds, physical sensations, or intuitive (internal), possibility, ideas, through hunches?

Through which sensorial channel do the students tend to receive information more effectively: visual (images, diagrams, graphics), or verbal (spoken words, sounds)?

With which information setting do the students prefer to work: inductive or deductive?

How is the information processed: actively, through physical activities and discussions, or reflexively, through introspection?

How does the student make progress: sequentially, with continuous steps, or globally, through leaps and an integral approach.

Table 3.1 shows the learning styles dimensions that resulted from the latter questions:

Dimension	Type	Description
Perception	Sensitive	Rather deal with facts, raw data and experiments, they're patient with details, but don't like complications
	Intuitive	Rather deal with principles and theories, are easily bored when presented with details and tend to accept complications
Entry Channel	Visual	Easy for them to remember what they see: images, diagrams, time tables, films, etc.
	Verbal	Remember what they've heard, read or said.
Organization	Inductive	Rather deal with information that goes from particular instances to general conclusion, it is human's natural way of learning.
	Deductive	Rather deal with information going from general to particular instances
Processing	Active	Learn by working in groups and handling stuff.
	Reflexive	Learn better when they can think and reflect about the information presented to them. Work better alone or with one more person at most.
Understanding	Sequential	Follow a lineal reasoning process when solving problems and can work with a specific material once they've comprehended it partially or superficially.
	Global	Take big intuitive leaps with the information, may have a difficulty when explaining how they got to a certain result, need an integral vision.

Table 3-1 Felder dimensions

In 2002, Felder introduced the following changes to his model: he eliminated the inductive/deductive dimension due to pedagogic reasons, and he also switched the visual/auditory dimension for the visual/verbal dimension because the verbal dimension may include spoken and written words, which was a little confusing for the auditory dimension. In this work, such changes are considered and thus only four of the five dimensions will be used: Perception (Sensitive, Intuitive), Entry Channel (Visual, Verbal), Processing (Active, Reflexive) and Understanding (Sequential, Global).

A model of learning styles classifies students according to a scale that reflects the way they receive and process information. While there is a number of learning style assessment tools and methodologies (Coffield et al., 2004), two similar assessment instruments are predominant in science and engineering education Kolb's Learning Styles Inventory (LSI) (Kolb, 1984) and the Soloman – Felder Index of Learning Styles (ILS). (Felder & Soloman, 1993). Each instrument classifies learning dispositions based on opinion surveys.

Paredes and Rodriguez (2002) propose an adaptation procedure for moderate and strong sensing-intuitive learners, as classified in the Felder-Silverman model. In their approach, a course is described in terms of teaching tasks and knowledge rules. The teaching tasks are represented through exposition tasks, practical activities or examples. Adaptation lies in presenting examples before expositions to moderate and strong sensing learners and the opposite to moderate and strong intuitive learners.

The Dunn and Dunn model describes the following sensory modalities: auditory, visual, tactile and kinesthetic. The visual modality is split in two, indicating preferences for pictures and text. This dimension is correlated with the verbalizer-imager dimension of Riding's model and the verbal-visual dimension of the Felder-Silverman model.

Riding and Rayner (1995) suggest that the teacher should provide written material to the verbalizers and pictorial presentations to the visualizers (such as pictures, diagrams, charts and graphs).

Inductive learners prefer information that proceeds from particularities to generalities (Garcia et al., 2005), and deductive learners information that proceeds from generalities to particularities. The natural learning style for humans is inductive. Studies have proved that most of the engineering students are inductive (Klobas, 2005). In 2002, Felder removed the organizational dimension from his test.

Active learners learn better when they work in groups and manipulate things, whereas reflective learners learn better when they can think and reflect about the information that is presented to them and they work better alone.

Pask's wholists are correlated with the global style of the Dunn and Dunn, Riding and Felder-Silverman models, whereas serialists are correlated with the analytic style of the Dunn and Dunn and Riding's models and the sequential style of Felder-Silverman model. Series of Pask's experiments with wholists and serialists in 1970s showed that material structured in breadth-first order maps well to the strategies adopted by wholists whereas depth-first navigational paths suit serialists.

3.2 Incorporating learning styles in an e-learning system

Several systems which provide adaptation to users' learning styles exist. Table 3-2 presents some of these systems, the learning styles they implement, the methods for

identifying these learning styles and the provided types of adaptation. We discuss these issues in more detail as follow.

Recent investigations (Kwok & Jones, 1985; Carver, et al., 1999; Gilbert & Han 1999; Grigoriadou, Papanikolaou & Kornilakis 2001; Stash & De Bra 2004; Hong & Kinshuk 2004), try to integrate the learning styles in the design of an adaptation of their applications. This is not an easy process, however. One of the main difficulties on the designing of hypermedia systems, is linking the learning styles with the hypermedia applications. Most of the teaching systems adaptation that integrates learning styles is based on the premise that adapting the teaching strategies with the students learning styles will give better results (Dagger, Wade & Conlan 2003; Paredes & Rodriguez 2002; Stern & Woolf 2000; Triantafillou, Pomportsis & Georgia 2002). Table 3-2 shows some of the systems found, their learning styles and the type of adaptation.

System	Learning style	The adaptation Model
ARTHUR (Gilbert & Han 1999)	visual-interactive, auditory-lecture and text styles	The adaptation is achieved by providing different media representations for each learner. Auditory representation is achieved using sounds and streaming audio. To appeal to visual and kinesthetic learners puzzles, animations, drag and drop examples and riddles are used.
CS388 (Carver, Howard & Lane 1999)	Felder-Silverman learning styles model - global-sequential, visual-verbal, sensing-intuitive, inductive-deductive styles	The adaptation is achieved by providing different media representations for each learner. Uses different types of media such as graphs, movies, text, slideshows
MANIC (Stern & Woolf 2000)	applies preferences for graphic versus textual information	The adaptation is achieved by providing different media representations for each learner. Uses graphic and textual information
INSPIRE (Grigoriadou, Papanikolaou & Kornilakis 2001)	Honey and Mumford categorization of activists, pragmatists, reflectors and theorists based on Kolb	The Adaptation lies in presenting a different sequence of alternative contents of the concepts. Concepts can be represented by 'example', 'activity', 'theory', 'exercise'
Tangow (Paredes & Rodriguez 2002)	sensing-intuitive dimension from the Felder-Silverman learning style model	The Adaptation lies in presenting a different sequence of alternative contents of the concepts. Concepts can be represented by 'example', 'exposition'

AEC-ES (Triantafillou, Pomportsis & Georgia 2002)	field-dependent (FD) and field-independent (FI) style	Provides field-dependent learners with navigational support tools, such as concept map, graphic path indicator, advanced organizer, in order to help them organize the structure of the knowledge domain. The system guides them through the learning material via adaptive navigation support. Field-independent learners are provided with a learner control option - for them, the system shows a menu from which they can proceed with the course in any order. Learners can switch between different instructional strategies
PHP Programming Course (Hong & Kinshuk 2004)	Active – Reflective, Sensing – Intuitive, Visual – Verbal, Sequential - Global dimension from the Felder-Silverman learning style model	The adaptation is achieved by providing different representations for each learner. Uses different types of resources such as concepts, theory, colors, text, slideshows, audio, etc.
Algorithms Programming Course (Franzoni & Assar 2007)	Active – Reflective, Sensing – Intuitive, Visual – Verbal, Sequential - Global dimension from the Felder-Silverman learning style model	The adaptation is achieved by providing different representations for each learner. Uses different types of resources

Table 3-2 Learning Styles and Systems Adaptation Models

This review shows that the different adaptation to learning styles systems are made in terms of content adaptation, navigation routes or the use of multiple navigation instruments. However, the election of learning styles seems to be limited, while it is based on the appropriate technology. Also, most of the systems shown, except CS388 and PHP Programming Course, evaluate and adapt to the chosen learning styles dimensions. One disadvantage of CS388 and the PHP Programming Course is that electronic media is limited to graphics, hypertext, audio and video, and that it doesn't integrate teaching strategies. In this dissertation we are trying to address these issues. Based on the previous reviews, in the following section we identify the types of strategies that we foresee as needed in our system, in order to provide adaptation to learning styles. In the next section we show the architecture of e-learning system.

3.3 e-learning system

3.3.1 Introduction

The problem relies on the tutor's ability to adapt itself to the prior knowledge and psychosocial characteristics of a particular student. We must picture this change in terms of integration and complementarity. The teaching principles which support the educational process must offer the necessary space to incorporate "the powerful tools" which technology provides at the service of better ways of teaching and learning. We create environments which support the development of individuals with different skills by using the vast resources offered by IT. For example, impelling intellectual growth and expansion of abilities based on the correct use of electronic media and the teaching-learning methods when learning a new subject. In this chapter, a computer program is provided for instructional aide in whom two educational aspects that have only been partially integrated before are incorporated: computer science and educational psychology (although both of them were previously used in education).

Regarding learning, we find that not everyone learns the same way. Each person has a particular set of learning abilities; thus we can identify the preferences that constitute his or her learning style. Knowing our learning styles helps us both, teachers and students. We can elaborate better teaching-learning strategies in order to allow students to assimilate in an effective and more efficient way new information and knowledge. The understanding of learning styles can be used to identify and implement better teaching and learning strategies (Felder & Soloman, 1993; Coffield et al., 2004). Learning styles have also been shown to have an impact on the effectiveness of online learning (Allert, 2003; Carver et al., 1999).

Nowadays, the use of electronic media in education enhances and supports the learning process. It enhances it because a person can acquire new knowledge in a more flexible and adaptable way than with the traditional method and it supports it by introducing innovative elements that help students reaffirm the subjects studied in class.

The objective of this chapter is to bring together the concept of learning styles and the use of electronic media in education with the aim of providing a system which presents the course material in different ways to the student, based on his or her learning style. In this sense, we think that students should be given the opportunity to learn a subject, or simply to reaffirm the concepts previously studied. That's why it is important to evaluate if the students learn worse, similarly or better with the use of this system. We designed a tool to help students of "Algorithms and Programs", for the first semester

in Computing Engineering program at the Instituto Tecnológico Autónomo de México (ITAM).

3.3.2 Methodology

First we analyzed and designed the e-learning system with the previous learning styles theory that was mentioned above, second we explained the implementation of the architecture obtained, third we selected a subject to use in the system, and finally an approach evaluation: experiment with students. In general, we created a system, for each topic:

- Evaluates the learning style(s) of a student (called his/her 'profile').
- Matches course content with the corresponding student profile (stored in a database).
- Creates specific teaching material for the student.
- Use the system to validate the approach on different populations of students.

The system implemented use dynamic objects of learning to allow presenting the content of a course according to the preferences of the person who uses it.

3.3.2.1 Modeling and analysis requirements

Case modeling can show how the system works. A number of diagrams are presented showing how very simple actors interact with the examples of uses, as well as tables where the use cases are explained in more detail, illustrating how they communicate with each other use cases.

This part also presents the kind of cards that give a very brief description of the class, as well as the attributes and methods that make it up. Also shown are the sequence diagrams that help to communicate or see how the classes interact with each other when a user performs an action on the system.

3.3.2.2 Use cases model

Figure 3-1 shows the limits of the individualized system.

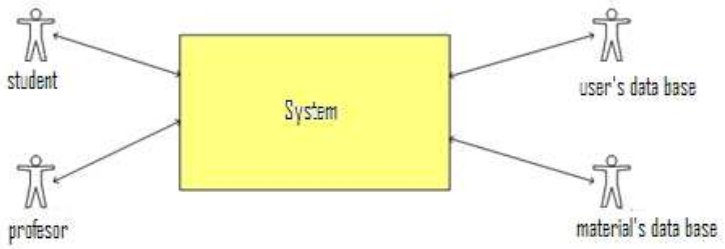


Figure 3-1 System delimitation

Below are the use cases of the system (See Figure 3-2).

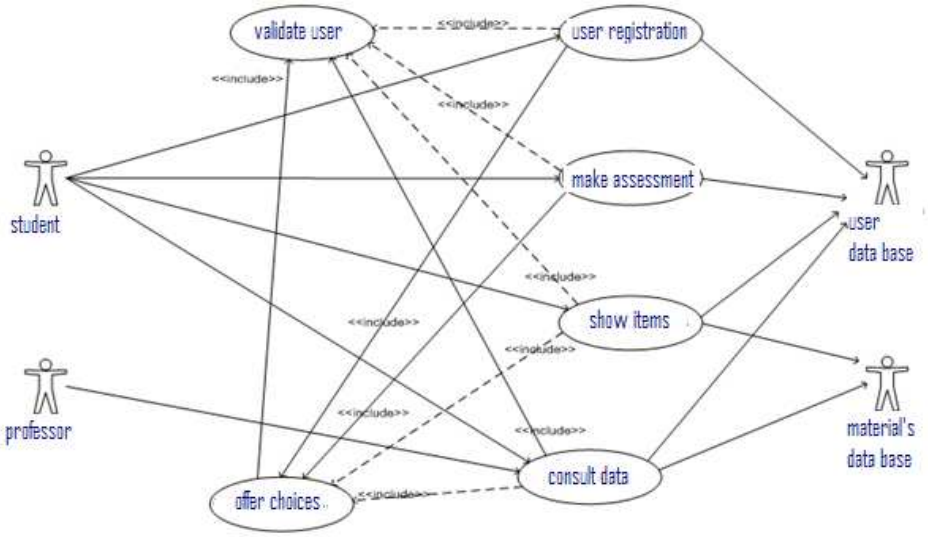


Figure 3-2 Use case system

The descriptions of the actors are exposed below:

• Student: It is the main actor is any person wishing to use the system of individualized instruction to study the course that was selected.

• Professor / Administrator: This is the main actor in the system administration; he may see all the information of students, their skills and use of the system.

• Database Users: It is an actor and is the database that stores all information about system users (students and professors / administrators), but independent of the course materials.

• Materials Database: An actor represents the database that stores information on the topics and course materials to study.

The description of the use cases is shown below:

• Validate User: Validate a user already registered for the use of individualized learning system.

• Provide/offer Options: Provide a variety of options to students already registered to use the system of individualized instruction.

• Register Username: Allow a user to register with the school system for individual use.

• Making assessment: Allow the user to take a test Felder learning styles to identify and save what their learning styles in different dimensions.

• Display Topics/Show Items: View the agenda and topics of the course is offered through a system of individualized instruction.

• Consult data/Information: Get the information requested by system users.

The explanation of the symbols used is as follows (see Figure 3-2)

• A use case is a way to use the system and is represented by an ellipse.

• An actor represents a role performed by a real person and is represented by the figure of a person.

• The solid lines show how to relate the different use cases and actors.

• The lines represent non-continuous, in the case of the diagram of Figure 3-3, the inclusion is defined as a section of a use case that is a essential part of the basic use case (Weitzenfeld, 2005).

3.3.2.3 Actors and use cases description

This section presents the tables with a more detailed description of the previous section of the actors and use cases of the system.

Actor	Student
Use Case	Validate user, Provide/offer Options, Register Username, Making assessment, Display topics/Show, and Consult data/Information:
Type	Principal
Description	It is the main actor and represents any person wishing to use the system to study the course that was selected

Table 3-3 Student actor

Table 3-3 presents the description of the student actor, the use cases with which they interact and the type of actor.

Actor	Administrator /professor
Use Case	Validate user, Register Username, and Consult data/Information:
Type	Principal
Description	It's the principal actor for administration system; he can see all the students' information, their skills and use of the system.

Table 3-4 Administrator/professor actor

Table 3-4 shows the characteristics of the actor Administrator / Professor

Actor	User database
Use Case	Validate user, Provide/offer Options, Register Username, Making assessment, Display topics/Show, and Consult data/Information:
Type	Secondary
Description	Is a secondary actor and is the database that stores all information about system users (students and teachers / administrators), but independent of the course materials.

Table 3-5 User data base actor

Table 3-5 presents the description of the user database actor, the use cases with which they interact and the type of actor.

Actor	Material database
Use Case	Display topics/Show, and Consult data/Information:
Type	Secondary
Description	Is a secondary actor and is the database that stores information on the topics and course materials.

Table 3-6 Material database actor

Table 3-6 contains a description of the materials database actor.

Use case	Validate user
Actor	Student, Administrator/Professor, user database, materials database
Type	Inclusion.
Purpose	Validate the user already registered for the use of system.
Summary	This use case begins with the user (administrator or student / teacher).

	Validates the user through a login and password to verify the user registration data, so you can use the system.
Preconditions	Must have previously implemented the use case Register. Register Login Login Create
Main Flow	Presents the user with the login screen (P-1). The user can select from the options: "Log", "Register" and "Exit." If the activity selected is "Log", is running the use case Register User. Create User Registration (S-1). If the activity selected is "Enter", it validates the user by your login and password embedded in the login screen (P-1). Once validated the user (E-1), if students are continuing with the use case Provide Options, if Administrator / Teacher will continue with the use case Check information, consult Information for Teachers (S-1). If the activity selected is "quit" will exit the system
Sub-flow	None.
Exceptions	E-1 there was no validation: the login / password is not validated properly or were not empty fields. It asks the user to re-register.

Table 3-7 Use Case: Validate User

Table 3-7 contains a detailed description of the Validate User use case.

Use case	Provide/offer Options
Actor	Student
Type	Inclusion.
Purpose	To offer the diverse options to a student already registered so that it uses the system of individualized instruction.
Summary	The user initiates this use case. He has capacity to use the diverse options of the system of reservations.
Preconditions	One correctly requires to have validated the user
Main Flow	The screen appears to the user options (P-2). The user can select between the following activities: “To see Agenda”, “Results of Styles of Learning”, “To again take Test from Styles of Learning”, “To begin Course”, “To modify Data” and “To end”. If the selected activity is “To see Agenda”, it is continued with the case of use Of showing Subjects, showing syllabus (S-1).

	If the selected activity is “Results of Styles of Learning”, it is continued with the case of use Of consulting Information; consult Results of the Test (S-2). If the selected activity is “To again take Test from Styles of Learning”, it is continued with the case of use Of making Evaluation. If the selected activity is “To begin Course”, it is continued with the case of use Of showing Subjects, Show Subject (S-2). If the selected activity is “To modify Data”, it is continued with the case of use Of registering User, obtain Registry of User (S-2). If the selected activity is “To end”, it will log-off itself
Sub-flow	None.
Exceptions	None

Table 3-8 Use Case: Provide/offer Options

Table 3-8 presents a detailed description of the offering Options case of use, it shows the actors with whom it communicates, its intention, a summary of what it does, the preconditions to use it, their main flow, the sub-flows and the exceptions that can be displayed.

Use case	Register Username
Actor	Student, Administrator/Professor, user database, materials database
Type	Basic
Purpose	To allow a user to register itself in the system of individualized education to use it.
Summary	The user initiates this use case. Provides functionality to create and modify the user with the system of individualized instruction.
Preconditions	All except the sub-flows Create User Registration required to run initially for use Validate User
Main Flow	Implementing the use case Validate User. Depending on the options selected by the user, will continue with various sub-flows this use case
Sub-flow	S-1 Create User Registration Presents the user create the user registration screen (P-3), which contains the information needed to complete the user registration, including name (s), surname, address, telephone number, e-mail, type, login and

	password and an additional repeat password. The system will use the login and password to validate the user. The user can select from the following: "Registration" and "Exit." If the activity selected is "Register", the system generates a new user registration (E-1, E-2, E-3, E-4). If the user is kind of students ", continues with the use case Make Evaluation sub-flow Start Test. If the type of user is Administrator / Teacher, is continued with the use case Check information, sub-flow consult Information for Teachers (S-1). If the activity selected is "quit" is out of the system (if not already pressed "Register" means information will be lost). S-2 Get User Registration The system obtains the user record of user database. It continues with the sub-flow Manage User Registration (S-3). S-3 Managing User Registration Presents the user with the Edit user registration screen (P-4) with the user registration information. He may select from the following: "Edit", "Back" and "Exit." If you select the action "Edit" execution sub-flow User Registration Update (S-4). If you select the activity "Return" is the use case continues to offer options. If you select the activity "Exit", it will exit the system. S-4 Update User Registration Updates the user record with the modified data (E-1, E-3, E-4). It continues with the flow or sub-flow above.-
Exceptions	E-1 incomplete Information to fill in the user. Asks the user to complete the registration.

	E-2 Register already exists: if there is a record under this login, the user is prompted to change it or end the use case. E-3 Login incorrect: the login is invalid. Asks the user to correct the login. E-4 Incorrect Password: the password is not validated properly. Asks the user to correct the password.

Table 3-9 Use Case: Register Username

Table 3-9 shows a description of the use case Login Register, it contains information about the actors with whom it communicates its purpose, a summary of what it does, the preconditions for use, its main flow, and the exceptions.

Use case	Making assessment
Actor	Student, user database
Type	Basic
Purpose	Allow the user to take a test Felder learning styles to identify and save what their learning styles in different sizes.
Summary	This use case begins with the user. Offers the functionality to apply the test of Felder's learning styles and keep the information obtained through this test.
Preconditions	Must have validated the use case Validate User
Main Flow	Presents the user with the screen test (P-5), which shows the 44 questions in the test of learning styles Felder. The student can choose between the "Evaluate" and "Clear test". If you choose to "evaluate", it is verified that the test has been completed (E-1) and continues to the sub-flow assess Student (S-1). If you choose to "test clean" deletes all the answers you have selected so far.
Sub-flow	S-1 evaluate Student Assesses students according to test and get Felder learning styles for that student in each dimension, updates the data in the test user database and continue with the use case Check Information Check sub-flow Test Results.
Exceptions	E-1 Test incomplete if any of the questions has no answer. Asks the student to complete the test.

Table 3-10 Use Case: Make Assessment

Table 3-10 contains a detailed description of the use case Make Assessment, shows the players that communicates with, its purpose, a summary of what it does, the preconditions for use, its main flow, the sub-flow and exceptions..

Use case	Display Topics/Show Items
Actor	Student, user database, materials database
Type	Basic
Purpose	View the syllabus and topics of the course is offered through a system of individualized instruction.
Summary	This use case begins with the student. Provides functionality to view the syllabus of the course is delivered through the system and show the items that comprise the syllabus..
Preconditions	Must have initially implemented the use case Validate User
Main Flow	Depending on the options selected by the user continues with the various sub-flows this use case If the activity selected is "quit" will exit the system
Sub-flow	S-1 Show syllabus Presents the topic display (P-6). The student can select the following options "Show Summary", "View Item", "Start Course" and "Exit." If you select the action "View Abstract", continues the sub-flow Show Summary (S-3). If you select the action "View Item", continues the topic sub-flow Show (S-2). If you select the activity "Exit", it will exit the system. S-2 Item Display You get the materials of the item or section according to the characteristics obtained in the test Felder of the Materials Database. Display screen shows the subject (P-7). It contains the following: "Options", "Previous Topic / Sub", "Next Topic / Sub" and "Exit." If you choose the activity "Options" to continue the use case Provide options. If you choose the activity "Previous Topic / Sub", continues in the same

	sub-flow but getting the materials of the item or previous item. If you choose the activity "Next Topic / Subtopic" continues in the same but getting sub-flow materials or sub-topic below. If you choose the activity "Exit", it will exit the system. S-3 View Abstract Is obtained from the database of materials on the topic selected, the screen displays abstracts (P-8), which shows the summary of the topic. The activities offered are "Close" and "Exit." If you choose "Close" to continue the flow or sub-flow earlier and close the screen. If you choose "Exit" will exit the system.
Exceptions	E-1 Incorrect Topic: If the item does not exist in the database of materials. E-2: Not note If the note is blank. Students are asked to write a note or do not save any note..

Table 3-11 Use Case: Show Items

Table 3-11 presents the characteristics of the use case Show Topics, shows the players that communicates with, its purpose, a summary of what it does, the preconditions for use, its main flow, the sub-flows and exceptions.

Use case	Consult data/Information
Actor	Student, Administrator/Professor, user database, materials database
Type	Basic
Purpose	Obtain the information requested by the actors involved in this use case..
Summary	This use case begins with the Administrator or Student / Teacher. Offers the possibility to consult the information that is stored in databases.
Preconditions	Must have implemented the use case Validate user in advance
Main Flow	Depending on the options selected by the user continues with the various sub-flows this use case
Sub-flow	S-1 See Information for Teachers Obtained information from all students registered in the system for individualized instruction in the user database. Presents the results screen students (P-9), which contains the options "View Test Results" and "Exit."

	If you choose the action "View Test Results", continues the sub-flow See Test Results (S-2). If you choose the activity "Exit", it will exit the system. See S-2 Test Results Are obtained from the user database of student test results indicated. Screen is displayed in the Student Learning Styles (P-10). The choices are "Close" and "Exit." If you choose "Close" is the use case continues to offer options. If you choose "Exit", it will exit the system..
Exceptions	E-1 Not note If the note is blank. Students are asked to write a note or do not save any note

Table 3-12 Use Case Consult data/Information

Table 3-12 explains the use case consult information indicates the actor that communicates with, its purpose, a summary of what it does, the preconditions for use, its main flow, the sub-flows and exceptions.

3.3.2.4 Diagram and class dictionary

This section describes the class diagram was made from the use cases, and the dictionary for them in which explains briefly what the role of each of the classes that are used in the system. The class diagrams are made for each use case.

Validate user: This case involves the use of Web Service WSLearning the module variables and frmLogin (see Figure 3-3).

Figure 3-3 Classes for the use case validate user

- Provide Options: This case involves the use of module variables and how frmOpciones (see Figure 3-4).

Figure 3-4 Classes use case to provide options

- Register username: This use case includes the Web Service WSLearning the module variables and ways frmRegistrar and frmModificar (see Figure 3-5).

Figure 3-5 Classes for the use case register username

- Consult Information: This use case is the Web Service classes WSLearning the module variables and ways frmResultadoTest and frmAlumnos (see Figure 3-6).

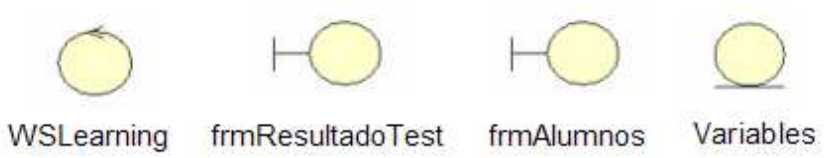


Figure 3-6 Classes for the use case consult Information

- Display items: This case involves the use of Web Service WSLearning the module variables and ways frmResumen, frmTemario, frmMostrarTema and frmMostrarTemaVIS (see Figure 3-7).

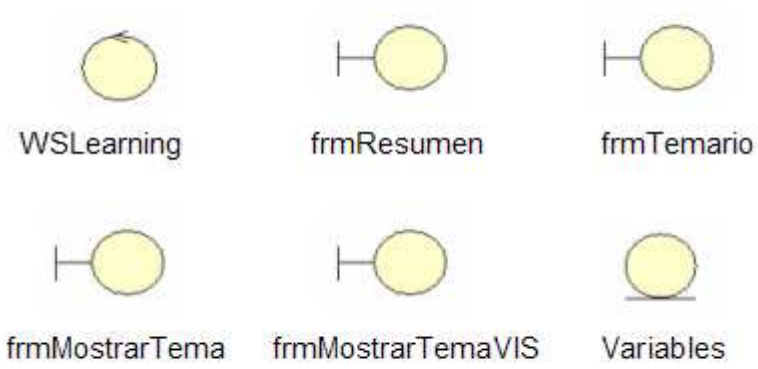


Figure 3-7 Classes for the use case show items

- Making assessment: This use case includes the Web Service WSLearning the module variables and how frmExamen (see Figure 3-8).

Figure 3-8 Classes for the use case make assessment

Next, we illustrate the functionality of the classes mentioned above.

• WSLearning: Class Control. Web service communicates with the database and the application of the client or student. Consider responsible for obtaining and updating information in the database for the application to work correctly.

• Variables: Entity class. Module that contains variables that help to store data at runtime required for the proper functioning of the system of individualized instruction.

• frmLogin: Class Border. Form responsible way to validate a user. Login screen (P-1).

• frmOpciones: Class Border. Form responsible way to show the options you can choose the student. Options screen (P-2).

• frmRegistrar: Class Border. Form, whose goal is to form a new record student, Register Login screen (P-3).

• frmModificar: Class Border. Form, whose goal is to modify the data of a registered student, Modify User Data screen (P-4).

• frmResultadoTest: Class Border. Form shows the results obtained in a test of student learning styles Felder. Screen Test Results (P-10).

• frmAlumnos: Class Border. Form shows a teacher or an administrator of the students registered in the system. Display Result Students (P-9).

• frmResumen: Class Border. Form shows the summary of a topic or item previously chosen by the student. Summary screen (P-8)

• frmTemario: Class Border. Way that shows the topic of the course. Syllabus screen (P-6).

• frmMuestraTema: Class Border. Form shows a particular topic or item when the student is verbal. Topic Screen Display (P-7)

• frmMuestraTemaVIS: Class Border. Form shows a particular topic or item when the student is visual. Topic Screen Display (P-11)

• frmExamen: Class Border. Form that shows the student a question from the test Felder learning styles of their possible responses to it to answer it, Screen Test (P-5).

3.3.2.5 Sequence Diagrams

This section shows the sequence diagram of the system, the way in which the various classes interact with each other system.

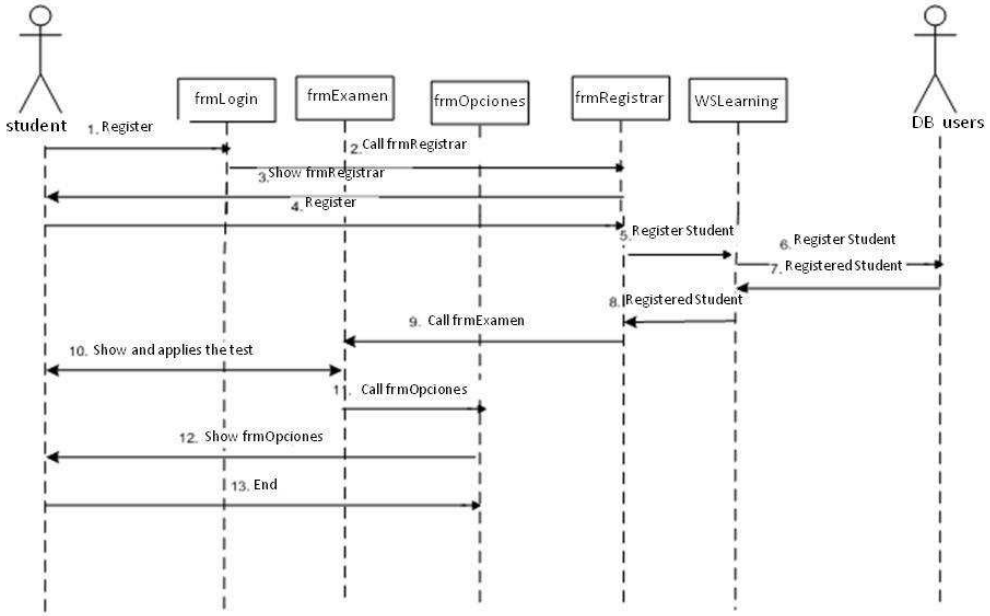


Figure 3-9 Sequence Diagram for use case Register Sub-flow user create new user

Figure 3-9 shows the sequence for the use case register sub-flow User Create New User, this begins when the student wants to register in the system, class frmLogin call frmRegistrar, it is shown to the student who fills the data and records in the system, which calls the Web Service WSLearning, who creates the ResgistroAlumno. Once registered, students have to test Felder, when complete shows how frmOpciones and hence can leave the system.

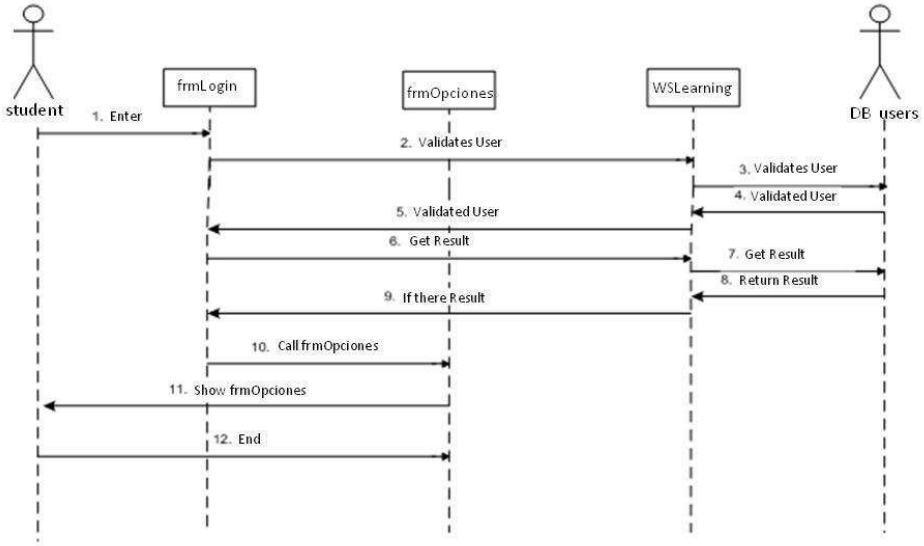


Figure 3-10 Sequence diagram for use case validate user

Figure 3-10 shows the sequence of use case validate user. The student has to enter the frmLogin your username and password to be validated by the Web Service WSLearning, once validated frmLogin sends a call to display the form frmOpciones, in which the student can exit the system.

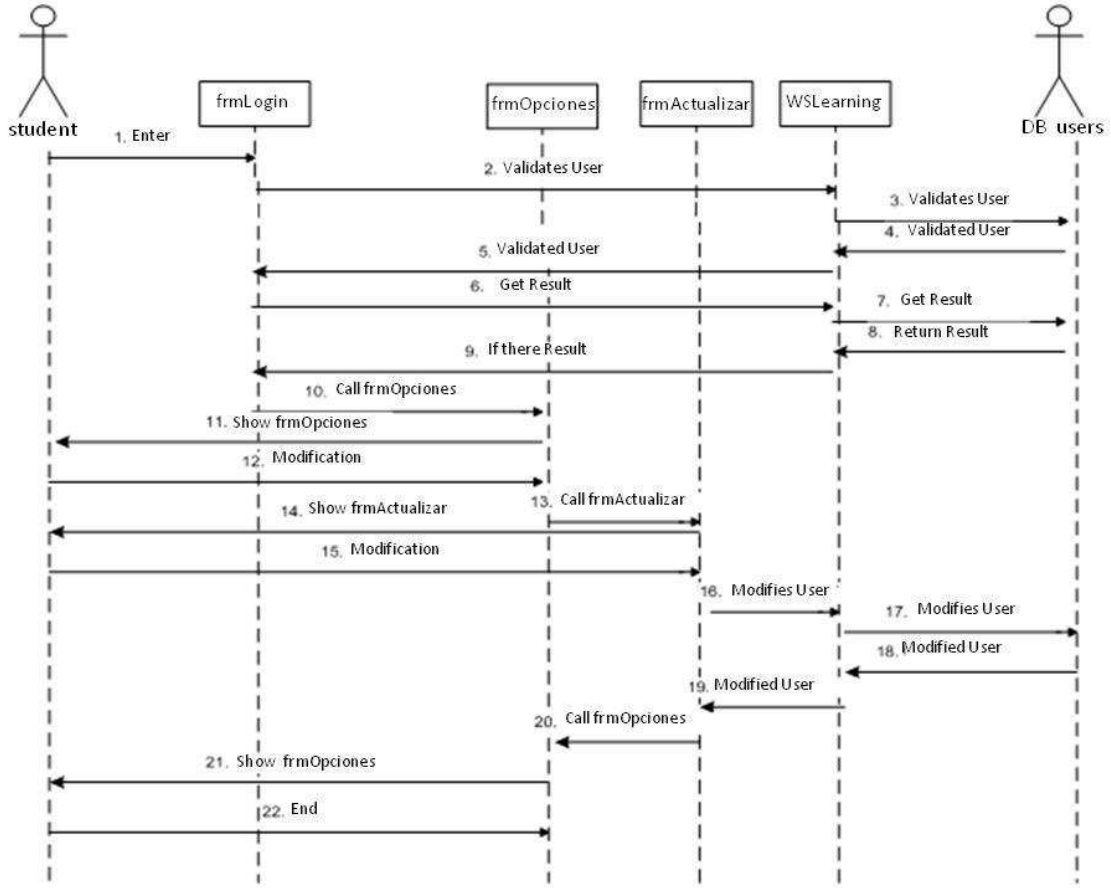


Figure 3-11 Sequence diagram for use case register Sub-flow user update user registration

Figure 3-11 shows the sequence for the use case register sub-flow user update user registration for this first validates the user as in Figure 3-10, then choose the modify option in frmOpciones, to show how frmActualizar. The student modifies the data you need to update, then click on the Edit button, communicates with the WSLearning, who modifies the data in the database Users. When the modified student data can return to form frmOpciones and end the system.

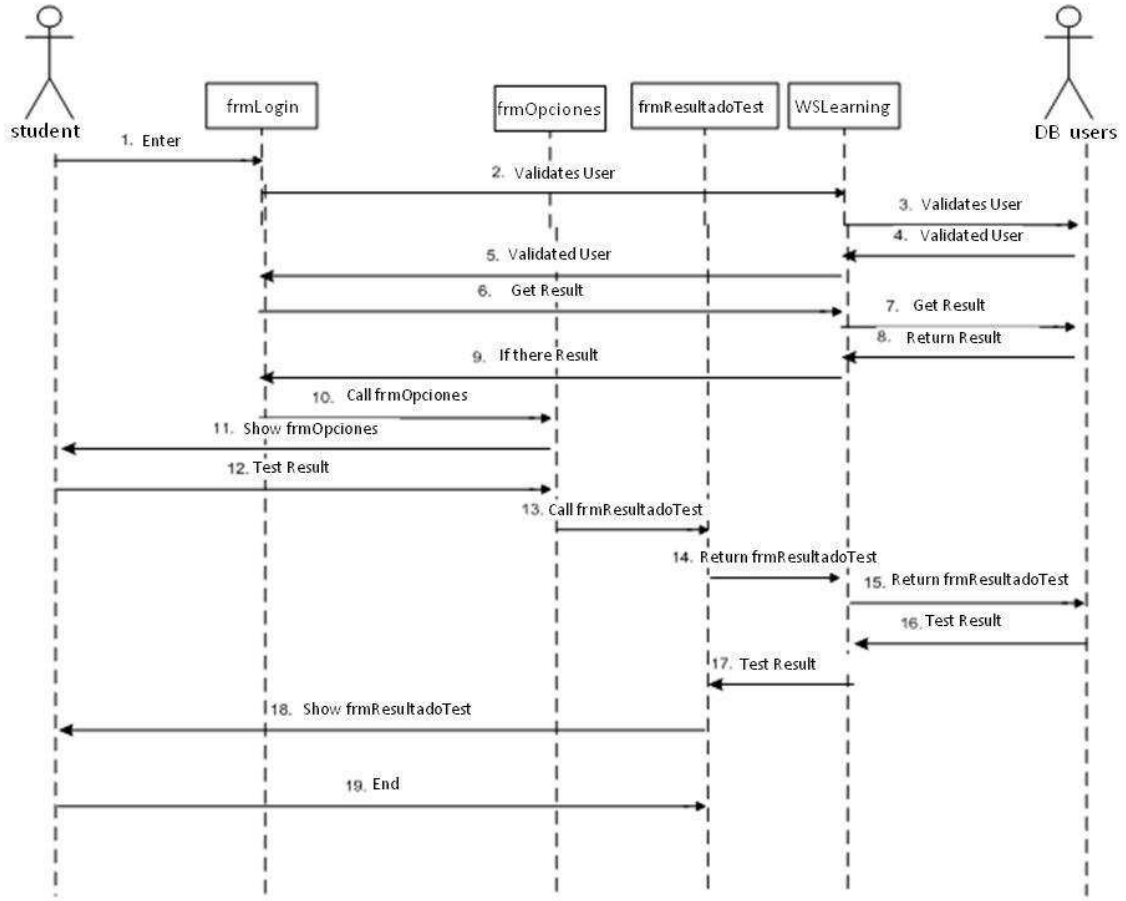


Figure 3-12 Sequence diagram for use case consult information sub-flow check test.

Figure 3-12 shows the sequence diagram for use case consult information consult Result Information sub-flow Test, in which case the student is first validated in the system as in Figure 3-10, then select the option in frmOpciones Test Results. When this button is pressed it calls the frmResultadoTest who in turn obtains the student's test results by calling WSLearning. The latter retrieves the results of the BDUsuarios, who in turn were shown to students. Finally, the student can exit the system.

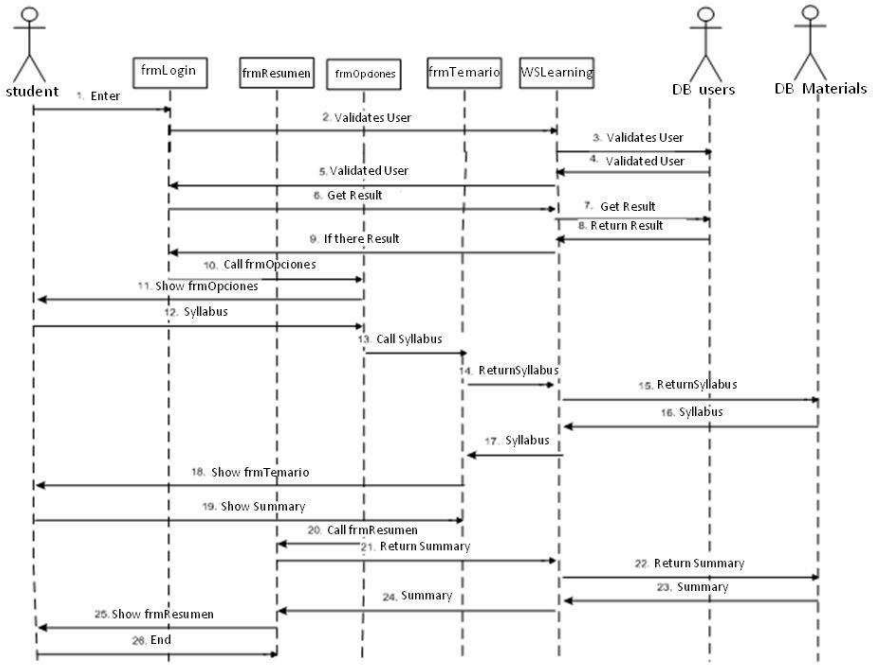


Figure 3-13 Sequence diagram for use case view item sub-flow show syllabus

Figure 3-13 shows the sequence diagram for use case show sub-flow Show syllabus Item. The first thing the student is validated as in Figure 3-10, once in the form frmOpciones choosing Syllabus. It calls frmTemario, who in turn calls the WSLearning for the agenda of the database materials. WSLearning returns to the agenda frmTemario, who shows how the agenda. This sequence is also the case in which the student asks to see a summary of a particular subject, so the sum is obtained by the database Materials WSLearning, data is returned to the form frmResumen, who shows Student abstract. Finally, the student can exit the system.

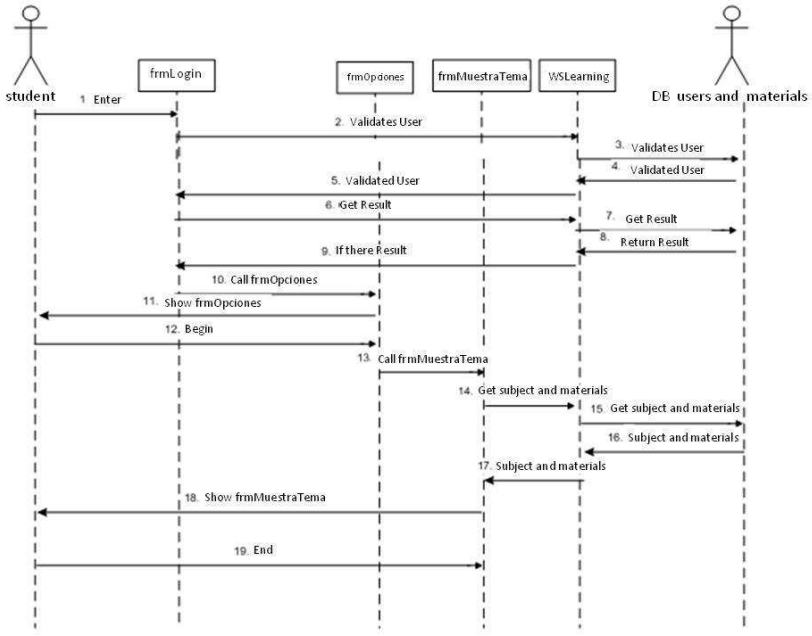


Figure 3-14 Sequence diagram for use case sub-flow show topics show item

Figure 3-14 shows the sequence diagram for use case sub-flow Show Topics Show item. First, the student should be validated as in Figure 3-10, then frmOpciones how to choose the Start option in this case will show the first item on the agenda will be drawn from the materials by the database Web WSLearning according to the characteristics Student obtained with the test Felder. Once the item shown to the student, he may exit the system.

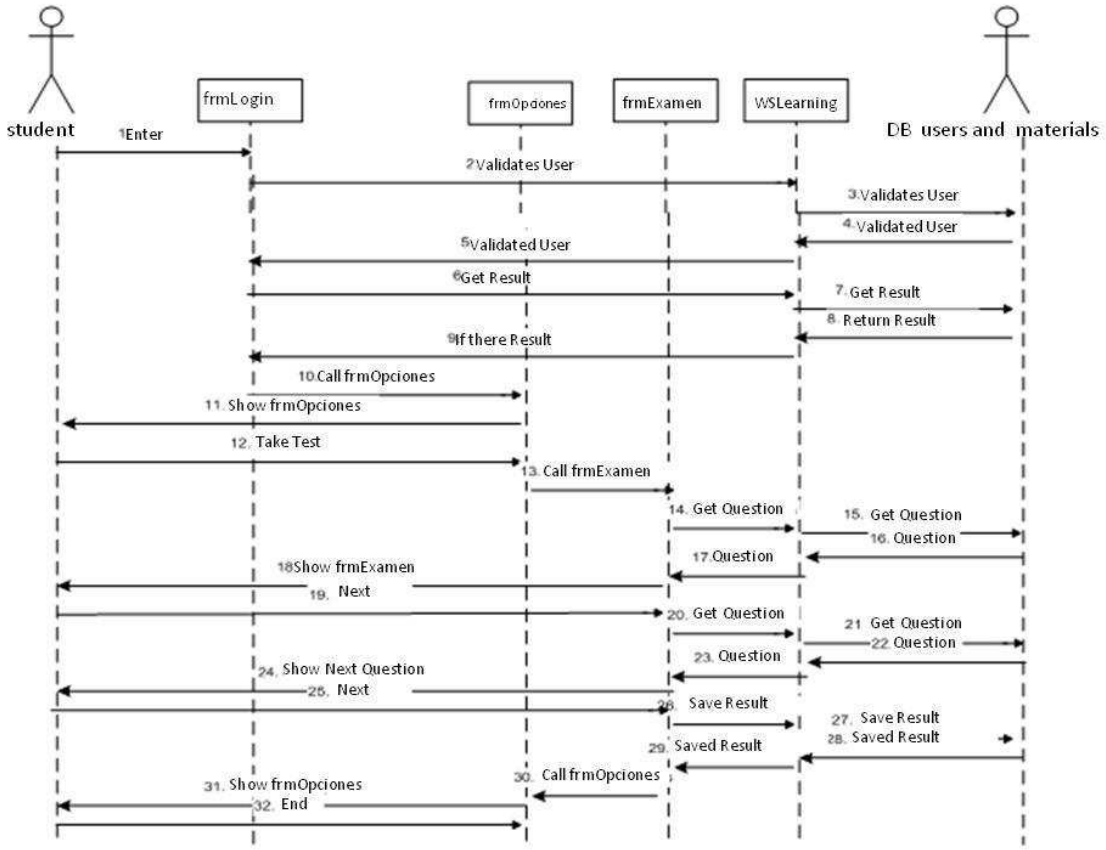


Figure 3-15 Sequence diagram for use case make assessment

Figure 3-15 shows the sequence diagram for use case make assessment. The student must validate the system as shown in Figure 3-10. When it is on the way to choose the option frmOpciones take test, so you call the frmExamen, who in turn calls for it to get WSLearning questions of Felder test. Once you display the first question of the test, the student will answer the following and press again and repeat the process for obtaining the question until the test again and see how frmOpciones, where the student may exit the system.

3.3.3 System design

Using the model system in the previous section, this chapter describes the functional and technical architecture of the system, system components and presents the design of the system database.

3.3.3.1 System architecture

The architecture of the system is explained in the following way: First, the functional diagram is shown and all its elements are described in Figure 3-16 and Figure 3-17. Then, the technical diagram is depicted and its elements are explained.

3.3.3.2 Functional Diagram

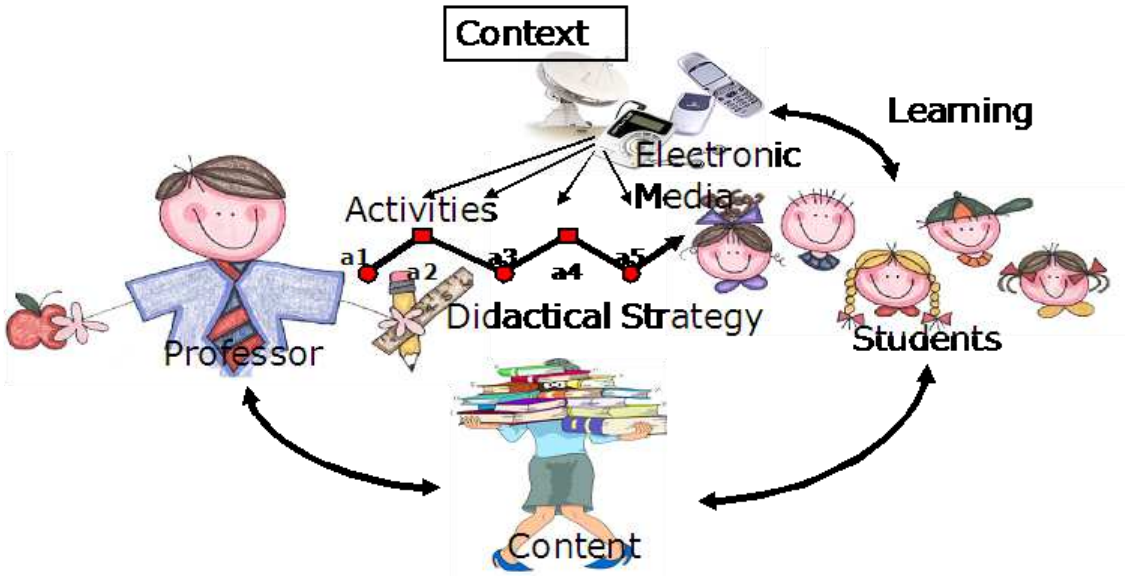


Figure 3-16 Functional diagram

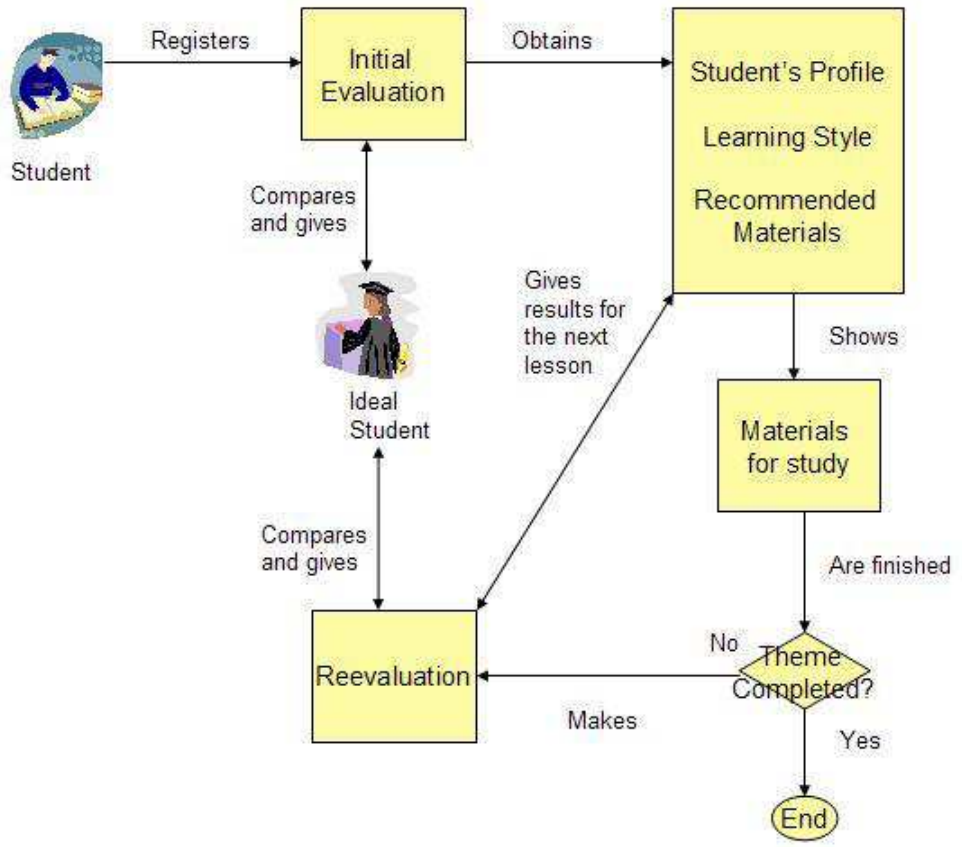


Figure 3-17 Functional Diagram

Explanation of Functional Diagram

The elements of the functional diagram (see Figure 3-16, 3-17) are:

Student: The person that uses the system and is evaluated during the learning process. First, he or she has to be registered in the system and then the system makes an initial evaluation of his/her learning style. The system then recommends specific materials for the first lesson of the course that adapts best to the students' characteristics.

Ideal Student: This element contains information about a perfect student who uses all types of learning styles, and develops all his/her learning capabilities. It is used to compare the answers given by the real student to obtain which is the learning style that best fits him/her, in order to have a better learning experience.

Initial Evaluation: It's the first test that the system presents to a new student to obtain his/her profile, and the characteristics of the way he/she learns. With this information the system compares the characteristics of the student and the ideal student's ones and determines the learning style that best approximates the student's learning strategy.

Student Profile, Learning Style and Recommended Materials: Based on the student profile and the learning style obtained through the evaluation, the system chooses the materials based on what's best for the student according to his/her learning style.

Materials for study: These are the recommended materials once the evaluation has been made. The materials correspond to one lesson.

Reevaluation: If there are still more lessons after a student has finished studying the material for a lesson, a reevaluation is performed to estimate the student's progress and check whether his/her learning style has changed. When the learning style varies, new recommendations for materials are given to the system so it can show the materials for the new student characteristics.

Therefore, the logic behind the system is this: first, a new student is registered and completes an evaluation of his/her learning strategies to obtain his/her learning style; second, with the obtained learning style, the system can make recommendations about what materials are best for the student; third, the systems shows the materials to the student, who uses them until he/she is done with the lesson; finally, if there are more lessons, the student is reevaluated and the system returns to the second step. If not, the system communicates to the student that he/she has finished the course. This cycle continues until the student has finished the course.

3.3.3.3 Technical diagram

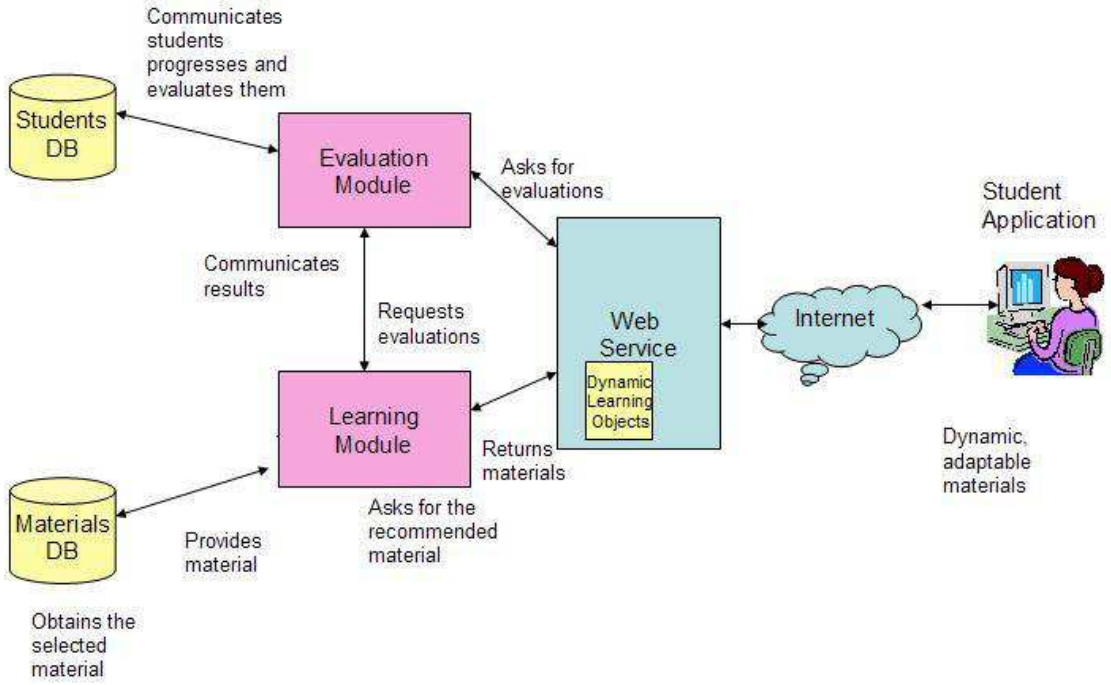


Figure 3-18 Technical diagram

Explanation of Technical Diagram

The elements of the technical diagram (see Figure 3-18) are as follows:

Students Database: It contains and stores the data of the ideal student and the students that use the system. The information contained in this database is used by the system to make the evaluations and to resolve the learning styles of the students.

Materials Database: It stores the course's materials. In order to assure the dynamism of the system, it has several types of resources stored (video, audio, text, etc), for each lesson of the course. This is because some resources are useful only for certain types of learning styles.

Evaluation Module: This module is used to perform the evaluations needed when a new student is registered in the system, or when a student finishes a lesson. This module evaluates results by comparing the answers of the student with the ones of the ideal student stored in the Students Database. It then shows the student's learning style and recommends which materials should be used for the next lesson.

Learning Module: This module uses the results from the evaluation module and presents the materials that where recommended by the system. These materials are then retrieved from the Materials Database. Once the materials are obtained, they are sent to the Web Service which contains the Dynamic Learning Objects. These will then send the materials through the Internet to the student application.

Dynamic Learning Objects: These are objects that help sending and displaying the correct materials for a certain student. They can transport different types of resources based on the materials and information that the Learning Module sends to them. They're adapted to send these materials through the net. They are stored in the Web Service.

Web Service: Part of the system is used to communicate with the user (in our case, the student). This part stores the Dynamic Learning Objects that are used to send the recommended materials to the student according to his/her learning style. The student application invokes the Web Service's operations to function. Some of the operations that the Web Service handles are the initial evaluation, the (possible) reevaluations, the getting and displaying of the materials and finishing a lesson.

Internet: It is the media through which all the requests and responses to and from the Web Service and the Student Application travel.

Student Application: The client-side service. It's the front-end, responsible for collecting input from the student, and later displaying the results according to such input.

The general idea for the system is that a student registers and his/her information is stored in the Students Database. An initial analysis using that information and the ideal student information is made by the Evaluation Module. Then the Evaluation Module communicates the assessment results to the Learning Module which requests the recommended materials to the Materials Database. When the materials are returned to the Learning Module, it sends them back to the Web Service, which contains the Dynamic Learning Objects that adjust according to the types of materials that are returned by the Learning Module. Then, the Web Service sends the materials through the Internet to their final destination, the Student Application. Once the student has finished a lesson, the Student Application informs this to the Web Service. Next, the

Web Service informs the Evaluation Module and the Evaluation Module gets the proper test and returns the test to the Web Service. Finally, the Web Service sends the test to the Student Application. The student takes the test and the answers are returned to the Web Service and the Evaluation Module, which evaluates the progress of the student and chooses the materials for the next lesson. These are then re-transmitted to the Learning Module. This process continues until the student makes a pause or finishes the course.

One thing to consider is that the system has to have a mechanism to remember the place in a lesson where a student left during the previous session. The student should be able to close the system and then re-open it and continue the lesson right where he/she left it.

3.3.4 Design database

The database used by the system is a relational database, containing data about the users and the materials that you can use the system. This section shows the design of the database: first shows a diagram of the user database and materials and then explains each of its components.

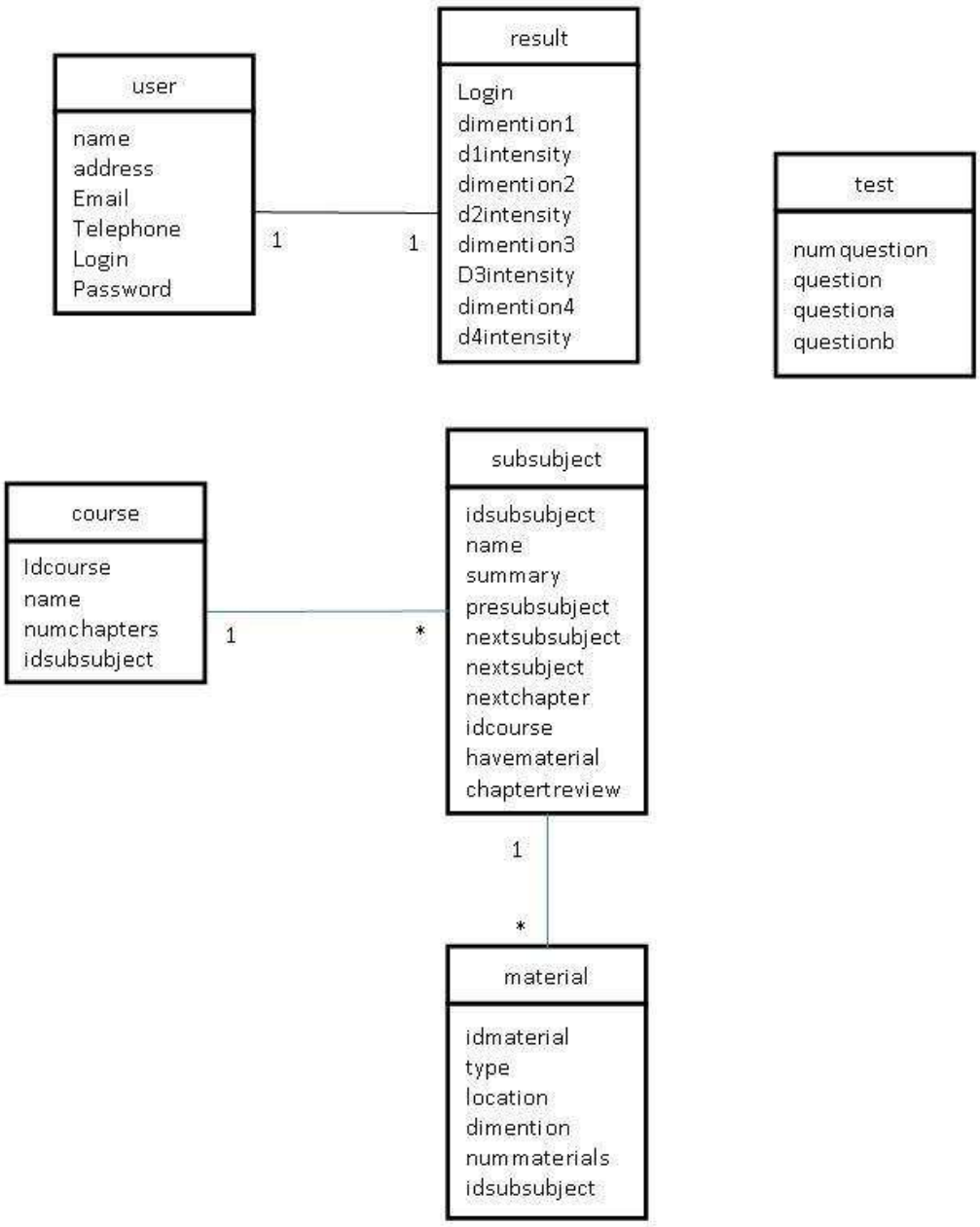


Figure 3-19 Outline of database users and materials

the color gray shows the table name, the key is indicated by bold letters, the relationships are indicated by lines and a number to indicate that only 1 may be associated with a record of that table or an asterisk (*) to indicate that it may be related to 1 or more records of that table.

The components of the user database and materials shown in Figure 3-19 are:

• User: Table containing the data from users who are name, address, email, phone, login and password. It is related to the result table.

• Result: Table containing the results of a student's tests Felder learning styles. The data are login, dimensión1, d1intensidad, dimensión2, d2intensidad, dimensión3, d3intensidad, dimensión4 and d4intensidad. It is related to the users table.

• Test: Table lists the questions that test learning styles Felder. The data contained in it are nopregunta, question, respuestaa and respuestab.

• Course: table containing data for the current system that are offered fall, name, nocapitulos, idsubtema. It is related to the item table.

• Sub: Table containing data about each item that exists in the course. The data contained in it are idsubtema, name, summary, presubtema, sigsubtema, sigtema, sigcapítulo, fall, tienematerial, capítuloexamen. It is related to the tables and course material.

• Material: Table containing information about a material corresponding to an item as a specific learning style. The data you have is idmaterial, type, location, size, nomateriales, idsubtema. It s related to the item table.

In the table in the material dimension is showing what kind of dimension of Felder owned by this system may find the material suitable for students according to their learning style according to Felder in any of the four dimensions. For dimension active / reflective the field can have values ACT and REF for the visual / verbal the values are VIS and VRB, the sensory / intuitive the values are SNS and INT, To the sequential / global value is not checked because the students can choose both , for the sequentially the student wants to go at any time during the course, this was done to give more flexibility to students, and it is advisable to develop both dimensions and that there is a balance between the sequential and the global.

3.3.5 Implementation

The technical architecture was implemented using Microsoft Visual Studio .NET 2003 as the programming language, MySql 5.0 as the database server and MySQL Connector Net 1.0.7 to connect the database with the web service WSLearning.

These components were used because they allow the system to be accessed online, so that the student does not need to stay in the place where the Web Service is to enter the system, so you can connect from elsewhere. The database manager was chosen because it is a tool that had previously worked and because it appears easy to use, besides it serves to store the data for the students and the course allowing the system to function properly. Visual Basic. NET was chosen as a simple language, but provides great potential for development of system. Moreover, you can use graphic elements easily.

3.3.5.1 Implementing the web service WSLearning

WSLearning Web Service was implemented using Visual Basic. NET. The first thing we did was implement in the user database stored procedures and materials to carry out the tasks of integration and update the database. Stored procedures that were developed were:

CrearUsuario: Allows you to insert information from a new user. Get all the information needed to fill in a user record in the database.

ModificaUsuario: Allows you to edit information for a new user. Get the data to be modified in the registry of the user is indicated by the login and password that are sent.

CrearResultado: Allows you to create a test for learning styles Felder. Get the student to login to be created along with the outcome of the test results.

ModificaResultado: Allows you to change the outcome was determined that a student in the test of learning styles Felder. Get the login and the new results of the student in question.

Once created and verified to operate stored procedures, continued to the programming of the Web Service methods.

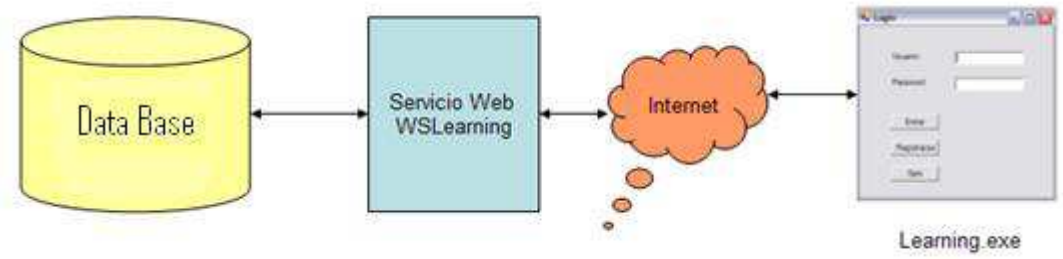


Figure 3-20 Implementation system

Figure 3-20 shows roughly how the system was implemented. First, there is a database that stores user information and course materials. Then Web Service that contains the methods responsible for providing services to users of the system and communicates

with both the database as the application of the student. Subsequently, the Internet is the means by which it becomes possible to communicate between the user and the Web Service. Finally, the program user will use the services of the Web Service to function.

3.3.5.2 Testing the system

Below are diagrams of the sequences to be met by the system to function properly.

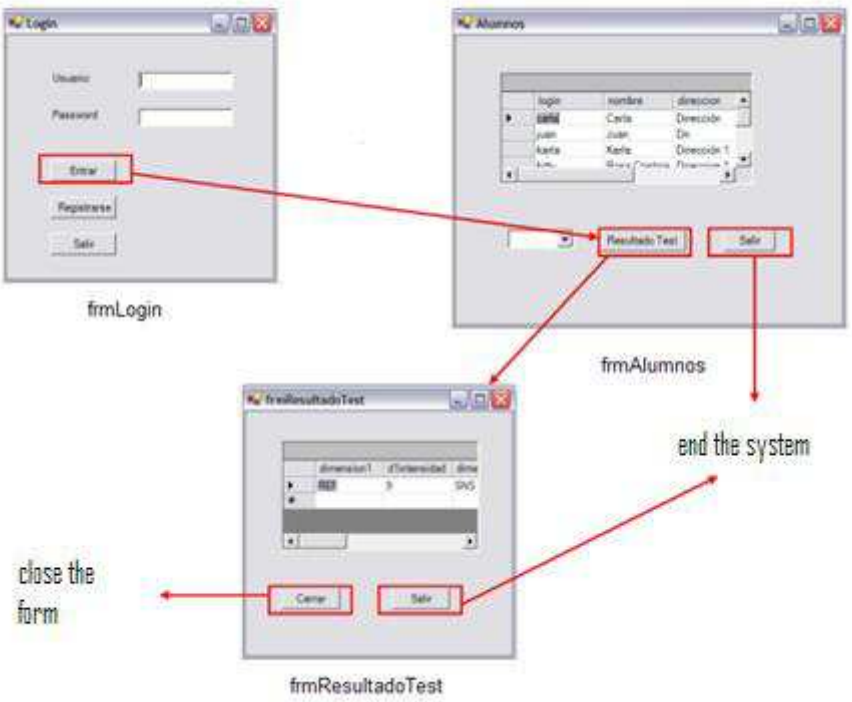


Figure 3-21 Professor string user / administrator

Figure 3-21 shows the sequence for the system user type's professor / administrator. In this case the user enters their login and password, the system validates frmAlumnos and the screen that contains information for students attending the course. You can also select the key to a student to see that the result obtained in the test of learning styles of the Felder frmResultadoTest screen.

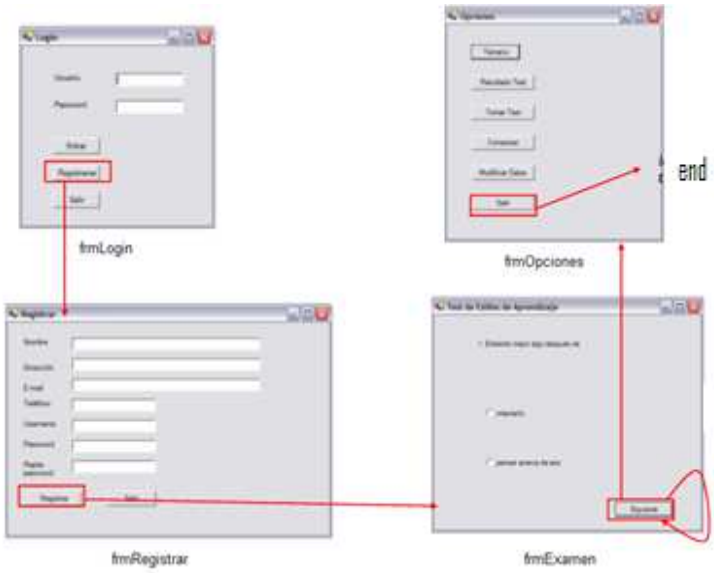


Figure 3-22 Test sequence for a new user

Figure 3-22 shows the test sequence to register a new student, this student should press "Register", frmRegistrar screen appears, enter your details and press "Enter", then exit the screen so that it frmExamen applied the test, finally frmOpciones screen appears where you can select the desired option.

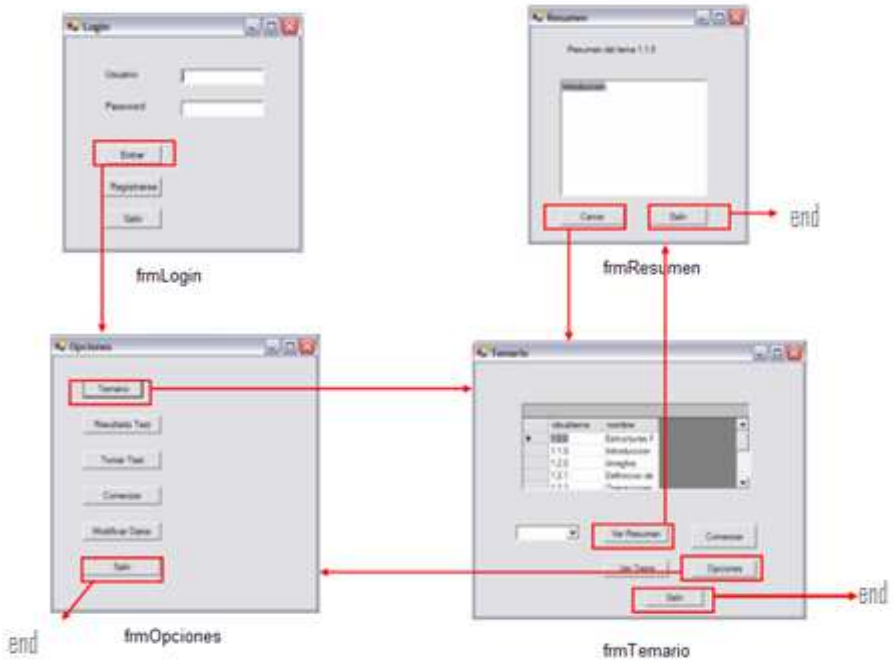


Figure 3-23 Show syllabus sequence

Figure 3-23 shows the sequence to show syllabus, once the student entered the system, select "Topics" and the screen frmTemario. Show the agenda, read the summary of an item on the screen frmResumen, go directly to the first issue or topic of your choice and you can leave the system.

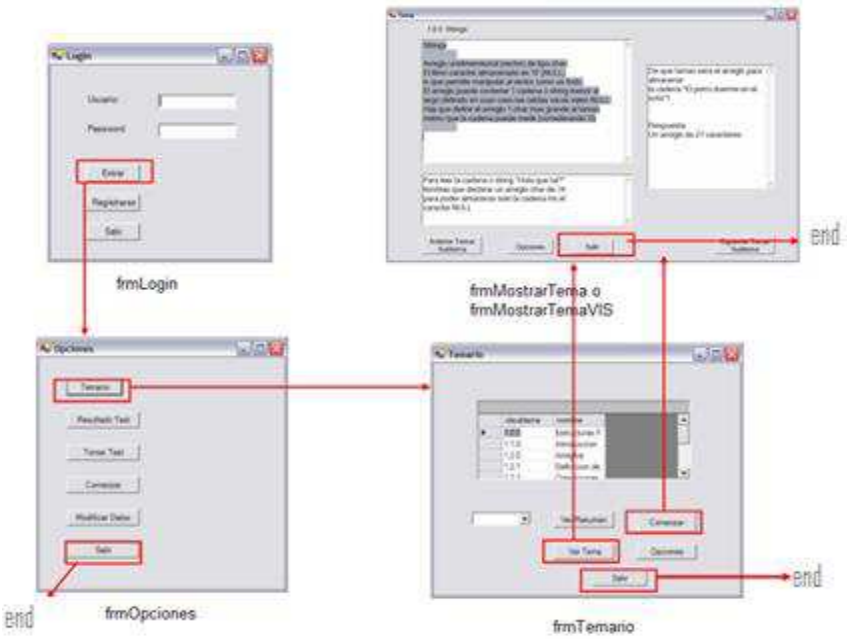


Figure 3-24 Show syllabus sequence and topic

Figure 3-24 shows the sequence to show syllabus item, here follows the same sequence described in Figure 3-14 except that the screen is pressed frmTemario the button "Start" or "View Item" (if already selected a topic) and the screen frmMostrarTema or frmMostrarTemaVIS according to student's learning style (visual or verbal) that outlines the selected topic.

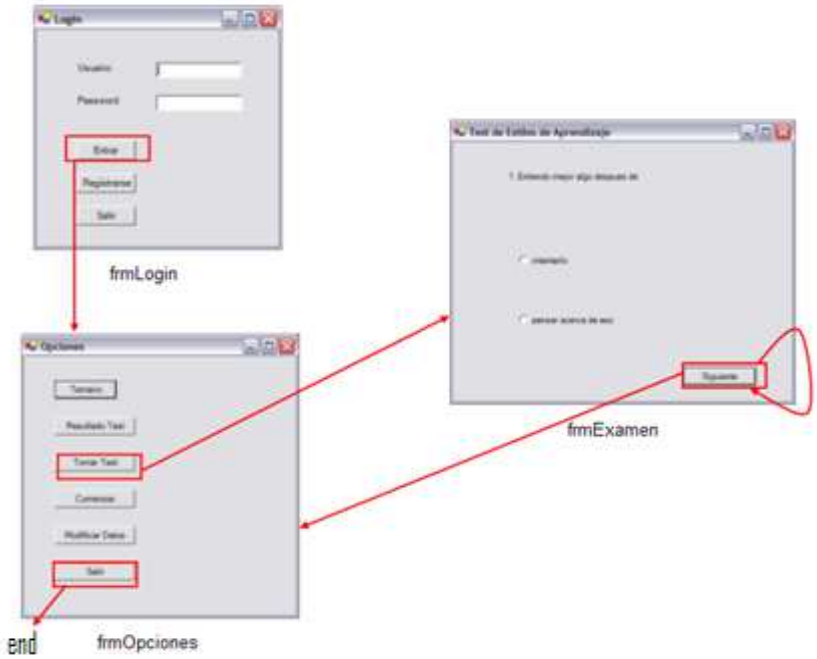


Figure 3-25 Test for sequence learning styles

Figure 3-25 shows the sequence to re-take the test of learning styles, once the student has been validated by the system, select the "Take Test" and the screen frmExamen, where they appear sequentially in the 44 questions test. The reason for re-take the

test is so that students can modify the type of materials that appear in each lesson, in this case the learning style obtained during the test at the beginning of system use is not suited to the student. This can happen if the student, while answering the quick test, did not think her response, so this will give you the opportunity to test it in stride.

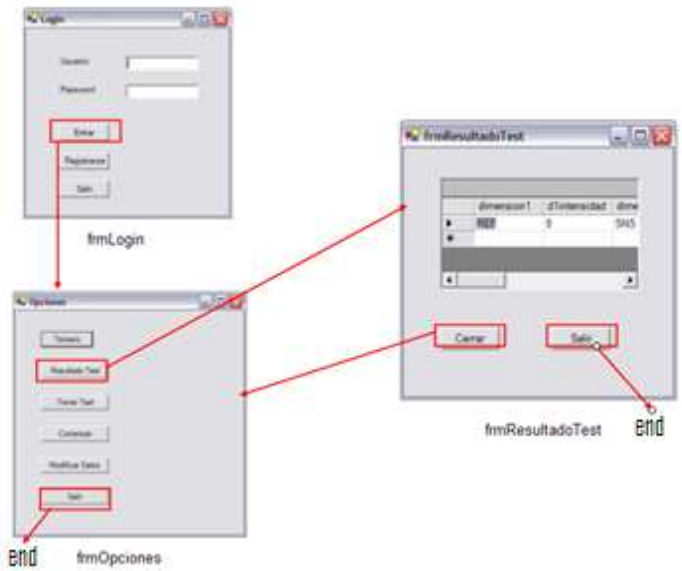


Figure 3-26 Sequence for test results show learning styles

Figure 3-26 shows the sequence to see the result obtained in the test of learning styles. First the user must be validated in the system and the frmOpciones screen should appear. Then the user must select "Test Results" to exit the screen frmResultado where they can view the result obtained in the test.

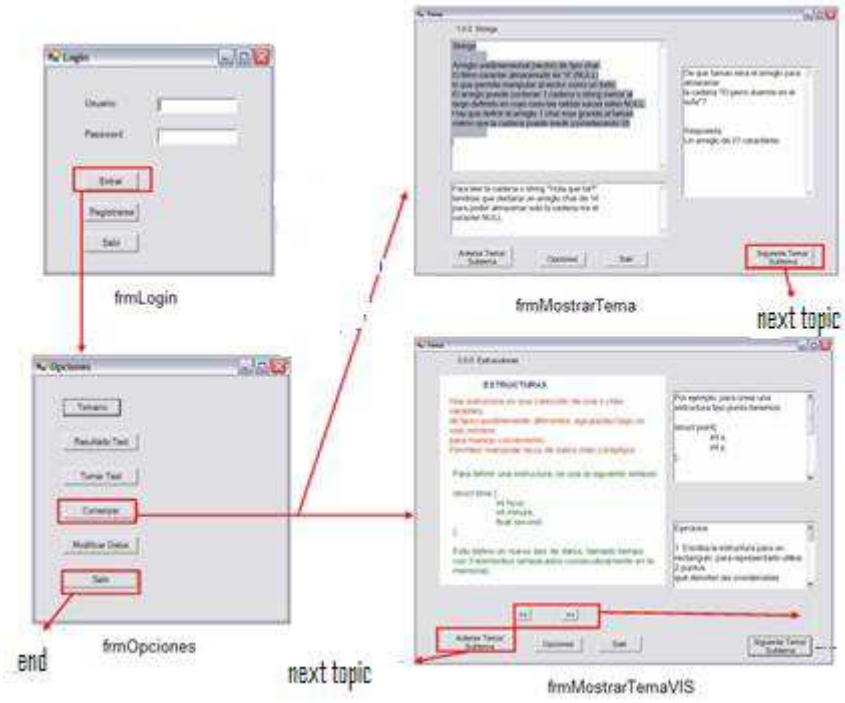


Figure 3-27 Display sequence for an item

Figure 3-27 shows the sequence to display an item. The first thing that is done is validated and entered into the system. Then choose the "Display Item" screen appears frmMostrarTema or frmMostrarTemaVIS as the learning style in the visual or verbal dimension of the pupil. In these screens we can go to the next or previous item, if any, or, if the visual dimension can display multiple images or figures on the screen.

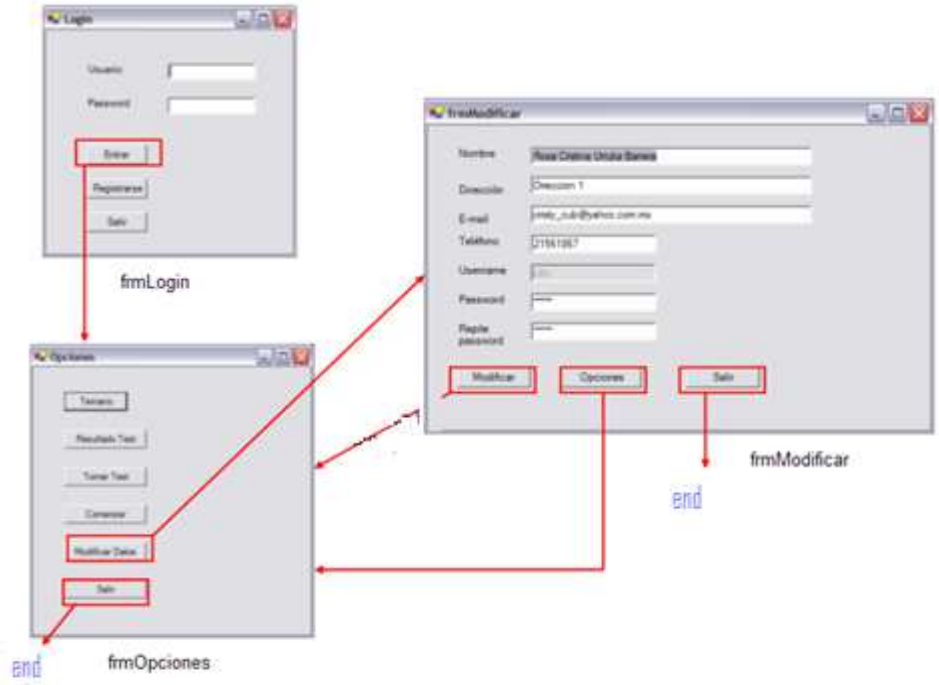


Figure 3-28 Sequence to modify the data of a student

Figure 3-28 shows the sequence to modify the data of a student; this must first be validated and entered into the system. Once the screen is frmOpciones select the "Change Data" and the screen frmModificar here to change the data necessary and select "Edit" to update the data in the database.

3.4 Approach evaluation: experiment with students

3.4.1 Course selection

Computing Engineering Students in the 2006 introductory programming course at ITAM were used as subjects. Twenty six students had three hours of lectures each week. The course was based on teaching the C Programming Language. At the beginning the Felder – Solomon Index of Learning Styles Instrument was applied to determine the students individual learning styles. The course took place during the students' first semester. The Instrument was integrated into the system, and all of the students answered the test. The student used the selected material during the course and at the end of the semester we analyzed the results (see the full contents of the assignment in Appendix A).

3.4.2 Field work

The practical part initiated when trying the system with real students this new form of learning.

A test of the system was made with 26 students from the "Algorithms and Programs" class. Each student first had to register his/her data in the system, then had to answer a test to obtain his/her learning style, and finally got a chance to explore the system and study the materials that best fitted his/her learning style.

The most important differences shown by the system are in the input dimension (visual and verbal), given that the system, for the students that the learning style was visual the system shows the topic material with more pictures and graphics materials or the students with verbal learning styles the system shows the explanations with more plain text, for sequential learning styles students the system is not flexible with the syllabus, the syllabus is mandatory , the students take the lesson topic by topic, that is, sequentially, and for the global students the syllabus is completely flexible, they can choose the topic with a hyperlinks even though it has prerequisites, the students can follow their road. For the other dimensions, such as the active or reflexive, it shows very similar materials, since they were exercises with their answers. For the sensitive or intuitive case, the materials were examples with little explanations about them.

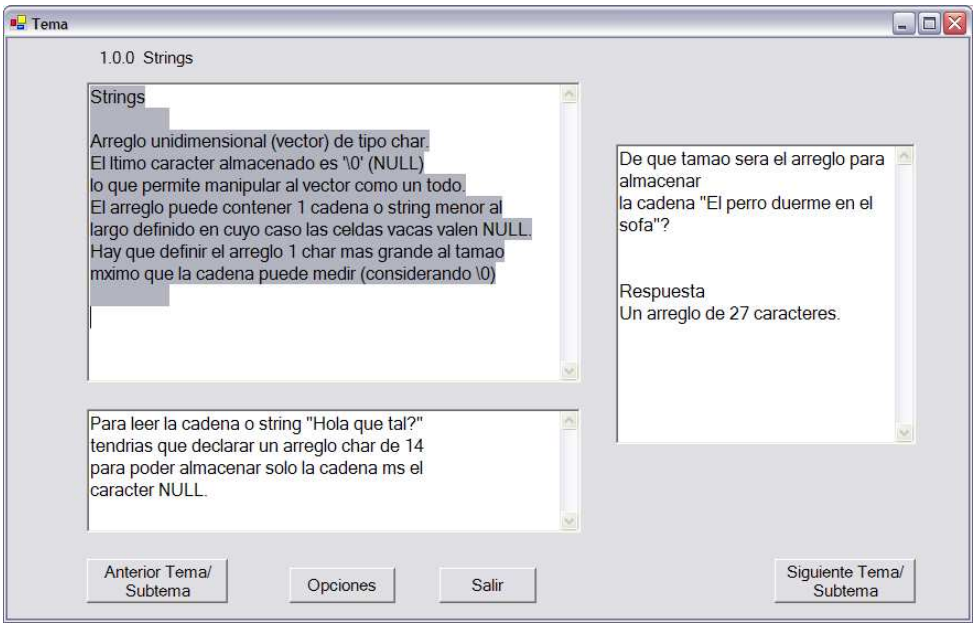


Figure 3-29 Topic for verbal students

Figure 3-29 shows the way a verbal student would see the information about a certain subject.

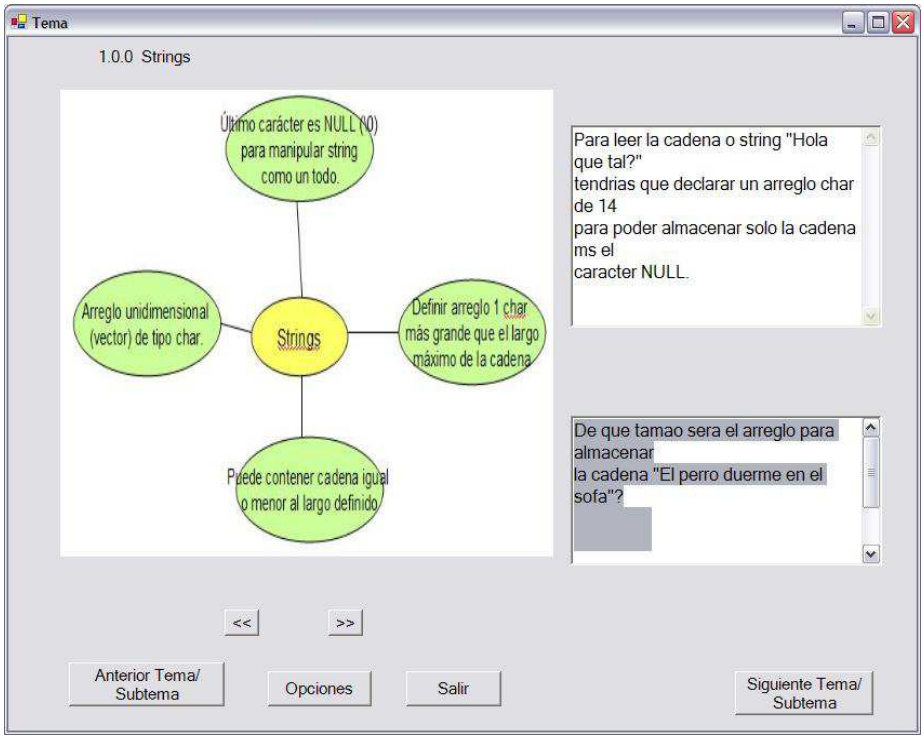


Figure 3-30 Topic for visual students

Figure 3-30 shows the way the system would arrange the materials for a visual student.

The results of the Felder's learning styles test are shown in the Table 3-13:

Group	Style	Number of students
S1	Active	62%
	Reflexive	38%
S2	Sensitive	62%
	Intuitive	38%
S3	Visual	**85%**
	Verbal	15%
S4	Sequential	62%
	Global	38%

Table 3-13 Felder test results

Comparing the active and reflective dimensions, the majority of students were active. Between the sensitive and intuitive dimensions, more students were sensitive. The greatest gap was found between the visual and verbal dimensions, where 22 students were visual and only 4 of them were verbal. Finally, in the sequential and global dimensions, the preponderance was sequential.

After they used the system, a survey was given to the students in order to know if they had learned more or less than the average performance of prior students taking the same class without the system. The results from this survey are the following:

- 76.9% thought that the system helped them understand better a subject, while 23.1% said they understood the lesson the same way they would have understood it with a teacher.
- 53.85% said they learned more with the small interaction they had with the system than with a traditional method, while 46.15% said they had learned the same.

The overall comments to the system were:

Possible improvements, changes or enhancements: 92.31% of the comments asked for more information, more visual materials, audio materials, more examples and more theory. Note that these comments are about the materials, not about the structure of the system. Only 7.69% asked for a friendlier interface.

Concerning how students felt when they interacted with the system, 92.31% said they felt all right with the system, while the remaining 7.69% said they wanted a friendlier interface.

The students thought that the system is based on an interesting idea, a nice alternative for people with trouble understanding a particular subject.

Regarding the handling of the system, 92.31% thought that the system was easy to use since it's clear, friendly, simple, well structured and explained, but they still asked for more tables and different options. Only 7.69% had complaints vis-à-vis the friendliness of the interface.

3.5 Conclusions

The results obtained with the system were interpreted and analyzed, and it reached conclusions on the importance of looking for new forms of learning in a world that continuously is advancing in this field

The use of a system with architecture similar to the one described above helps raise the learning abilities of the student, as the system adapts to each student's particularities. Furthermore, the system will be able to display the same information in different ways, with different resources, making the learning process easier due to the fact that some people are more receptive to some kind of information than other. Therefore, the use of several resources will help all kinds of students.

There are many studies concerning nothing but learning styles; there are many tutoring systems without a pedagogical method (Gilbert et al., 2005). What makes this system different is that it integrates both points of view, and that it shows the material on a user-customized basis.

Psychologists who have studied learning styles generally diagnose the average style of a given group of students and give recommendations on how to teach them based on this average. On the other hand, in our system, it is the specific learning style of each student that is both diagnosed and targeted by the teaching module of the system, thus providing individualized instruction.

The system's design is generic in the sense that we have used it to teach the C programming language, but can easily replace this course material with other subject matter by modifying only the Materials Database, without the need to alter any other parts of the system.

Therefore an answer to research question 1: Is it helpful for a student in a course to learn and acquire knowledge using his/her particular learning style and e-media combined in a learning system? Yes is very helpful. The results obtained with the system were very satisfactory, since we confirmed the fact that a student can learn more if the teaching is accorded to his/her learning style. The system was accepted positively by the students who participated in the test. They thought that this is an innovative idea that can help people have a better performance whilst learning.

It was essential to make this experiment because we could test the feasibility of our research and we conclude that it is possible also we introduced the concept of personalization based on learning styles and electronic media as being well accepted by students, but we know that the matching was limited to only two learning styles and one teaching strategy, so we found several problems: which is the correct e-media material for the each learning styles? Are the teaching strategies important to that selection? We, therefore, have chosen a different approach and decided to concentrate on generating the guide for the user. Then we consider a different approach and decided to concentrate on generating a framework for matching the learning styles and electronic media, but not only the electronic media, also the teaching strategies. We suggest a solution of these in the next chapter.

Chapter 4

4 Student learning styles adaptation method

In the previous chapter we identified the types of strategies that can be applied in an e-learning system as a response to users' learning styles. We distinguish between instructional strategies such as selection of items, ordering information or providing different instructional material. To provide this strategy classification we looked through the chapter at the recommendations from the psychological literature as well as at the existing examples of e-learning systems providing adaptation to learning styles.

Recent research on the learning process has shown that students tend to learn in different ways and that they prefer to use different teaching resources as well. Many researchers agree on the fact that learning materials shouldn't just reflect of the teacher's style, but should be designed for all kinds of students and all kind of learning styles.

Even though they agree on the importance of applying these learning styles to different learning systems, we found with the previous application that various problems still need to be solved, such as matching teaching contents with the student's learning style.

The current chapter[2] presents our approach to try to solve this problem. We describe the design of a personalized teaching method that is based on an adaptive framework using Felder and Silverman's learning styles and which is combined with the selection of the appropriate teaching strategy and the appropriate electronic media. Students are able to learn and to efficiently improve their learning process with such method. Section 4.1 describes the introduction and the related works. Section 4.2 explains the pedagogical model that includes learning and teaching styles, summary theory discussed in the previous chapters. Section 4.3 explains the adaptive teaching framework, the results of validation of our framework through interviews with and questionnaires for a number of psychologists with expertise in the field of learning styles and how they are visualized by end-users. Section 4.4 first refers to guidelines for use the framework, and then it presents the application method of evaluation of our framework from the point of view of authoring ease and satisfaction with the resulting presentation which we performed with students of our university. Finally in

[2] *The content of this chapter was presented in III Congreso Mundial de Estilos de Aprendizaje 2008, at the 8th IEEE Int. Conf. on Advanced Learning Technologies (ICALT'08) and published in the Educational Technology and Society Journal (october 2009 issue).*

Section 4.5 provides the results of validation and evaluation of our approach. By presenting the actual implementation this chapter answer research question 2 of this dissertation.

4.1 Incorporating learning styles, teaching styles and electronic media

4.1.1 Introduction

Humans have different ways of learning. Some can assimilate in a better way the knowledge received visually, auditory or through a certain sense. Psychology and cognitive sciences have longtime explored this question. The Dual Coding Theory, for example, states that information is processed through one of two usually independent channels (Beacham et al., 2002). While one channel processes verbal information such as text or audio, the other one processes visual information like diagrams, images, animations, etc. The Sperry's Nobel Prize winning left-brain / right-brain model of thinking suggested that the right hand side and the left hand side of our brain possessed specialized and differentiated functions (Dervan, et al. 2006). The left cerebral hemisphere is thought to be more verbal, logical or clinical, that is, more analytical, while the right cerebral hemisphere influences more the artistic and the sensing side of our intellectual. Powerful encoding and visualization techniques have shown to enable the creation lasting memory and improve recall. Dual encoding, for example, has proven to be an extremely effective learning tool. The simplest and most common form of which involves presenting the information both textually and visually. “Whole brain” learning is known to be a far more effective way to learn. The better connected the two halves of the brain, the greater the potential of the brain for learning and creativity (Rose, 1998; Dervan, et al. 2006).

However, most educational systems have ignored individual differences that exist between learners, such as the learning ability, the background knowledge, the learning goals and the learning style (Ford & Chen, 2001). Educational systems generally provide a unique and standardized teaching material to all learners which tend to benefit to those whose learning style and background knowledge fits well with the teaching material. If the teaching style employed closely matches the student preferred style of acquiring knowledge, learning becomes easier and more natural, results improve and learning time is reduced (Rose, 1998). On the other hand, if a student, for example, is more visual than verbal and everything is written on the blackboard without auditory resources, the student will experience difficulties in attaining the pedagogical goals in the requested time. In a few words, traditional

teaching material and strategies generally tend to benefit some students more than others.

In this sense, it is necessary to deploy resources to support the learning process in a way that it not only suits the characteristics of a few, but that it adapts to the characteristics of each student. In the context of Information Technology evolution and the availability of large number of electronic media, the idea of matching e-media with appropriate teaching and learning styles has been explored since the late 90's. There are many studies on the effectiveness of combining multimedia and hypermedia with learning styles in educational systems (Najjar, 1996; Liao, 1999). They attempt to associate specific e-media characteristics to different categories of learners and propose instruments and methods for assessing learning style (Riding & Rayner, 1998). Most of these studies rely on Kolb's Learning Styles Inventory (LSI) (Kolb 1984) and Soloman-Felder Index of Learning Styles (ILS) (Soloman & Felder, 1993).

However, very few researchers give an idea of which appropriate combinations of electronic media and learning styles are more effective than others. An electronic media can be used in different ways to implement different teaching strategies which can be matched with different learning styles. For example, a discussion forum can be used in different ways. It can be used to assign a practical task to students in such a way that students solve the assigned problem in a collective manner. This fits well with sensitive learning style. The discussion forum can also be used to give a sequential series of theoretical presentations to students who can interact with the teacher. The sequence of presentations associated with the corresponding discussion is an adequate teaching material for sequential style students.

The goal of this chapter is the creation of teaching methods and environments that use the vast resources offered by IT in such a way to adapt teaching material and strategies to the learner's skills and learning style. We use Felder and Silverman (1988) model for defining learning style, together with empirically built adaptation framework for matching e-media with combinations of teaching strategies and learning styles. In a previous work, we explored some basic ideas concerning the matching of e-media and learning styles in the context of an experimental e-learning system (Franzoni & Assar, 2007). In this dissertation, we present a general framework for combining and adapting teaching strategies, learning styles and electronic media. This framework has been experimented in an undergraduate computer science course. First results show that a majority of students have a better assimilation of knowledge and that students appreciated positively the personalized pedagogical material proposed in the course.

4.1.2 Examples of e-learning systems with adaptation to LS

Recent investigations (Kwok & Jones 1985; Carver et al., 1999; Gilbert & Han 1999; Grigoriadou, Papanikolaou & Kornilakis 2001; Stash & De Bra 2004; Hong & Kinshuk 2004), try to integrate the learning styles and e-media in the design of their applications. This is not an easy process, however. One of the main difficulties on the designing of hypermedia systems, is linking the learning styles with the hypermedia applications. Most of the teaching systems adaptation that integrates learning styles is based on the premise that adapting the teaching strategies with the students' learning styles will give better results (Dagger, Wade & Conlan 2003; Paredes & Rodriguez 2002; Stern & Woolf 2000; Triantafillou, Pomportsis & Georgia 2002). Table 4-1 shows some of the systems found, their learning styles and the type of adaptation.

System	Learning style	The adaptation Model	The adaptation behavior
ARTHUR (Gilbert & Han 1999)	visual-interactive, auditory-lecture and text styles	The adaptation is achieved by providing different media representations for each learner. Auditory representation is achieved using sounds and streaming audio. To appeal to visual and kinesthetic learners puzzles, animations, drag and drop examples and riddles are used.	Type and usually the sequencing of material they offer based on a framework proposed by the authors
CS388 (Carver, Howard & Lane 1999)	Felder-Silverman learning styles model global-sequential, visual-verbal, sensing-intuitive, inductive-deductive styles (Felder & Silverman, 1988)	The adaptation is achieved by providing different media representations for each learner. Uses different types of media such as graphs, movies, text, slideshows	Based on research studies, (Felder and Silverman, 1988) about the type of instructional material that learners with different learning style prefer
MANIC (Stern & Woolf 2000)	applies preferences for graphic versus textual information	The adaptation is achieved by providing different media representations for each learner. Uses graphic and textual information	Type and usually the sequencing of material they offer based on a framework proposed by the authors
INSPIRE (Grigoriadou, Papanikol	Honey and Mumford categorization of activists,	The Adaptation lies in presenting a different sequence of alternative contents of the concepts. Concepts can be	Based on research studies (Honey & Mumford, 1992), about the type of instructional

aou & Kornilakis 2001)	pragmatists, reflectors and theorists based on Kolb (Honey & Mumford, 1992)	represented by 'example', 'activity', 'theory', 'exercise'	material that learners with different learning style prefer (Papanikolaou et al., 2003)
Tangow (Paredes & Rodríguez 2002)	sensing-intuitive dimension from the Felder-Silverman learning style model (Felder & Silverman, 1988)	The Adaptation lies in presenting a different sequence of alternative contents of the concepts. Concepts can be represented by 'example', 'exposition'	Type and usually the sequencing of material they offer based on a framework proposed by the authors
AES-CS (Triantafillou, Pomportsis & Georgia 2002) (Triantafillou et al., 2003)	field-dependent (FD) and field-independent (FI) style (Witkin et al., 1977)	Provides field-dependent learners with navigational support tools, such as concept map, graphic path indicator, advanced organizer, in order to help them organize the structure of the knowledge domain. The system guides them through the learning material via adaptive navigation support. Field-independent learners are provided with a learner control option - for them, the system shows a menu from which they can proceed with the course in any order. Learners can switch between different instructional strategies	Adopts several instructional strategies that accommodate learners' learning style in relation with: the approaches, the control options, the contextual organizers, the study instructions, the feedback, and the lesson structure.
PHP Programming Course (Hong & Kinshuk 2004)	Active – Reflective, Sensing – Intuitive, Visual – Verbal, Sequential - Global dimension from the Felder-Silverman learning style model (Felder & Silverman, 1988)	The adaptation is achieved by providing different representations for each learner. Uses different types of resources such as concepts, theory, colors, text, slideshows, audio, etc.	Based on research studies, (Felder & Silverman, 1988) about the type of instructional material that learners with different learning style prefer

Table 4-1 Learning Styles and Systems Adaptation Models

This review shows that the different adaptation to learning styles systems are done in terms of content adaptation, navigation routes or the use of multiple navigation instruments. However, the election of learning styles seems to be limited, while it is

based on the appropriate technology. Also, most of the systems shown, except CS388 and PHP Programming Course, evaluate and adapt to the chosen learning styles dimensions. One disadvantage of CS388 and the PHP Programming Course is that electronic media is limited to graphics, hypertext, audio and video, and that it doesn't integrate teaching strategies. In this sense, this work is new and significantly different from the previous efforts done by others in the field.

4.2 Pedagogic model

4.2.1 Learning styles model by Felder-Silverman

We have selected the Felder and Silverman model as the basis of our framework of adaptive teaching for the following reasons (how we mentioned in chapter three):

- it has been successfully implemented in previous work when individually adapting the electronic learning material (Carver, Howard & Lane, 1999; Hong & Kinshuk, 2004; Paredes & Rodriguez, 2002),
- it has been approved by its author and other specialists (Zywno, 2003; Felder & Spurlin, 2005),
- it is user friendly and the results are easy to interpret,
- the number of dimensions is controlled and can actually be implemented (Paredes & Rodriguez, 2002).

Table 4-2 shows the learning styles dimensions (LSD):

Learning Style Dimension	Type	Description
Perception (**LSD1**)	Sensitive (**S**)	Rather deal with facts, raw data and experiments, they're patient with details, but don't like complications
	Intuitive (**I**)	Rather deal with principles and theories, are easily bored when presented with details and tend to accept complications
Entry Channel (**LSD2**)	Visual (**Vi**)	Easy for them to remember what they see: images, diagrams, time tables, films, etc.
	Verbal (**Ve**)	Remember what they've heard, read or said.

Processing (**LSD3**)	Active (**A**)	Learn by working in groups and handling stuff
	Reflexive (**Re**)	Learn better when they can think and reflect about the information presented to them. Work better alone or with one more person at most.
Understanding (**LSD4**)	Sequential (**Seq**)	Follow a lineal reasoning process when solving problems and can work with a specific material once they've comprehended it partially or superficially
	Global (**G**)	Take big intuitive leaps with the information, may have a difficulty when explaining how they got to a certain result, need an integral vision

Table 4-2 Felder Learning Styles Dimensions

4.2.2 Teaching strategies

Teaching strategies (TS) are the elements given to the students by the teachers to facilitate a deeper understanding of the information. The emphasis relies on the design, programming, elaboration and accomplishment of the learning content. Teaching strategies must be designed in a way that students are encouraged to observe, analyze, express an opinion, create a hypothesis, look for a solution and discover knowledge by themselves. Teaching strategy, for example, refers to an organized and systematized sequence of activities and resources that teachers use while teaching. The main objective is to facilitate the students´ learning.

One crucial aspect of our research is the integration of electronic media with teaching strategies, because of the informational technology breakthroughs that allow us to use a variety of them. On the other hand, we need to link such teaching strategies with the concept of learning styles, something that hasn't been exploited to the extent that is intended here. The teaching strategies for this case are in table 4-3.

Teaching Strategies
TS1 = Games and simulations
TS2 = Learning based on problem solving
TS3 = Role playing
TS4 = Presentation
TS5 = Discussion panel
TS6 = Brainstorming
TS7 = Case study
TS8 = Question and answer method
TS9 = Project design method

Table 4-3 Teaching strategies (TS)

4.3 Adaptive teaching framework

One usual definition of framework is the following: "a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality". From the point of view of teaching strategies and their definitions, there's a need to facilitate the implementation of Felder and Silverman´s theories of learning styles by selecting the proper electronic media and teaching strategies for each style (Hong & Kinshuk, 2004; Carver et al., 1999;Felder & Silverman, 1988; Gilbert & Han, 1999; Paredes & Rodriguez, 2002).

The proposed framework consists on matching the different learning styles with teaching strategies. It also suggests the suitable electronic media as a channel for its representation, thus personalizing it to every student. This framework has been constructed based on our own diverse experiences with Soloman – Felder learning style theory and usage of e-media (Franzoni et al., 2008). It has been checked through an expert panel using the Delphi method which was held during the III Congreso de Estilos de Aprendizaje at Cáceres (Spain) in July 2008 (see the full contents of the assignment in Appendix B).

This framework is based on the four learning styles dimensions (LSD):

$$LSD = \{LSD_1, LSD_2, LSD_3, LSD_4)\}$$

Each dimension is defined as a combination of four values according to the learning styles dimension (see Table 2):

LSD= {(Sensitive (**S**) / Intuitive (**I**)), (Visual (**Vi**) / Verbal (**Ve**)), (Active (**A**) / Reflexive (**Re**)), (Sequential (**Seq**) / Global (**G**))}.

In this case, there are 16 (2^4) learning styles combinations (LSC):

LSC={(S,Vi,A,Seq), (S,Vi,A,G), (S,Vi,R,Seq), (S,Vi,R,G), (S,Ve,A,Seq), (S,Ve,A,G), (S,Ve,R,Seq), (S,Ve,R,G), (I,Vi,A,Seq), (I,Vi,A,G), (I,Vi,R,Seq), (I,Vi,R,G), (I,Ve,A,Seq), (I,Ve,A,G), (I,Ve,R,Seq), (I,Ve,R,G)}.

A detailed review of the learning styles theory helped us establish the following three attributes for a learning style:

- description,
- appropriate pedagogical method
- characteristics of the media to used

Then, the description and the appropriate method were associated to find the suitable teaching strategies, and finally the characteristics of media to be used mentioned in the learning styles theory was linked with the electronic media.

Each LSC can be associated with a teaching strategy (TS_i):

$$TS = \{TS_1, TS_2, \dots, TS_9\}.$$

Teaching strategies hold a one-to-many relationship with the learning styles. There can be one or many teaching strategies that accommodate one learning style.

Each LS can be associated with an appropriate electronic media (EM_i):

$$EM= \{EM_1, EM_2, \dots, EM_{27}\}.$$

Learning style hold a one-to-many relationship with the electronic media. For each learning style, there are one or many teaching strategies that can be implemented by one or many electronic media based on adequate learning style (see Figure 4-1).

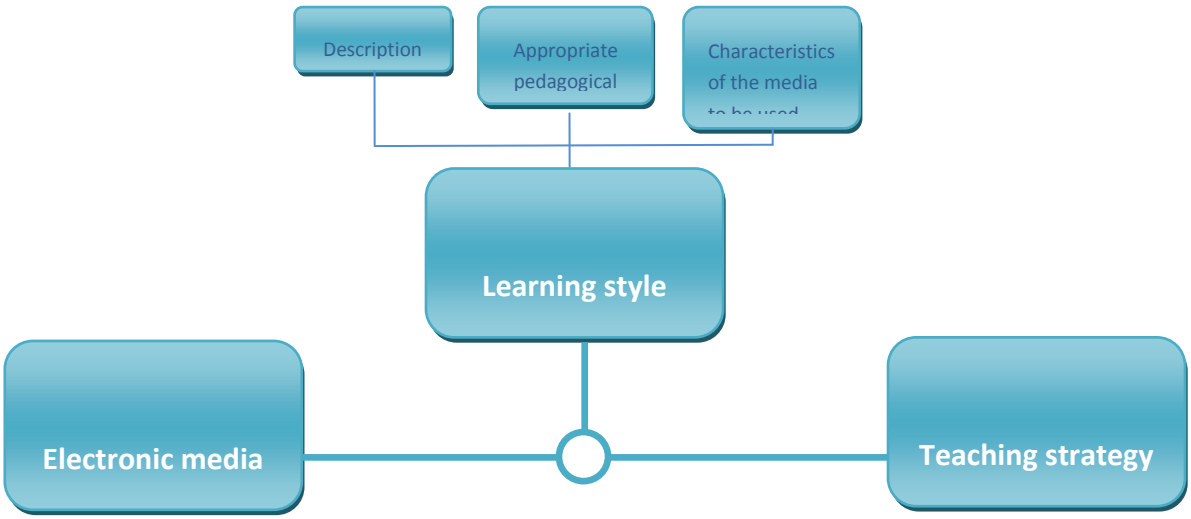


Figure 4-1 Adaptive Teaching Framework relation entity diagram

4.3.1 Delphi expert panel

Delphi is a structured group communication method for soliciting expert opinion about complex problems or novel ideas, through the use of a series of questionnaires and controlled feedback. Delphi has been well explored in a variety of areas, including government, medical, environmental and social studies, as well as business and industrial research (Linstone & Turoff, 2002), but had limited use in Information Systems (IS) research (e.g. Brancheau et al., 1996; Galliers et al., 1994, Schmidt et al., 2001). In all subject domains Delphi has been primarily employed for forecasting, planning, issue identification or for framework/strategies development (Okoli & Pawlowski, 2004). Thus the method has mainly been used for theory generation, rather than testing and evaluation (Holsapple & Joshi, 2002).

4.3.2 Characteristics of the Delphi method

The Delphi is founded upon the use of techniques that aim to develop from a group of informants an agreed view or shared interpretation of an emerging topic area or subject for which there is contradiction or indeed controversy.

4.3.3 Key stages in a Delphi study

An analysis of the process followed and the relevant literature yielded a generic Delphi model, comprising the exploration stage.

The exploration stage (Linstone and Turoff, 2002; Ziglio, 1996) is a free-flowing and unstructured investigation of the issues, limitations, challenges and problems that affect or are affected by the elements within the study domain. It includes the following activities:

- establishing criteria for selection of participants
- establishment of a Delphi panel
- design of the data collection and analysis instruments
- eliciting the initial set of issues to be tested through the Delphi rounds,
- Piloting of the toolkit.

We are describing how we did the framework. This framework has been constructed based first with the literature review and previous findings and a Delphi panel.

Activities for the Delphi panel, first we chose one panel to participate in the exercise, 10 teachers from ITAM with experience in computer courses, 10 teachers from different universities with experiences with e-learning in computer courses. After that we developed a questionnaire and tested electronically with a small different group for ITAM teachers (e.g., ambiguities, vagueness), then we send electronically the first questionnaires to the panelists, after that we analyzed the first round responses, then we send again the second round questionnaires, we analyzed the result again and prepared the report and the questioner again for 6 experts which were held during the "III Congreso de Estilos de Aprendizaje" at Cáceres (Spain)(Franzoni et al. 2008), finally we consolidate all the information and made some graphics to illustrate the results.

4.3.4 Results the Delphi expert panel

In order to establish the relationship between the different dimensions, the teaching strategies´ variables and the electronic media, a detailed review of the surveys was done, thus getting the components that relate to the content, method and media. Then, the methods and contents were associated to find the suitable teaching strategies, and finally the media mentioned in the learning styles theory was linked with the electronic media.

Figure 4-2 illustrates the results of the matching between the teaching strategies and learning styles. Note: the expert's results were based on the answers for twenty teachers, and they selected the teaching strategy that matches better with the learning style. The measure has up to 15 including their answers.

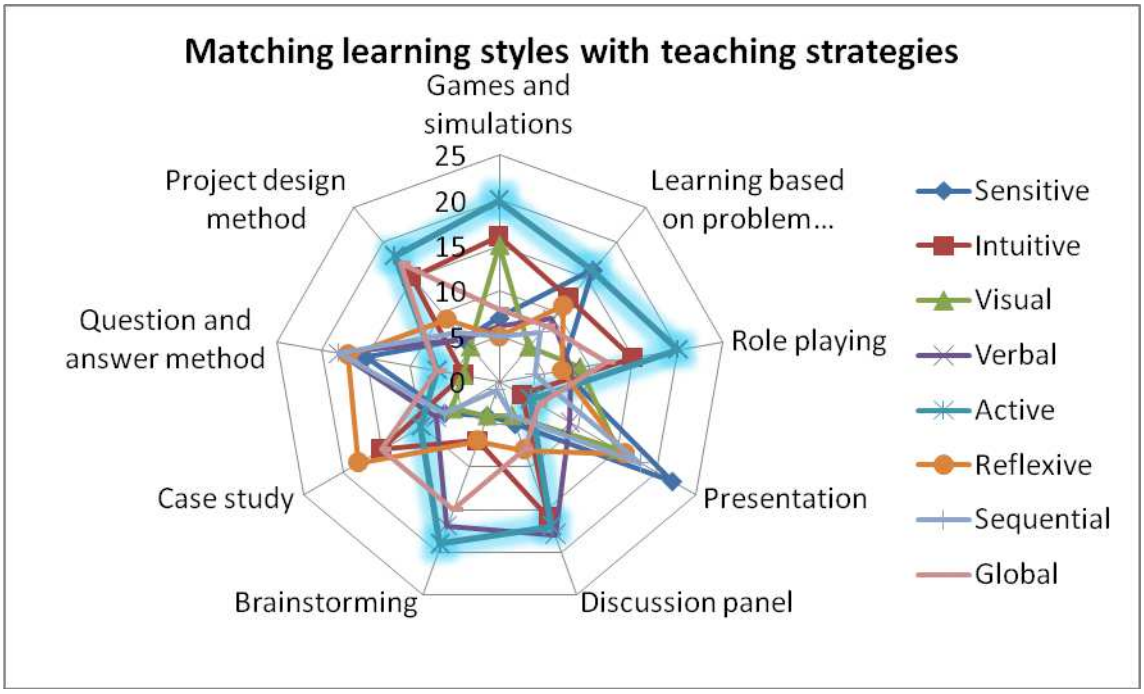


Figure 4-2 Matching learning styles with teaching strategies- example active LS

For example, a student with active learning styles match with games and simulation, learning based on problem solving, role playing, discussion panel, brainstorming and project design method. Other example is shown in the Figure 4-3, the student with sequential learning styles match with presentation and question and answer method.

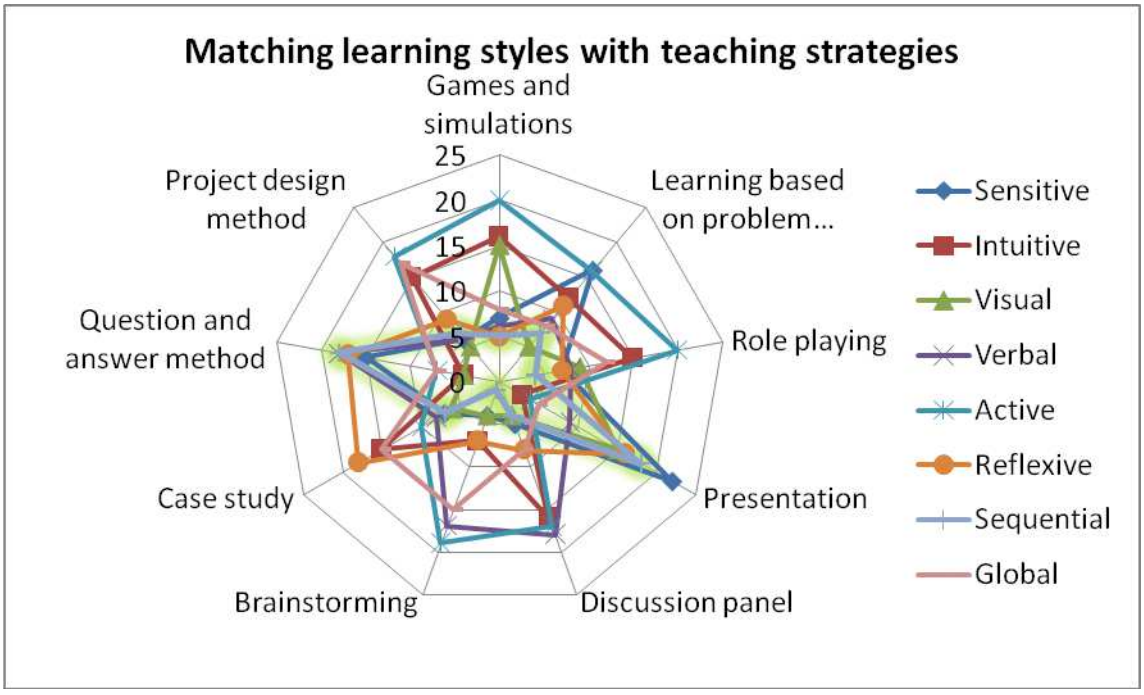


Figure 4-3 Matching learning styles with teaching strategies example sequential LS

Figure 4-4 illustrates the results of the matching between the electronic media and learning styles. Note: the expert's results were based on the answers for twenty teachers, and they selected de teaching strategy that matches better with the learning style. The measure has up to 15 including their answers.

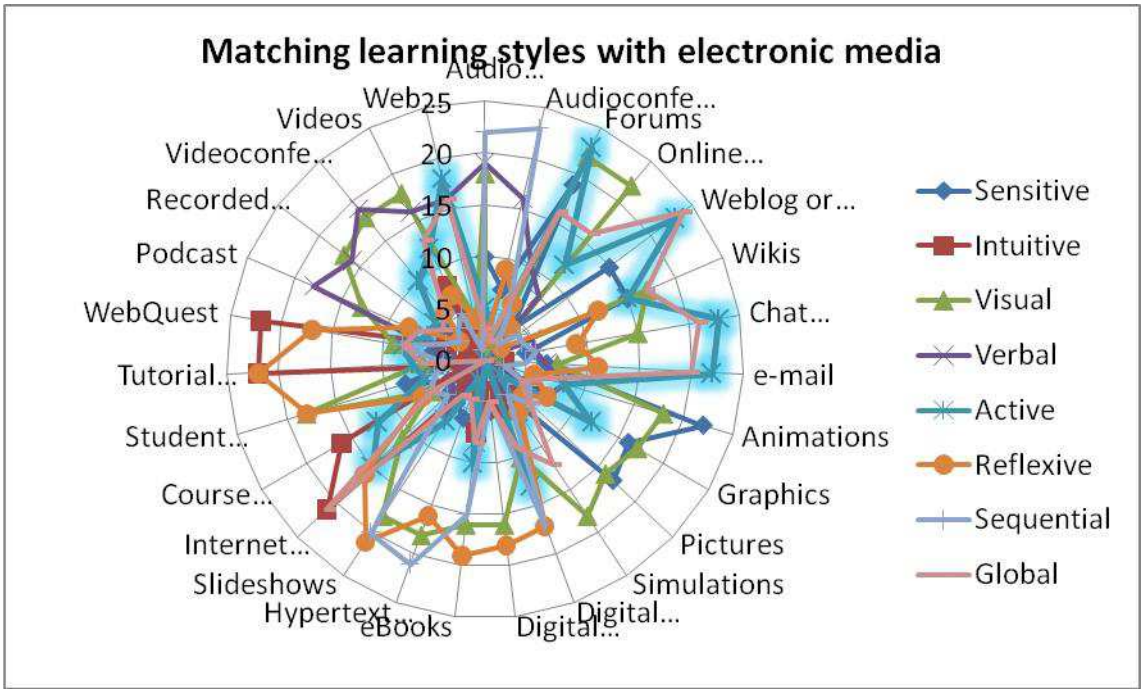


Figure 4-4 Matching learning styles with electronic media example active LS

For example, a student with active learning styles match with the electronic media like: Collaboration (Forums, blogs and wikis), Communication (Chat, e-mail) and Search (Internet search). And other example shows the Figure 4-5, student with sequential learning styles match with the electronic media like: Audio (Audiorecording, audioconference) and Read (Digital magazines, eBooks, hypertext (web pages), slideshows).

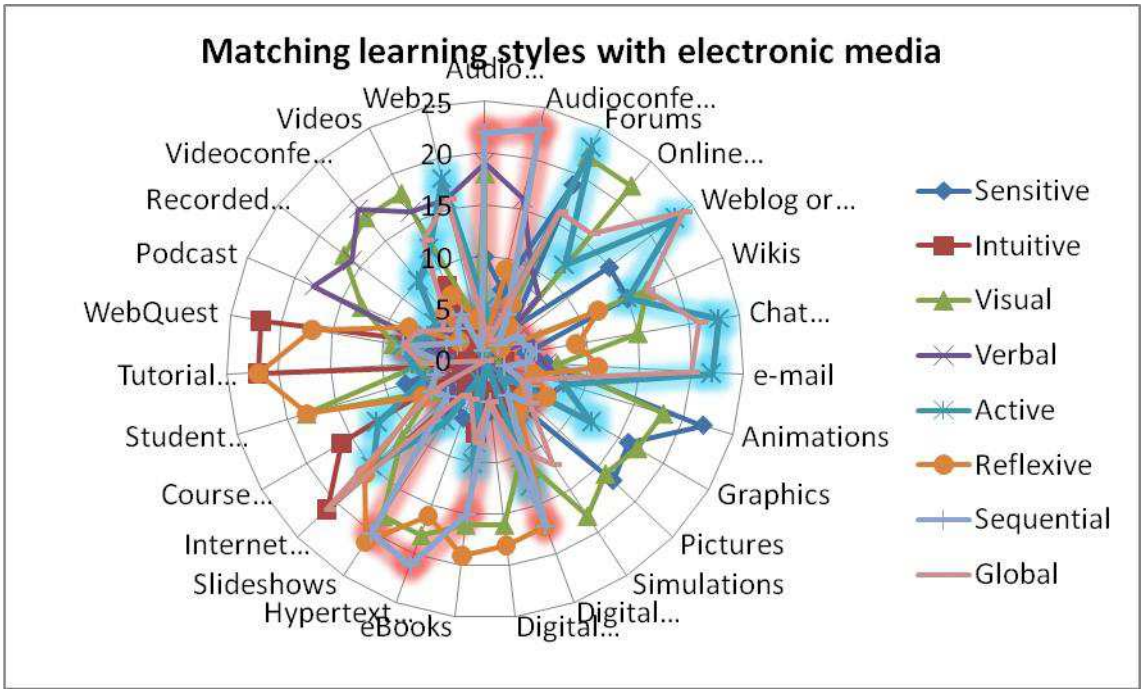


Figure 4-5 Matching learning styles with electronic media example sequential LS

Now we take the previous findings, the literature review and the results of the Delphi expert panel to generate the framework.

Table 4-4 shows the matching framework, this framework can help teachers, through knowledge of the ways our students learn to solve the problem of integrating new information technologies and configure new teaching and learning situations. Knowing the learning styles of students we will select the type of teaching strategies (see Figure 4-2 and Table 4-4) and the most appropriate electronic media (See Figure 4-4 and Table 4-5).

		Learning styles							
		Sensitive	Intuitive	Visual	Verbal	Active	Reflexive	Sequential	Global
Teaching strategy	Games and simulations		X	X		X			
	Learning based on problem solving	X				X			
	Role playing		X			X			X
	Presentation	X		X			X	X	
	Discussion panel		X		X	X			
	Brainstorming				X	X			X
	Case study		X				X		X
	Question and answer method	X			X		X	X	
	Project design method		X			X			X

Table 4-4 Adaptive framework LS and TS relationships

According to teaching strategies selected in the table above the teacher can select the specific electronic media that should be the best appropriate to the instruct knowledge based on the learning style (see Table 4-5).

			Learning styles							
			Sensitive	Intuitive	Visual	Verbal	Active	Reflexive	Sequential	Global
Electronic media	Audio	Audio Recording				X			X	
		Audioconference				X			X	
	Collaboration	Forums	X		X		X			X
		Online learning communities			X					X
		Weblog or blog	X				X			X
		Wikis	X		X		X			X
	Communication	Chat (Messenger)					X			X
		e-mail					X			X
	Diagrams	Animations	X		X					
		Graphics	X		X					
		Pictures	X		X					
		Simulations			X					
	Read	Digital magazines						X	X	
		Digital newspapers						X		
		eBooks			X			X	X	
		Hypertext (web pages)			X			X	X	
		Slideshows			X			X	X	
	Search	Internet research		X			X	X		X
	Tutoring	Course Legacy System		X						
		Student Response System						X		
		Tutorial systems		X				X		
		WebQuest		X				X		
	Video	Podcast				X				
		Recorded live events			X	X				
		Videoconference			X	X				
		Videos			X	X				
		Web seminars (broadcasts)								

Table 4-5 Adaptive framework LS and EM relationships

Tables 4-6, 4-7, 4-8 and 4-9, present in detail the adaptive teaching framework for each learning style dimension. Integration elements for LSD_1 (Perception (Sensitive, Intuitive)) are shown on Table 4-6.

Perception / Specifications	Sensitive	Intuitive
Description	Practical. Don´t like courses without an immediate link to the real world	Conceptual, innovative, oriented to theory and meaning, enjoy working with abstract problems and mathematic formulations.
Appropriate pedagogical method	Specific, facts and procedure oriented, enjoy problem solving by following well established procedures, patient when dealing with details, enjoy practical work, lab class and can memorize things easily	Are innovative and hate repetitive work, rather discover possibilities and relationships, assimilate new concepts easily, don´t like courses that require much memory and tedious calculation.
Characteristics of the media to be used	Practical, problem solving oriented, laboratory and experiments	Theoretical, abstraction and math related
Associated Teaching Strategies	Learning based on problem solving Presentation Question and answer method	Games and simulations Role playing Discussion panel Case study Project design method
Electronic Media	Collaboration(Forum, Weblog or blog, Wikis) Communication (e-mail, graphics, pictures)	Search (Internet research) Tutoring (Course legacy system, tutorial systems, WebQuest)

Table 4-6 Adaptive framework for the LSD1 (Perception (Sensitive, Intuitive))

Integration elements for LSD_2 (Entry Channel (Visual, Verbal)) are shown on Table 4-7.

Entry Channel / Specifications	Visual	Verbal
Description	Highly visual elements	Oral and text elements
Appropriate pedagogical method	Rather work with visual representations when receiving information and remember what they see	Rather receive information spoken or verbally and remember what they read or hear
Characteristics of the media to be used	Visual representations and diagrams	Text and sounds
Associated Teaching Strategies	Games and simulations Presentation	Discussion panel Brainstorming Question and answer method
Electronic Media	Collaboration(Forums, Online learning communities, Wikis) Communication (Chat (Messenger), e-mail, Diagrams, Animations, Graphics, Pictures, Simulations) Read (eBooks, Hypertext (web pages), Slideshows) Video (Recorded live events, Videoconference, Videos)	Collaboration (Forums, Online learning, communities) Video (Podcast, Recorded live events, Videoconference, Videos, Web seminars (broadcasts))

Table 4-7 Adaptive framework for the LSD2 (Entry Channel (Visual, Verbal))

Integration elements for LSD_3 (Processing (Active, Reflexive)) are shown on Table 4-8.

Processing / Specifications	Active	Reflexive
Description	Applicable and group work	Write short summaries
Appropriate pedagogical method	Tend to comprehend and assimilate new information when they practice using it (discussion, implementation, group presentations) and rather learn working with others	Think about quietly before go ahead Stop periodically to review what have been learning Stop periodically to think possible questions Stop periodically to think possible applications
Characteristics of the media to be used	Group work and cooperation	Watching Listening
Associated Teaching Strategies	Games and simulations Learning based on problem solving Role playing Discussion panel Brainstorming Project design method	Presentation Case study Question and answer method
Electronic Media	Collaboration (Forums, blogs and wikis) Communication (Chat, e-mail) Search(Internet search)	Read(Digital magazines, Digital newspapers, eBooks, Hypertext (web pages),Slideshows) Search (Internet research) Tutoring (Student Response System, Tutorial systems, WebQuest)

Table 4-8 Adaptive framework for the LSD3 (Processing (Active, Reflexive))

Integration elements for LSD_4 (Understanding (Sequential, Global)) are shown on Table 4-9.

Understanding / Specifications	Sequential	Global
Description	Orderly, step by step and sequential	See everything as a whole
Appropriate pedagogical method	Learn through small orderly steps when these are logically associated and follow small orderly steps logically associated when solving problems	Learn through big leaps, suddenly and almost randomly, can solve complex problems quickly and put things together in an innovative way may have difficulties to explain how they did it
Characteristics of the media to be used	That allows content to be shown in steps (chapters)	That allow to see everything as a whole
Associated Teaching Strategies	Presentation Question and answer method	Role playing Brainstorming Case study Project design method
Electronic Media	Audio (Audiorecording, audioconference) Read (Digital magazines, eBooks, hypertext (web pages), slideshows)	Collaboration (Forums, online learning communities, Weblog or blog, Wikis, Communication, Chat (Messenger),e-mail) Search (Internet research) Video (Web seminars (broadcasts))

Table 4-9 Adaptive framework for the LSD4 (Understanding (Sequential, Global))

4.4 Guidelines for use

The analysis of tables 4-4 and 4-5 should allow the teacher to determine the most appropriate teaching strategy and course material. Different approaches can be used. A recommendable approach consists in clustering students with similar learning styles and using the appropriate teaching strategy and material for each of the groups. Usually, the teacher is not able to implement such an approach, due for example to course time constraints, unavailability of the appropriate resources, etc.

Should this be the case, another plausible approach consists of the identification of the "group average style" and the selection of the material accordingly. A third alternate approach (and perhaps the most recommendable one, should the resources allow it) consists of the use of different types of materials (thus targeting different styles) for a set of two or three learning units at a time.

The selected material would be used on a rotational basis. This can be done with the integration of teams or groups of students having different learning styles. The adoption of this third approach allows the creation of team group skills for the students. Since the analysis of the table can result in having a list of suggestions (on teaching strategies to employ) that is still too long/complex to really serve as a guide for the teacher. In this situation the teacher might want to focus only on the teaching strategy that is representative of each category of learning style. This is illustrated in the following, overall recommendations are presented to select teaching strategy and prepare e-media material for each learning style.

Sensitive Learning Style: The content must be practical, courses must have an immediate connection with the real world, using concrete methods that are oriented towards facts and procedures that follow previously established techniques. The requested homework must be detailed, not global, including problem solving, laboratory exercises and concept memorization.
Teaching Strategy: Learning based on problem solving.
Electronic Media: Forums

Intuitive Learning Style: The content must be innovative, courses must have an oriented to theory and meanings, with abstractions and mathematical formulae, avoiding repetitive methods. The requested homework must include the discovery of relations and actions. The introduction of new concepts can be used but not as memorizing facts but as abstractions.
Teaching Strategy: Discussion panel
Electronic Media: WebQuest

Visual Learning Style: The content must be a heavy on visual components. The requested homework must include actions to visualize, the information gathering must use visual representations, images must be used in order to make it easier for the students to remember the contents, and the teacher can request diagrams that summarize the homework.
Teaching Strategy: games and simulations
Electronic Media: Animations

Verbal Learning Style: The content must have a lot of oral and textual components. The requested homework must include written essays or oral presentations, the information gathering must use textual representations, texts must be used in order to make it easier for the students to remember the contents, and the teacher can request abstracts that summarize the homework.
Teaching Strategy: Brainstorm
Electronic Media: Audioconference.

Active Learning Style: The content must be applicable, courses must have an immediate connection with using practice (discussion, implementation, group presentations).
The requested homework must include experimentation and work in groups.
Teaching Strategy: Role playing
Electronic Media: Forums

Reflexive Learning Style: Students observe and ponder experiences. Data are collected and analyzed thoroughly about before any conclusion is made. The content must be related with experiences. The requested homework must include personal work.
Teaching Strategy: Cases study
Electronic Media: Hypertext

Sequential Learning Style: The content must be written orderly, step by step, courses must have a lineal reasoning process.
The requested homework must consist of small orderly steps that are logically associated to the problems being solved.
Teaching Strategy: Presentation
Electronic Media: Slideshows

Global Learning Style: The content must be written in big leaps, suddenly and almost randomly. Students can solve complex problems quickly and put things together in an innovative way but may have difficulties to explain how they did it. This allows seeing everything as a whole.
Teaching Strategy: Project design method
Electronic Media: Wiki

4.4.1 Application method

The adaptive teaching framework is a suggestion to change our way of teaching, student-centered, knowing the meaning and practical applications of the theory of learning styles. It's not that each of our actions conform to the teaching styles of student learning. Applying the method in this example would be impossible because of the diversity of styles found in the classroom. It is throughout our classes that we offer a clear attention to the students of different learning styles, we organize activities that take into account individual learning style, those consultations are designed taking into account the variety of learning styles of students, by this way the student learning can guide properly.

The proposed method will link learning styles, teaching strategies and electronic media based on the adaptive framework described above, according to a study plan or particular educational objectives to support teaching. There are three factors that affect the application method: teacher, student and the method itself.

Figure 4-6 Phases for the application method

There are three main phases for this method (see Figure4-6):

1. the application of the Felder and Silverman learning styles survey, when it's a traditional class, like the example shown in this article, as mentioned before, it is impossible to generate all the material in all styles of learning, therefore it is necessary to take into account the predominant styles of the students who will be the basis for the two examples selected targets of the material to cover,
2. select the guide use and study the plan is reviewed to set the course objectives,
3. Selection of the teaching strategies and electronic media is according to the adaptive teaching framework and based on the results of the learning styles questionnaire.

Not all the resulting teaching strategies and corresponding electronic media have to be used for every style. You can select the ones that are available.

4.4.2 Example of method application

The Instituto Tecnológico Autónomo de México´s (ITAM) Algorithms and Programs course (ID course - COM11101) for first year engineering students was used to test the validity of the method.

In the first phase the Felder and Silverman learning styles questionnaire was given to 30 students. The results are shown in Table 4-10.

Dimension	Learning Style	Percentage of Students
LSD_1 Perception	Sensitive	66%
	Intuitive	34%
LSD_2 Entry Channel	Visual	85%
	Verbal	15%
LSD_3 Processing	Active	74%
	Reflexive	26%
LSD_4 Understanding	Sequential	62%
	Global	38%

Table 4-10 Results from the Felder Learning Styles Questionnaire

The results show that in the Perception dimension, students are more sensible than intuitive. The most significant difference is in the Entry Channel dimension, where 85% students came out to be visual and only 15% were verbal. In the case Processing dimension, it was found that most of the students are active. Finally, in the Understanding dimension, it shows that they are mostly sequential. As a result, the predominant combination for each dimension style of the class is {(Sensitive/Visual/Active/Sequential)}.

In the second phase, we selected the second use Identify the “group average style” and select the material accordingly; the study plan is reviewed to specify the objectives of the course. The following information was used: The main objective of this prominently formative course is to develop within the student the ability to analyze and solve problems in a methodic way, as well as to express its solution in algorithmic terms. The student will get to know the basic techniques of procedural programming and will use them through C programming language.

This course is complemented with a two hour lab practice every other Friday. During this lab class the teacher will guide the students towards the solution of problems using “algorithms and programs”.

Considering this course’s characteristics, it is highly recommended that students solve the largest number of possible problems. Practice and application of the concepts seen in class on specific problems is what will allow a student to fully understand the theory.

These are the topics of the full course *“*Algorithms and Programs”, which are arranged based in the specific objectives. Here are the different modules: 1. Course Presentation. 2. Algorithms, Programs and Flowcharts. 3. C Programming Language. 4. Modular Programming. 5. Unidimensional Array. 6. Bidimensional Array. 7. File and Character Chains. 8. Introduction to Structures. In this case, topic number 2 “Algorithms, Programs and Flowcharts” are the base for our example.

In this third phase, a selection of the teaching strategies and electronic media based on the adaptive teaching framework is done according to the results of the learning styles questionnaire, and also based on the predominant style at this class {(Sensitive/Visual/Active/Sequential)}. Table 4-11 explain the description for each learning style selected, the appropriate pedagogical method, the characteristics of the media to be used, the teaching strategies and the fitting electronic media to be used for this particular style. The description give details about the preferences for the sensitive style, like must be practical, the material must be linked to the real world, with a highly visual approach and easily applicable; teamwork must be encouraged too, the teacher needs to consider all of this for create the course material. Tables 4-12 and 4-13 describe the example, how to consider this in the syllabus (Algorithms, Programs and Flowcharts topic).

Perception / Specifications	Sensitive	Visual	Active	Sequential
Description	Practical. Don´t like courses without an immediate link to the real world	Highly visual elements	Applicable and group work	Orderly, step by step and sequential
Appropriate pedagogical method	Specific, facts and procedure oriented, enjoy problem solving by following well established procedures, patient when dealing with details, enjoy practical work, lab class and can memorize things easily	Rather work with visual representations when receiving information and remember what they see	Tend to comprehend and assimilate new information when they practice using it (discussion, implementation, group presentations) and rather learn working with others	Learn through small orderly steps when these are logically associated and follow small orderly steps logically associated when solving problems
Characteristics of the media to be used	Practical, problem solving, laboratory and experiments	Visual representations and diagrams	Group work and cooperation	That allows content to be shown in steps (chapters)
Teaching Strategies	Learning based on problem solving Presentation Question and answer method	Games and simulations Presentation	Games and simulations Learning based on problem solving Role playing Discussion panel Brainstorming Project design method	Presentation Question and answer method
Electronic Media	Collaboratio(Forum, Weblog or blog, Wikis)	Collaboration(Forums, Online learning	Collaboration (Forums, blogs and wikis)	Audio (Audiorecording,

	Communication (e-mail, graphics, pictures)	communities, Wikis) Communication (Chat (Messenger), e-mail, Diagrams, Animations, Graphics, Pictures, Simulations) Read (eBooks, Hypertext (web pages), Slideshows) Video (Recorded live events, Videoconference, Videos)	Communication (Chat, e-mail) Search(Internet search)	audioconferenc e) Read (Digital magazines, eBooks, hypertext (web pages), slideshows)

Table 4-11 Representative student adaptive learning framework {(Sensitive/Visual/Active/Sequential)}

According to electronic media categories selected in the table above the teacher can select the specific electronic media that should be the most appropriate to instruct knowledge (see Table 4-11).

SPECIFIC OBJECTIVE	Content	Teaching Strategies	Electronic Media
1. Identify places where algorithms will be used.	- Set examples using algorithms.	*Learning based on problem solving *Brainstorming	Communication(chats, email), Collaboration (forums, wikis)
2. Define Algorithms.	- Define algorithms using previous examples - Establish problems to be solved using algorithms	* Role playing * Question and answer method * Discussion panel	Collaboration (forums, wikis) Internet research
3. Solve simple problems using algorithms.	- Solve a problem using algorithms	* Learning based on problem solving	Diagrams(animations, graphics, pictures)

Table 4-12 Using adaptive framework for algorithms topic

SPECIFIC OBJECTIVE	Content	Teaching Strategies	Electronic Media
1. Define flowcharts.	- Associate the concept of algorithm with diagrams or sketches	* Presentation	Audio(audio recording, audioconference)
2. Compare algorithms with flowcharts.	- Identify the pros of solving problems using flowcharts. - Establish the importance of using diagrams to help solving more complex problems.	* Presentation *Question and answer method	Read(eBooks, hypertext (web pages), slideshows)

Table 4-13 Using adaptive framework for flowcharts topic

The different ways of doing the course helps in raising the learning abilities of the student. The teacher displays the information in different ways, with different resources, making the learning process easier due to the fact that some people are more receptive to some kind of information than the others. The previous table displays the wide variety of resources that the teacher might use (if available), according to the course objectives. It is also helpful to identify and select the different tools that might be used.

Examination of the table allows the teacher to get a better knowledge of the different potentially useful tools, as well. This can result in a better integration of strategies and selection of instructional tools (some of which might be unknown by the teacher) in later courses. The results of the students were better than other courses which did not use our method. The student's evaluation of the course was much better as well. The use of several resources helps all kinds of students; they were globally very satisfied with the electronic media used. The method was accepted positively by the students. They thought that this is an innovative idea that can help people have a better performance whilst learning.

There are many studies concerning learning styles and their usage in teaching methods, and there are many tutoring systems without a pedagogical method (Gilbert et al., 2005). This adaptive teaching framework presented here is different because it deals directly with the problem of matching teaching strategies with electronic media based on learning styles. Even though the presented example is a traditional class (face to face), it can be completely automated if the discussed set of rules is applied. This way, if an e-learning system is implemented, full personalization of the learning process may be achieved.

4.5 Conclusions

The work presented in this chapter describes the development of an integrated framework combining learning styles, different teaching strategies and the corresponding appropriate electronic media and answer the question 2. Can we specify how to create a general framework for combining and adapting teaching strategies, learning styles and electronic media? The answer is to provide a structured method to help in facilitating the learning process and personalizing the pedagogical resources. This method can be used in traditional face to face classes where the teacher can calculate the course's student's representative learning style to choose the suitable media as proposed by the adaptive teaching framework. It can also be used in distance learning courses where it acts like a catalyst to achieve an automatic personalization in the hypermedia systems. It is worth mentioning that combining teaching strategies with electronic media as proposed by our method doesn't act in an excluding way. It can be combined with any additional teaching approach and/or teaching resources. Because the method and the adaptive framework are user friendly, the person implementing this method doesn't have to be information technology subject matter expert.

We consider the recommendations on teaching strategies and electronic media that match a certain learning style as an important contribution to the field of pedagogical teaching methods. The evaluation of student's learning style gives a strong insight about the students' ability to capture the teacher's message. The proposed framework offers a wide range of possibilities for building a course. Even if full personalization is not possible in face to face teaching, the teacher can develop different versions of the teaching material so that to fit to the learning styles of the largest number of students. It might happen that a teacher does not know the students' learning styles. Furthermore, he/she might not know either the appropriate educational strategies or instructional material for their courses. The presented framework is thus a useful tool to get a better knowledge of the wide variety of resources available to use in class.

Chapter 5

5 Matching learning styles with teaching strategies and e-media: two case studies

In this chapter we analyze the learning styles matching with teaching strategies and electronic media. In addition we analyze similarities and differences in learning styles among students enrolled in computing courses, offered to students in engineering and social sciences programs at the *Instituto Tecnológico Autónomo* de México (ITAM). We also analyze similarities and differences among the teaching strategies shown by their corresponding teachers. A comparative analysis on student learning with teaching strategies and electronic media, allow us to suggest that, despite academic program differences, there are strong similarities not only between the students learning styles but also between the teaching styles of their professors. We discuss how these findings have significant inference for validate the framework, as well as suggest the generalization.

Section 5.1 describes the introduction and the related works. Section 5.2 presents background material concerning students ITAM; it presents information about instruments used to identify learning styles. Section 5.3 presents the methodology used for this study. Section 5.4 presents the validation and generalization the framework, for this we explore the matching the learning styles with the teaching strategies and the learning styles with the electronic media, and also identify and contrast the learning styles of engineering and economic students and lists the factor contributing to their success in introductory computer courses. The implication of the findings on the pedagogical design of computer courses at ITAM are presented in Section 5.5, finally in section 5.6 presents concluding remarks.

5.1 Introduction

The advances on Information and Communications Technology have an influence in education and bring about transformations in regard to what and how to teach, among others aspects. Salinas (1997) says teachers' knowledge in relation to means, their design and pedagogical usage is extremely relevant, because teachers "are essential at the time of initiating any change. Their knowledge and skills are essential for the correct operation of a program", thus, it is needed to extend the type of educative experiences that they can offer to the students when using means that are available on

their environment and that form a part of the technological culture that surrounds them.

Nowadays, the use of electronic media in education enhances and supports the learning process. It enhances it because a person can acquire new knowledge in a more flexible and adaptable way than with the traditional method and it supports it by introducing innovative elements that help students reaffirm the subjects studied in class.

The above statements are representative of serious mismatches between the learning styles of students and the teaching style of the instructor. In a class where such a mismatch occurs, the students tend to be bored and inattentive, do poorly on tests, get discouraged about the course, and may conclude that they are not good at the subjects of the course and give up (Oxford et al, 1991). To reduce teacher-student style conflicts, some researchers in the area of learning styles advocate teaching and learning styles be matched (e.g. Griggs & Dunn, 1984; Smith & Renzulli, 1984; Charkins et al, 1985) and bridging the gap between teachers' and learners' perceptions plays an important role in enabling students to maximize their classroom experience.

This chapter[3] describes a comparative analysis of the learning styles of undergraduate engineering programs and social and economic programs at ITAM students and the assumption underlying the approach taken here is that**:** to which extent is it possible to validate and to generalize this framework?

To suggest a solution, this question addressed the following objectives in a comparative mode:

- Identification of learning styles for undergraduate engineering, economic, business, mathematics, law, accounting students and their correlation with teaching strategies;
- Identification of learning styles for undergraduate engineering, economic, business, mathematics, law, accounting students and their correlation with the electronic media;
- Identification of learning styles for undergraduate engineering, economic, business, mathematics, law, accounting students and their correlation with individual performance;

[3] *The content of this chapter was submitted in the Journal of Applied Research and Technology (JART)*

- Identification of learning styles for undergraduate engineering, economic, business, mathematics, law, accounting students and course performance;
- Identification of electronic media and their correlation with teaching strategies;
- Examination of the association between teaching style and learning style.

5.2 Background

5.2.1 Institutional and student body comparison

ITAM is a private school in México City, nonprofit research institution with an enrollment of approximately 4800 undergraduate students. This university is accredited by FIMPES. ITAM's main purpose is to contribute to its students' comprehensive education and to the development of a more prosperous, just, and free society. It also aims to become a community in its fullest sense, an institution of academic freedom and excellence, and a high quality autonomous research center.

The computer academic department was formed in 1983 and currently has over 550 full-time engineering students; also, the academic department offers computer courses to other programs, 80% of these students have economic-administrative academic programs. Students at ITAM come from a diverse set of backgrounds, including different cities from México. ITAM offer 12 undergraduate programs: Actuarial Science, Applied Mathematics, Business Administration, Business Engineering, Computer Science, Economics, Industrial Engineering, International Relations, Law, Political Science, Public Accounting and Financial Strategy, and Telematics Engineering. They provide a heterogeneous student population.

5.2.2 Learning styles

The concrete strategies may vary from person to person, but have been narrowed down to certain global trends. These global trends or preferences, plus particular ways of learning, constitute the learning style (Felder & Silverman, 1988).

The fact that not all people learn the same way can be seen in a classroom. The same lesson is given to a group of students. Some of them have better performance than

others. According to Sewall, there are several theories about learning styles (Sewall, 1986), how we described in chapter two.

The Felder model of 1988 has 32 learning styles. A student's style can be identified by considering the following five issues in table 5-I.

Dimension	Types
Perception	Sensitive Intuitive
Input	Visual Verbal
Organization	Inductive Deductive
Processing	Active Reflexive
Understanding	Sequential Global

Table 5-1 Felder dimensions

This study used the ILS. The ILS is the instrument that Felder uses to evaluate a student's learning style. The ILS is conveniently available on the Internet and consists of 44 multiple-choice questions designed to separate the learning style affinities of an individual. The 44 questions have two possible answers ('a' or 'b'). The intensity of a dimension can vary from 1 to 11. This is because each dimension has 11 questions (Felder & Soloman, 1993). The organization dimension cannot be measured through this type of question. ILS has also been used in several computer science and engineering studies (Allert, 2004; Chamillard & Karalick , 1999; Thomas, et al., 2002).

The natural learning style for humans is inductive. Studies have proved that most engineering students are inductive (Klobas, 2005). In 2002, Felder removed the organizational dimension from his test (see the full contents of the assignment in Appendix A).

5.2.3 Teaching strategies and teaching styles

This study used Teaching Styles Inventory (TSI) an instrument created by the Texas Higher Education Coordinating Board from 2002 to 2007 and it was designed by Center for Occupational Research and Development (CORD) to gauge the teaching preferences and styles, the Collaborative was created to support faculty at two-year colleges across Texas through a collegial, cooperative approach to professional development. The TSI instrument is conveniently available on internet. The scores will provide insight into your affective learning goals for students and the teaching methods that you use to support your goals. The instrument has been constructed using a forced choice technique similar to that used in the Meyers-Briggs Type Indicator and in Kolb's Learning Style Inventory and uses four scales for measuring your preferred teaching styles:

Learning—varies from Rote to Understanding
Concept Representation—varies from Abstract to Applied
Cognitive Processing—varies from Enactive to Symbolic
Interaction—varies from Individual to Cooperative Groups

5.2.4 e-learning tools

Emerging e-learning tools have the potential to enrich academic environments. The adoption level of emerging e-learning tools is on the rise in educational settings (Long, 2006). These tools include instant messengers (IM), social bookmarks, podcasts, vodcasts, blogs, wikis, etc. Several examples can be sighted for incorporating these tools into courses (Farmer & Bartelett-Bragg, 2005; Augar et al. 2004). A review of learning theory suggests that learning styles and preferences influence the effectiveness with which individual learners learn. Therefore this can help lecturers choose the right methods of instruction for the right audience (Smith & Dalton, 2005; Saeed & Yang, 2008). The web is transforming into a fully interactive space and the control of the content has been decentralized in order to allow everyone to collaborate, create, publish, subscribe and share information (Asmus et al, 2008; Saeed & Yang, 2008). In academic settings, students and teachers alike are achieving many of the benefits of these interactions (Baird & Fisher, 2005). For example, blogs facilitate publication of knowledge; opportunities for subsequent reflection and analysis, and help teachers understand the relational and contextual basis of knowledge (Ferding & Trammell, 2008 ; Saeed & Yang, 2008). Similarly, wikis facilitate the creation of shared knowledge, dissemination of information, and group interaction (Augar et al. 2004); social bookmarks allow quick and easy access online resources (Asmus et al, 2008); and

podcasts provide an innovative way for people to improve communication, collaboration and social networking (Ratchman & Zhang, 2006). All these features are key learning elements and make emerging tools appropriated for educational settings.

5.3 Methodology

5.3.1 Selection of courses

Introductory computer courses required of all students were chosen at the university in the second semester (august – December 2008). The study is based in three different courses. The first course is for students with economic and administrative program (Business Administration, Economics, Public Accounting and Financial Strategy, Actuarial Science and Applied Mathematics), the course name is computational tools and algorithms (CTA) , the second course is for students with law programs (International Relations, Law), the course name is computer I (CI) and the third course is for engineering programs (Computer Science, Business Engineering, Industrial Engineering, and Telematics Engineering), the course name is algorithms and programming (AP). The three courses were similar in many ways. The courses met for three hours or lecture in a laboratory. Laboratory sections were typically 30 students or less. Students at three courses were required to complete a number of homework. The three courses were for first semester.

5.3.2 Applied surveys

This study used the Index of Learning Styles Instrument (ILS) for the first part. The ILS is the instrument that Felder uses to evaluate a student's learning style. The ILS is conveniently available on the Internet and consists of 44 multiple-choice questions designed to separate the learning style affinities of an individual. The 44 questions have two possible answers ('a' or 'b'). The intensity of a dimension can vary from 1 to 11. This is because each dimension has 11 questions (Felder & Soloman, 1993). The organizational dimension cannot be measured through this type of question. ILS has also been used in several computer sciences and engineering studies (Allert, 2004; Chamillard & Karalick,1999; Thomas et al, 2002).

For the second part used Teaching Styles Inventory (TSI) an instrument created by the Texas Higher Education Coordinating Board from 2002 to 2007 and it was designed by Center for Occupational Research and Development (CORD) to gauge the teaching preferences and styles, the scores should provide food for thought regarding the type of students you may be best suited to teach based upon your style of teaching, or ways

in which you may want to alter your style of teaching based upon the kinds of students you have in your classroom. There is no right or wrong answer; there are 12 items, each of which contains four statements about ways you might respond in your teaching, through the way you might behave, think, or feel. The answer has to be ranked at 4 (Maximum) to 1 to reflect how well they describe the way you teach (Texas collaborative page, 2008) (see the full contents of the assignment in Appendix C).

And this study used the e-tools preferences survey. The e-tools preferences survey is the instrument that Saeed and Yang (2008) uses to evaluate a student's preferences by e-media. The survey is conveniently available on the Internet and consists of 43 multiple-choice questions. (see the full contents of the assignment in Appendix D).

5.3.3 Statistical methodology

Instead of using the X2 test [26] for ascertaining the normal distribution, a more strict statistical methodology of discordancy tests was applied (Barnett & Lewis, 1994). In fact, before calculating the statistical parameters of central tendency and dispersion estimates, it is mandatory to test the data for possible discordant outliers (Barnett & Lewis, 1994; Verma, 2005): We used unpublished computer program DODESYS, which is based on new precise and accurate critical values recently simulated for discordancy tests (Verma S. & Quiroz-Ruiz, 2006; Verma S. & Quiroz-Ruiz, 2006b; Verma S. & Quiroz-Ruiz, 2008).

This program ascertains the presence or otherwise of statistically contaminated observations in experimental data, and thus permits the user to calculate the mean and standard deviation values from normal samples. Then, the output data were used to estimate the mean, median, and standard deviation values. Properly rounded values were reported in Tables as suggested by Barnett and Lewis, 1994 and Verma, 2005).

For evaluating possible correlations between variables, commercial package SPSS was used. The results were confirmed from ordinary least-squares linear correlations through the software OYNYL Verma et al, 2006), which is capable of providing three types of linear correlations.

To analyze data from more than two groups, commercial package SPSS was used. One-way ANOVA is used to test for differences among two or more independent groups. Typically, however, the one-way ANOVA is used to test for differences among at least three groups, since the two-group case can be covered by a T-test (Howell, 1997). When there are only two means to compare, the T-test and the F-test are equivalent;

the relation between ANOVA and t is given by F = t2. New precisely interpolated critical values for Fisher F test were used to draw statistical conclusions (Verma, 2009).

The precise and accurate critical values programmed in this version of DODESYS correspond to 99% confidence level (see Verma, 2009) for other application examples). This version of DODESYS relies on the precise critical values for sample sizes of nmin(1)1000 corresponding to 99% confidence level. This strict confidence level is programmed in DODESYS because it is the level recommended (e.g.,Verma, 2009,verma, 2008 and Barnett and Lewis, 1994)

5.4 Analysis and results

All statistics reported in the results section assume an α (Type 1 error) value of 0.05.

5.4.1 Soloman – Felder index of learning styles instrument

During the second semester 2008, the Soloman – Felder ILS instrument was applied to all of three courses. Response rates were above 95% with 726 total students (CTA n = 499, CI n = 87 and AP n = 140), the gender was 66.5% male and 33.5% female students. The table 5-2 shows the percentage of the three groups with the gender, Figure 5-1 shows the distribution for course about the gender. The age of the students was 17 to 21 years (17 – 9%, 18 – 43%, 19 – 35.3%, 20 – 8% and 21 – 4.8%) this results are shown in the table 5-3 below.

			Gender		
			f	m	Total
Name Course	algorithms and programming	number	38	102	140
		frecuncy	46.9	93.1	140
		% gender	15.60%	21.10%	19.30%
		%total	5.20%	14.00%	19.30%
	computational tools and algorithms	number	172	327	499
		frecuncy	167	332	499
		% gender	70.80%	67.70%	68.70%
		%total	23.70%	45.00%	68.70%
	computer 1	number	33	54	87
		frecuncy	29	57.9	87
		% gender	13.60%	11.20%	12.00%
		%total	4.50%	7.40%	12.00%
	Total	number	243	483	726
		frecuncy	243	483	726
		% gender	100%	100%	100.00%
		%total	33.50%	66.50%	100.00%

Table 5-2 Percentage of the three groups with the gender

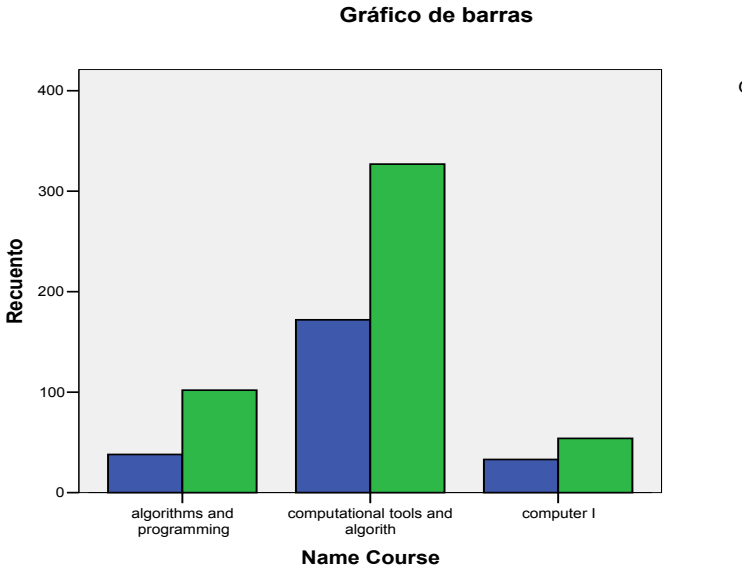


Figure 5-1 Distribution for course about the gender

5.4.2 Learning styles comparison between different students

Test Statistics

Course		Reflective - Active	Intuitive - Sensitive	Verbal - Visual	Global - Sequential
AP	Chi-Square	46.571[a]	69.943[b]	63.571[a]	100.900[b]
	Df	9	10	9	10
	Asymp. Sig.	.000	.000	.000	.000
CTA	Chi-Square	238.088[c]	218.513[c]	266.715[d]	412.735[d]
	Df	10	10	11	11
	Asymp. Sig.	.000	.000	.000	.000
CI	Chi-Square	78.414[e]	66.368[f]	35.770[f]	59.793[f]
	Df	8	10	10	10
	Asymp. Sig.	.000	.000	.000	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 14.0.

b. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 12.7.

c. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 45.4.

d. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 41.6.

e. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.7.

f. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 7.9.

Table 5-3 Chi square analysis of AP, CTA and CI

Table 5-3 shows, the Chi square analysis of 3 groups (AP, CTA and CI) and four learning styles scales revealed no significant differences.

Statistics

Number Course			Reflective - Active	Intuitive - Sensitive	Verbal - Visual	Global - Sequential
AP	N	Valid	140	140	140	140
		Missing	0	0	0	0
	Mean		.97	1.89	5.27	1.77
	Median		1.00	1.00	5.00	3.00
	Mode		-1	1	5	3
	Std. Deviation		4.190	4.320	4.171	3.820
	Variance		17.553	18.663	17.393	14.595
	Minimum		-9	-9	-7	-9
	Maximum		9	11	11	11
CTA	N	Valid	499	499	499	499
		Missing	0	0	0	0
	Mean		.86	2.30	3.81	1.54
	Median		1.00	3.00	5.00	1.00
	Mode		1	5	7	1
	Std. Deviation		4.173	4.325	4.544	3.750
	Variance		17.411	18.709	20.644	14.060
	Minimum		-9	-9	-11	-11
	Maximum		11	11	11	11
CI	N	Valid	87	87	87	87
		Missing	0	0	0	0
	Mean		1.55	2.70	2.40	1.53
	Median		1.00	3.00	3.00	1.00
	Mode		1	5	3	1
	Std. Deviation		3.076	3.900	4.504	4.029
	Variance		9.460	15.212	20.290	16.229
	Minimum		-7	-9	-9	-9
	Maximum		9	11	11	11

Table 5-4 Median, mean, mode and variance for AP, CTA and CI

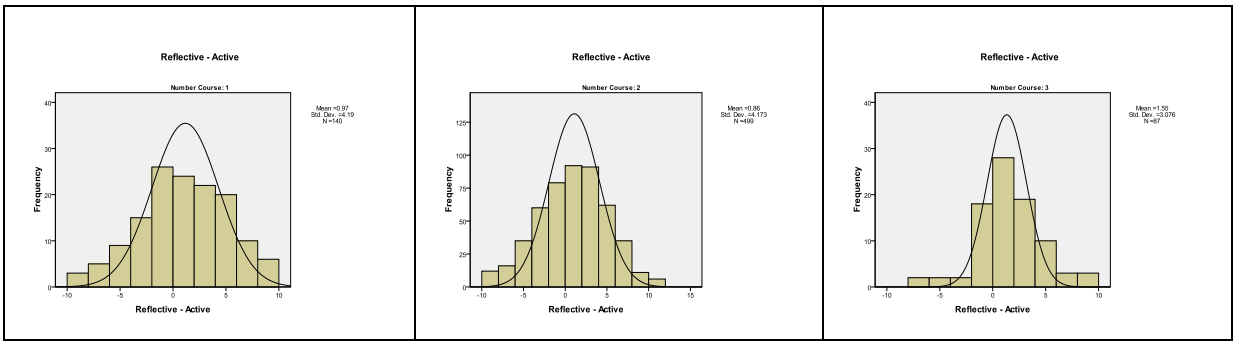


Figure 5-2 Results reflective – Active learning style for three groups

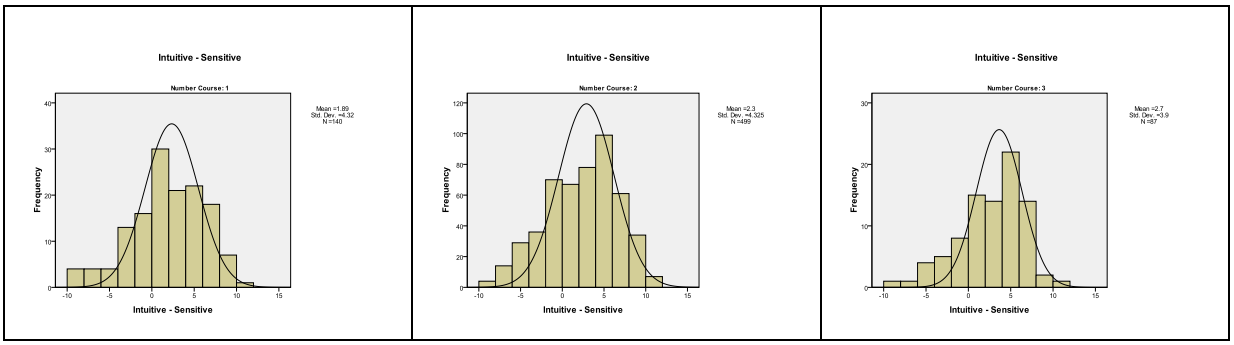


Figure 5-3 Results verbal - visual learning style for three groups

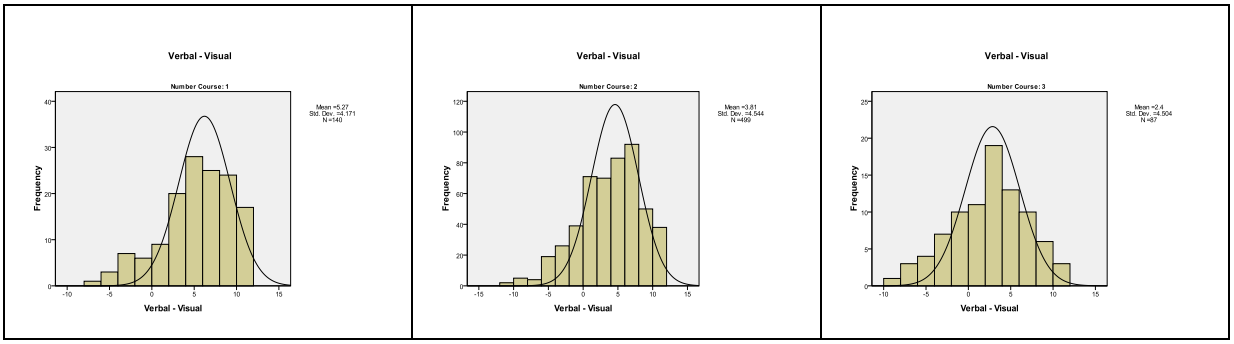


Figure 5-4 Results intuitive - sensitive learning style for three groups

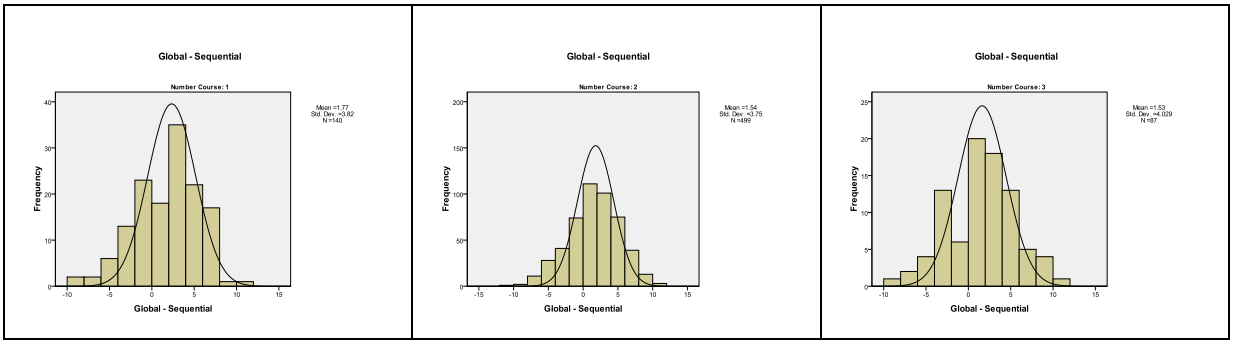


Figure 5-5 Results global - sequential learning style for three groups

		Sum of Squares	df	Mean Square	F	Sig.
Reflective - Active	Between Groups	35.070	2	17.535	1.063	.346
	Within Groups	11924.136	723	16.493		
	Total	11959.207	725			
Intuitive - Sensitive	Between Groups	37.377	2	18.689	1.022	.360
	Within Groups	13219.708	723	18.285		
	Total	13257.085	725			
Verbal - Visual	Between Groups	462.161	2	231.081	11.567	.000
	Within Groups	14443.519	723	19.977		
	Total	14905.680	725			
Global - Sequential	Between Groups	6.103	2	3.051	.212	.809
	Within Groups	10426.272	723	14.421		
	Total	10432.375	725			

Table 5-5 Percentage of the three groups with the gender

Figure 5-2 to 5-5 show comparative distributions of the various dimensions of learn learning styles for AP, CTA and CI students. Each dimension (for example, reflective-active, in Figure 5-1) is encoded from -11 to +11. A negative number (such as, -5 in Figure 1) indicates that the learner is predisposed towards a reflective style of learning. A positive number (such as, 5 in Figure 5-1) indicates that the learner is mostly active in his or her learning style. Values near zero tend to indicate that the learner does not have any marked preferences on a particular dimension.

As table 5-5 shows, AP, CTA and CI students have a similar learning style distribution along the reflective – active dimension. The AP students (μ = 0.97; SD = 4.19), CTA students (μ = 0.86; SD = 4.17) and CI students (μ = 1.55; SD = 3.07) do not differ on the reflective – active dimension of learning style $F(723)=1.063$, $p=.346$.

As table 5-5 shows, AP, CTA and CI students have a similar learning style distribution along the verbal - visual dimension. The AP students (μ = 5.27; SD = 4.17), CTA students (μ = 3.81; SD = 4.54) and CI students (μ =2.4; SD = 4.50) differ on the visual – verbal dimension of learning style $F(723)=11.567$, $p=.000$.

As table 5-5 shows, AP, CTA and CI students have a similar learning style distribution along the intuitive - sensitive dimension. The AP students (μ = 1.89; SD = 4.32), CTA students (μ = 2.3; SD = 4.32) and CI students (μ =2.7; SD = 3.90) do not differ on the intuitive - sensitive dimension of learning style F(723)=1.022, p=.360.

As table 5-5 shows, AP, CTA and CI students have a similar learning style distribution along the global - sequential dimension. The AP students (μ = 1.77; SD = 3.82), CTA students (μ = 1.54; SD = 3.75) and CI students (μ =1.53; SD = 4.02) do not differ on the global - sequential dimension of learning style F(723)=.212, p=.809. In summary, despite the different courses backgrounds students at AP, CTA and CI have strikingly similar learning styles along all three leaning styles dimensions, only in visual and verbal differ.

In summary, despite the different courses backgrounds students at AP, CTA and CI have strikingly similar learning styles along all three leaning styles dimensions, only in visual and verbal differ.

5.4.3 Learning Styles matching with teaching strategies

For this matching we took into account 726 students answers of the two questionnaires, Felder and Soloman (1998) and teaching strategies questioner and we make the correlations (see Table 5-6).

		Sensitive	Intuitive	Visual	Verbal	Active	Reflexive	Sequential	Global
Games and simulations	Correlación de Pearson	-0.017	0.017	-.661(**)	.549(**)	-.086(*)	0.04	0.035	-0.035
	Sig. (bilateral)	0.65	0.284	0	0	0.021	0.284	0.352	0.352
	N	726	726	726	726	726	726	726	726
Learning based on problem solving	Correlación de Pearson	-.627(**)	.170(**)	-0.058	0.058	0.056	0.027	-.126(**)	-.130(**)
	Sig. (bilateral)	0	0	0.117	0.117	0.134	0.472	0.001	0
	N	726	726	726	726	726	726	726	726
Role playing	Correlación de Pearson	-0.033	-.146(**)	-0.033	0.057	-.115(**)	0.006	.495(**)	-.115(**)
	Sig. (bilateral)	0	0	0.376	0.126	0.002	0.869	0	0.002

	N	726	726	726	726	726	726	726	726
Presentation	Correlación de Pearson	-.431(**)	.384(**)	.941(**)	.549(**)	0.032	-.506(**)	-0.03	0.032
	Sig. (bilateral)	0	0	0	0	0.393	0	0.422	0.393
	N	726	726	726	726	726	726	726	726
Discussion panel	Correlación de Pearson	-0.013	.650(**)		-.650(**)	0.025	0.056	-0.012	0.045
	Sig. (bilateral)	0.726	0.726	0	0	0.494	0.134	0.753	0.228
	N	726	726	726	726	726	726	726	726
Brainstorming	Correlación de Pearson	.130(**)	-.130(**)	-0.045	0.045	.116(**)	-0.004	.498(**)	-.498(**)
	Sig. (bilateral)	0	0	0.228	0.228	0.002	0.905	0	0
	N	726	726	726	726	726	726	726	726
Case study	Correlación de Pearson	.096(**)	-.096(**)	0.01	-0.01	.453(**)	-.567(**)	.384(**)	-.384(**)
	Sig. (bilateral)	0.009	0.009	0.789	0.789	0	0	0	0
	N	726	726	726	726	726	726	726	726
Question and	Correlación de Pearson	-.779(**)	.779(**)	-.092(*)	.092(*)	-.281(**)	.549(**)	-.170(**)	.170(**)
answer method	Sig. (bilateral)	0	0	0.013	0.013	0	0	0	0
	N	726	726	726	726	726	726	726	726
Project design	Correlación de Pearson	0.009	-0.009	0.059	-0.059	.610(**)	-0.011	-0.013	0.014
method	Sig. (bilateral)	0.815	0.815	0.114	0.114	0	0.772	0.726	0.708
	N	726	726	726	726	726	726	726	726

* The correlation is significant at level 0,05 (bilateral). ** The correlation is significant at level 0,01 (bilateral).

Table 5-6 Correlations between learning styles and teaching strategies

As Table 5-6 shows, a positive correlation exists between some learning styles with teaching strategies, in this case this correlations corresponding to the matching result by the Delphi panel (see chapter 4.3.1), so with this information, we can suggest that the framework is validated and the results of this data is for all students not only for engineering students, we think that it's possible to generalize the framework.

5.4.4 Learning Styles matching with electronic media

For this matching we used 726 students' answers of the two questionnaires, Felder and Soloman (1998) and teaching strategies questioner and we make the correlations (see Table 5-7).

		Sensitive	Intuitive	Visual	Verbal	Active	Reflexive	Sequential	Blobal
Audio Recording	Pearson Correlation	.022	.049	-.002	.210(**)	-.028	.024	-.007	.216(**)
	Sig. (bilateral)	.555	.190	.961	.000	.448	.521	.850	.000
	N	726	726	726	726	726	726	726	726
Audioconference	Pearson Correlation	-.023	-.026	.027	.279(**)	.053	.031	-.040	.012
	Sig. (bilateral)	.532	.476	.466	.000	.156	.405	.283	.742
	N	726	726	726	726	726	726	726	726
Forums	Pearson Correlation	.159(**)	.207(**)	.193(**)	-.028	.126(**)	.198(**)	.072	-.013
	Sig. (bilateral)	.000	.000	.000	.448	.001	.000	.053	.731
	N	726	726	726	726	726	726	726	726
Online learning communities	Pearson Correlation	.060	.125(**)	.216(**)	.053	.057	.039	.162(**)	-.007
	Sig. (bilateral)	.105	.001	.000	.156	.125	.296	.000	.850
	N	726	726	726	726	726	726	726	726
Weblog or blog	Pearson Correlation	.234(**)	.295(**)	.087(*)	-.006	.186(**)	.243(**)	.213(**)	.209(**)
	Sig. (bilateral)	.000	.000	.020	.874	.000	.000	.000	.000
	N	726	726	726	726	726	726	726	726
Wikis	Pearson Correlation	.097(**)	.183(**)	.117(**)	.116(**)	.077(*)	.077(*)	.088(*)	.056
	Sig. (bilateral)	.009	.000	.002	.002	.039	.037	.018	.132
	N	726	726	726	726	726	726	726	726
Chat (Messenger)	Pearson Correlation	.083(*)	.070	.033	.011	.238(**)	.295(**)	.273(**)	.303(**)
	Sig. (bilateral)	.026	.058	.371	.762	.000	.000	.000	.000
	N	726	726	726	726	726	726	726	726
e-mail	Pearson Correlation	.098(**)	.094(*)	.069	.002	.233(**)	.250(**)	.267(**)	.230(**)
	Sig. (bilateral)	.008	.011	.065	.951	.000	.000	.000	.000
	N	726	726	726	726	726	726	726	726
Animations	Pearson Correlation	.255(**)	.301(**)	.310(**)	.037	.100(**)	.101(**)	.080(*)	.037
	Sig. (bilateral)	.000	.000	.000	.322	.007	.006	.030	.322

	N	726	726	726	726	726	726	726	726
Graphics	Pearson Correlation	.252(**)	.317(**)	.033	.306(**)	.104(**)	.118(**)	.102(**)	.033
	Sig. (bilateral)	.000	.000	.367	.000	.005	.001	.006	.367
	N	726	726	726	726	726	726	726	726
Pictures	Pearson Correlation	.259(**)	.349(**)	.314(**)	.339(**)	.111(**)	.086(*)	.095(*)	.077(*)
	Sig. (bilateral)	.000	.000	.000	.000	.003	.021	.011	.039
	N	726	726	726	726	726	726	726	726
Simulations	Pearson Correlation	.086(*)	.061	.432(**)	.564(**)	.097(**)	.070	.026	-.020
	Sig. (bilateral)	.020	.100	.000	.000	.009	.061	.478	.595
	N	726	726	726	726	726	726	726	726
Digital magazines	Pearson Correlation	-.044	-.011	.027	.015	-.048	.077(*)	.097(**)	-.041
	Sig. (bilateral)	.232	.771	.462	.685	.200	.564(**)	.009	.274
	N	726	726	726	726	726	.000	726	726
Digital newspapers	Pearson Correlation	-.035	-.028	-.057	-.032	-.058	726	.041	.009
	Sig. (bilateral)	.346	.451	.124	.388	.119	.326	.272	.808
	N	726	726	726	726	726	726	726	726
eBooks	Pearson Correlation	.060	.056	.429(**)	.589(**)	.081(*)	.081(*)	-.001	-.048
	Sig. (bilateral)	.104	.130	.000	.000	.028	.028	.981	.194
	N	726	726	726	726	726	726	726	726
Hypertext (web pages)	Pearson Correlation	.059	.085(*)	.382(**)	.457(**)	.087(*)	.032	.029	.044
	Sig. (bilateral)	.112	.022	.000	.000	.020	.387	.441	.232
	N	726	726	726	726	726	726	726	726
Slideshows	Pearson Correlation	.055	.032	.409(**)	.534(**)	.088(*)	.072	.056	.060
	Sig. (bilateral)	.140	.393	.000	.000	.018	.054	.130	.106
	N	726	726	726	726	726	726	726	726
Internet research	Pearson Correlation	.087(*)	.151(**)	.023	.015	.233(**)	.205(**)	.267(**)	.206(**)
	Sig. (bilateral)	.019	.000	.533	.678	.000	.000	.000	.000
	N	726	726	726	726	726	726	726	726
Course Legacy System	Pearson Correlation	.007	-.049	.024	-.016	.028	.031	-.023	.031
	Sig. (bilateral)	.840	.185	.522	.672	.446	.411	.538	.400
	N	726	726	726	726	726	726	726	726

Student Response System	Pearson Correlation	-.100(**)	-.023	-.065	-.056	-.033	-.041	-.006	.004
	Sig. (bilateral)	.007	.544	.081	.131	.378	.274	.863	.914
	N	726	726	726	726	726	726	726	726
Tutorial systems	Pearson Correlation	.063	.002	-.026	.005	.022	.009	-.019	.054
	Sig. (bilateral)	.088	.957	.478	.888	.556	.804	.603	.143
	N	726	726	726	726	726	726	726	726
WebQuest	Pearson Correlation	-.019	-.011	.003	.003	.003	.061	-.026	-.061
	Sig. (bilateral)	.617	.768	.929	.945	.927	.098	.485	.102
	N	726	726	726	726	726	726	726	726
Podcast	Pearson Correlation	-.068	-.034	-.065	.008	-.041	-.042	-.053	-.054
	Sig. (bilateral)	.068	.366	.080	.824	.275	.255	.153	.147
	N	726	726	726	726	726	726	726	726
Recorded live events	Pearson Correlation	.036	.044	.432(**)	.586(**)	.102(**)	.037	.005	.001
	Sig. (bilateral)	.332	.235	.000	.000	.006	.316	.888	.987
	N	726	726	726	726	726	726	726	726
Videoconference	Pearson Correlation	.072	.095(*)	.435(**)	.595(**)	.053	.075(*)	-.025	.026
	Sig. (bilateral)	.051	.011	.000	.000	.153	.043	.494	.482
	N	726	726	726	726	726	726	726	726
Videos	Pearson Correlation	.056	.021	.382(**)	.407(**)	.100(**)	.025	-.034	.011
	Sig. (bilateral)	.133	.576	.000	.000	.007	.501	.364	.775
	N	726	726	726	726	726	726	726	726
Web seminars (broadcasts)	Pearson Correlation	.153(**)	.231(**)	.044	-.042	.221(**)	.191(**)	.253(**)	.233(**)
	Sig. (bilateral)	.000	.000	.237	.255	.000	.000	.000	.000
	N	726	726	726	726	726	726	726	726

* The correlation is significant at level 0,05 (bilateral). **The correlation is significant at level 0,01 (bilateral).

Table 5-7 Correlations between learning styles and electronic media

As Table 5-7 shows, a positive correlation exists between some learning styles with electronic media, in this case this correlations corresponding to the matching result by the Delphi panel (see chapter 4.3.1), so with this information, we can suggest that the framework is validated. The results of this data are for all students, not only for engineering students, so it's possible to generalize the framework.

5.4.5 Learning Styles and Class Performance

		Grade	ref-act	int-sns	vrb-vis	glob-seq
Grade	Pearson Correlation	1	-,222(**)	-,092	-,169(*)	-,104
	Sig. (bilateral)		,008	,279	,046	,222
	N	140	140	140	140	140
ref-act	Pearson Correlation	-,222(**)	1	-,084	,277(**)	-,106
	Sig. (bilateral)	,008		,321	,001	,210
	N	140	140	140	140	140
int-sns	Pearson Correlation	-,092	-,084	1	,130	,379(**)
	Sig. (bilateral)	,279	,321		,125	,000
	N	140	140	140	140	140
vrb-vis	Pearson Correlation	-,169(*)	,277(**)	,130	1	-,033
	Sig. (bilateral)	,046	,001	,125		,698
	N	140	140	140	140	140
glob-seq	Pearson Correlation	-,104	-,106	,379(**)	-,033	1
	Sig. (bilateral)	,222	,210	,000	,698	
	N	140	140	140	140	140

**The correlation is significant at level 0,01 (bilateral).* The correlation is significant at level 0,05 (bilateral)..

Table 5-8 Correlations AP

		Grade	ref-act	int-sns	vrb-vis	glob-seq
Grade	Pearson Correlation	1	-,028	,037	-,002	-,003
	Sig. (bilateral)		,537	,412	,962	,943
	N	499	499	499	499	499
ref-act	Pearson Correlation	-,028	1	,118(**)	,198(**)	,091(*)
	Sig. (bilateral)	,537		,009	,000	,042
	N	499	499	499	499	499
int-sns	Pearson Correlation	,037	,118(**)	1	,138(**)	,237(**)
	Sig. (bilateral)	,412	,009		,002	,000
	N	499	499	499	499	499
vrb-vis	Pearson Correlation	-,002	,198(**)	,138(**)	1	,039
	Sig. (bilateral)	,962	,000	,002		,387
	N	499	499	499	499	499
glob-seq	Pearson Correlation	-,003	,091(*)	,237(**)	,039	1
	Sig. (bilateral)	,943	,042	,000	,387	
	N	499	499	499	499	499

**The correlation is significant at level 0,01 (bilateral).* The correlation is significant at level 0,05 (bilateral)..

Table 5-9 Correlations CTA

		Grade	ref-act	int-sns	vrb-vis	glob-seq
Grade	Pearson Correlation	1	,135	-,017	-,075	,084
	Sig. (bilateral)		,211	,879	,489	,439
	N	87	87	87	87	87
ref-act	Pearson Correlation	,135	1	,022	,034	,010
	Sig. (bilateral)	,211		,842	,753	,927
	N	87	87	87	87	87
int-sns	Pearson Correlation	-,017	,022	1	-,058	,152
	Sig. (bilateral)	,879	,842		,594	,159
	N	87	87	87	87	87
vrb-vis	Pearson Correlation	-,075	,034	-,058	1	,033
	Sig. (bilateral)	,489	,753	,594		,762
	N	87	87	87	87	87
glob-seq	Pearson Correlation	,084	,010	,152	,033	1
	Sig. (bilateral)	,439	,927	,159	,762	
	N	87	87	87	87	87

**The correlation is significant at level 0,01 (bilateral).* The correlation is significant at level 0,05 (bilateral)..

Table 5-10 Correlations CI

To determine if learning style preferences had any relationship to the final grade in the class, a correlation between learning styles and class performance was calculate as shown in Tables 5-8, 5-9, and 5-10.

As Table 5-8 shows, a positive correlation exists between the reflective – active dimension and class performance for AP students, meaning that reflective students at AP tended to achieve higher grades in the programming class than the students with an active learning orientation. This result is consistent with prior research (Asmus et al, 2008; Chamilard & Karolick, 1999; Allert, 2004) which found that students with a predominant reflective learning style achieved higher grades. No such correlation was present for CTA and CI. These results suggest that our current teaching approach is biased towards verbal learning style, which is consistent with the findings of Chamillard and Karolick report that reflective and verbal learners performed better than other (Chamilard & Karolick, 1999).

The only other significant correlation in Table 5-8 is between the verbal – visual dimension and class performance for AP students; students who were more visual in their learning also tended to do better in the programming class. No such correlation was present for CTA and CI.

As Table 5-8 and Table5-9 shows, a positive correlation exists between the reflective – active dimension and verbal – visual dimension for AP and CTA students, and another positive correlation exists between the intuitive – sensing and global – sequential dimension for AP and CTA students. These results suggest that reflective learners are correlated with the verbal learners while intuitive learners are correlated with global learners. These findings are also consistent with prior research (Alfonseca et al., 2006; Saeed & Yang, 2008).

5.4.6 e-learning tools preference survey results

A self-designed questionnaire was used to collect students' current experience and preferences of using emerging e-learning tools mentioned earlier, along with some other traditional e-learning tools like email and blackboard.

Estatistics

		Age	Sex
N	Valid	140	140
	Lost	0	0
Mean		18,6286	1,7286
Median		19,0000	2,0000
Mode		18,00	2,00
Standard Dev.		,97702	,44629
Variance		,955	,199

Table 5-11 Mean, Median, Mode and Variance for AP

Tabla de contingencia Age * Sex

		Sex		Total	
		M	f		
Age	17,00	1	12	13	9%
	18,00	18	37	55	39%
	19,00	13	38	51	36%
	20,00	1	12	13	9%
	21,00	5	3	8	7%
Total		38	102	140	100%

Table 5-12 Distribution sex and age for AP

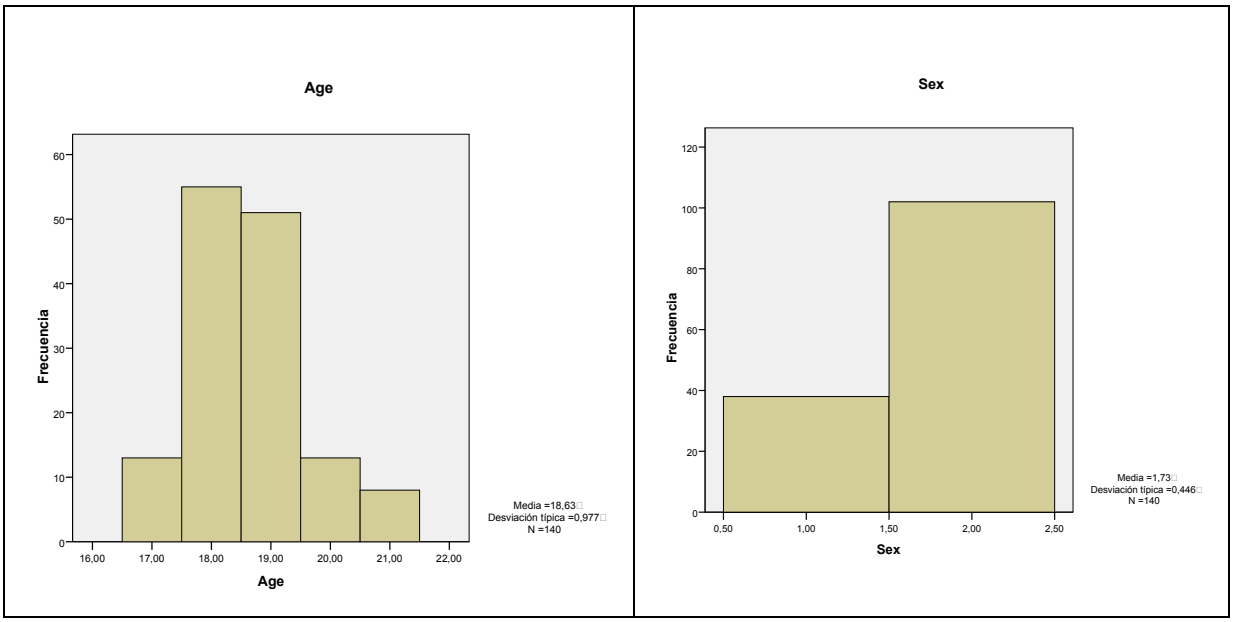


Figure 5-6 Distribution for AP about the gender and age

During the second semester 2008, survey was administrated to all of AP students only (no such was present for CTA and CI). Response rates were above 100% with 140 total students (AP n = 140), the gender was 73% male and 27% female students. The table 5-11 shows the percentage of AP group with the gender, Figure 5-6 shows the distribution for AP about the gender and age. The age of the students was 17 to 21 years (17 – 9%, 18 – 39%, 19 – 36%, 20 – 9% and 21 – 7%) this results are shown in the table 5-12.

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	5-10 hours	60	38,0	**42,9**	42,9
	10-15 hours	45	28,5	**32,1**	75,0
	15-20 hours	12	7,6	8,6	83,6
	more than 20 hours	23	14,6	16,4	100,0
	Total	140	88,6	100,0	
Lost	System	18	11,4		
Total		158	100,0		

Table 5-13 Hours used the Internet per week

As Table 5-13 shows, 43% reported their Internet usage is 5 to 10 hours per week, 32% reported their Internet usage is 10 to 15 hours per week, while 29% described communication, 24% entertainment and 20% study as their major use of the Internet. These results suggest that our students are well aware of the Web usage, are shown in the table 5-14.

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	self learning	10	6,3	7,1	7,1
	Collaboration	2	1,3	1,4	8,6
	information sharing	9	5,7	6,4	15,0
	communicate with family/friends	41	25,9	**29,3**	44,3
	entertainment (music/movies)	33	20,9	**23,6**	67,9
	to make social contacts	7	4,4	5,0	72,9
	Study	28	17,7	**20,0**	92,9
	other (please specify	2	1,3	1,4	94,3
	Work	8	5,1	5,7	100,0
	Total	140	88,6	100,0	
Lost	System	18	11,4		
Total		158	100,0		

Table 5-14 Hours used the Internet per week

Students were asked to rate their learning preferences on a scale of one (least preferred) to seven (most preferred). Table 5-15 shows, the students AP preferences aligned with various academic activities. The result suggest that besides relying on the traditional tools like blackboard and email tools, students also prefer to try emerging e-learning tools such as vodcast, IM and videoconferencing. The results also suggest that students AP prefer synchronous (IM) and asynchronous (email, blackboard, vodcast) modes of communication.

		listening to podcast (audio recording) of the lecture	watching vodcast (video recording) of the lecture	discussing it on the unit blog	discussing it on the unit wiki	text chatting with my peers on IM	text chatting with my peers on IM	talking to my peers on IM
I would prefer to revise lecture online by:		11%	**26%**	10%	11%	11%	16%	16%
		as a podcast presentation	as a vodcast presentation	through unit blog	through unit wiki	through email	through Blackboard	Messenger
I would prefer to submit online a group project to lecturer:		7%	11%	9%	8%	**40%**	11%	13%
		audio conferencing	video conferencing	wiki	blog	email	Blackboard	Messenger
I would prefer to have online class discussion with lecturer through:		14%	**33%**	9%	5%	12%	6%	21%
I would prefer to have online group discussion through:		14%	**32%**	1%	6%	9%	13%	26%
I would prefer to have online study discussion with a friend through:		10%	22%	6%	9%	7%	16%	**28%**
I would prefer my lecturer to conduct online office hours through:		9%	9%	8%	9%	23%	15%	**25%**
I would prefer to receive assignments online from lecturer through:		11%	8%	7%	6%	**24%**	18%	21%
I would prefer to store my online bookmarks on:		6%	1%	1%	2%	**37%**	31%	16%

Table 5-15 Tools preferences against various academic activities

		emailFrec	blogsFrec	pvcostFrec	sociFrec	wikiFrec
emailFrec	Pearson Correlation	1	-,163	,022	,041	-,029
	Sig. (bilateral)		,054	,793	,629	,737
	N	140	140	140	140	140
blogsFrec	Pearson Correlation	-,163	1	,396(**)	,332(**)	,340(**)
	Sig. (bilateral)	,054		,000	,000	,000
	N	140	140	140	140	140
pvcostFrec	Pearson Correlation	,022	,396(**)	1	,231(**)	,341(**)
	Sig. (bilateral)	,793	,000		,006	,000
	N	140	140	140	140	140
sociFrec	Pearson Correlation	,041	,332(**)	,231(**)	1	,366(**)
	Sig. (bilateral)	,629	,000	,006		,000
	N	140	140	140	140	140
wikiFrec	Pearson Correlation	-,029	,340(**)	,341(**)	,366(**)	1
	Sig. (bilateral)	,737	,000	,000	,000	
	N	140	140	140	140	140

** Significative correlation at level 0,01 (bilateral).

Table 5-16 Correlation between tools preferences

As Table 5-16 shows, correlations between tools preferences, these results suggest that the learning preferences of various e-learning tools are closely related, for example students prefer to try various tools in their study routines instead of relying on one particular tool.

5.4.7 Learning styles vs. tools preferences

A total of 140 students from AP only, students answered the two surveys (Learning styles and tools preference). The results suggest that there were little relationships when preferences of emerging e-learning tools were correlated with each of learning styles scales, are shown in the table 5-17 and 5-18.

		emailFrec	blogsFrec	pvcostFrec	sociFrec	wikiFrec	id_ref_act
emailFrec	Pearson Correlation	1	-,163	,022	,041	-,029	-,038
	Sig. (bilateral)		,054	,793	,629	,737	,655
	N	140	140	140	140	140	140
blogsFrec	Pearson Correlation	-,163	1	,396(**)	,332(**)	,340(**)	,069
	Sig. (bilateral)	,054		,000	,000	,000	,419
	N	140	140	140	140	140	140
pvcostFrec	Pearson Correlation	,022	,396(**)	1	,231(**)	,341(**)	,190(*)
	Sig. (bilateral)	,793	,000		,006	,000	,025
	N	140	140	140	140	140	140
sociFrec	Pearson Correlation	,041	,332(**)	,231(**)	1	,366(**)	,032
	Sig. (bilateral)	,629	,000	,006		,000	,703
	N	140	140	140	140	140	140
wikiFrec	Pearson Correlation	-,029	,340(**)	,341(**)	,366(**)	1	-,008
	Sig. (bilateral)	,737	,000	,000	,000		,929
	N	140	140	140	140	140	140
id_ref_act	Pearson Correlation	-,038	,069	,190(*)	,032	-,008	1
	Sig. (bilateral)	,655	,419	,025	,703	,929	
	N	140	140	140	140	140	140

** Significative correlation at level 0,01 (bilateral).

* Significative correlation at level 0,05 (bilateral).

Table 5-17 Correlation Learning styles & tools preferences

The comparison of learning styles and tools preferences also resulted in some interesting relationships. Reflective learners tend to gain better understanding when they can think and reflect about the information presented to them. Work better alone or with one more person at most, stop periodically to review what have been learning, and stop periodically to think possible questions. The characteristics of the media to be used is watching and listening (Franzoni et al., 2008), hence podcast and vodcast was a good choice for them to run the sequence of lectures at their own pace over and over

again to get a better understanding of the course contents, which is in contrast with Saeed's study reporting that active-reflective did not yield any significant relationship (Saeed & Yang, 2008).

Sequential learners tend to gain understanding through small orderly steps when these are logically associated and follow small orderly steps logically associated when solving problems. The characteristics of the media to be used is that allows content to be shown in steps (chapters) (Franzoni et al., 2008), hence social bookmarks was a good choice for them to store, organize, search, and manage bookmarks of web pages on the Internet with the help of metadata, typically in the form of tags that collectively and/or collaboratively become a folksonomy. Folksonomy is also called social tagging, "the process by which many users add metadata in the form of keywords to shared content". We believe that above outcomes can serve as a guideline for the lectures in choosing the right technology for the right audience in their courses.

		emailFrec	blogsFrec	pvcostFrec	sociFrec	wikiFrec	idglobseq
emailFrec	Pearson Correlation	1	-,163	,022	,041	-,029	-,114
	Sig. (bilateral)		,054	,793	,629	,737	,179
	N	140	140	140	140	140	140
blogsFrec	Pearson Correlation	-,163	1	,396(**)	,332(**)	,340(**)	-,139
	Sig. (bilateral)	,054		,000	,000	,000	,100
	N	140	140	140	140	140	140
pvcostFrec	Pearson Correlation	,022	,396(**)	1	,231(**)	,341(**)	-,024
	Sig. (bilateral)	,793	,000		,006	,000	,774
	N	140	140	140	140	140	140
sociFrec	Pearson Correlation	,041	,332(**)	,231(**)	1	,366(**)	-,180(*)
	Sig. (bilateral)	,629	,000	,006		,000	,033
	N	140	140	140	140	140	140
wikiFrec	Pearson Correlation	-,029	,340(**)	,341(**)	,366(**)	1	-,105
	Sig. (bilateral)	,737	,000	,000	,000		,218
	N	140	140	140	140	140	140
idglobseq	Pearson Correlation	-,114	-,139	-,024	-,180(*)	-,105	1
	Sig. (bilateral)	,179	,100	,774	,033	,218	
	N	140	140	140	140	140	140

** Significative correlation at level 0,01 (bilateral).

* Significative correlation at level 0,05 (bilateral).

Table 5-18 Correlation Learning styles & tools preferences

5.4.8 Dominant learning styles

Institution/Country	Active	Sensitive	Visual	Sequential
AUS, United Arab Emirates	51%	64%	79%	71%
U. of Minnesota Duluth, USA	46%	65%	90%	70%
Ryerson University, USA	53%	66%	86%	72%
U. Belo Horizonte, Brazil	65%	81%	79%	67%
University of Puerto Rico, USA	47%	61%	82%	67%
U. of Sao Paulo, Brazil	57%	68%	80%	51%
University of Kingston	51%	64%	79%	71%
ITAM, México	61%	70%	81%	68%

Table 5-19 AP students from ITAM dominant learning style percentages in comparison with institutions from other countries (Felder & Spurlin, 2005 and Zualkernan et al., 2006)

Table 5-19 shows the dominant learning style percentages of AP from ITAM learners as compared with similar learners from other countries as reported in (Felder & Spurlin, 2005; Zualkernan et al., 2006). For example, the first column shows that 61% of the respondents at ITAM were primarily active learners as similar to 57% in the University of Sao Paulo, Brazil. In general, Table III shows that the learning styles of ITAM in AP students are in ranges similar to those ranges or students from comparable universities in the United States and Latin America, the dominant learning style for these universities are Sensitive, visual and sequential learning styles, only in U. of Minnesota and University of Puerto Rico are under 50% in active learning style.

5.4.9 Teaching styles and learning styles

The Teaching styles survey was designed by Center for Occupational Research and Development (CORD) to gauge the teaching preferences and styles. It has twelve items, rank the statement that best describes the response with a “4”. The next most descriptive statement should receive a “3,” the next a “2,” and finally, rank the least descriptive statement with a “1”.

During the second semester 2008, the teaching styles instrument was administrated to instructors’ of three courses. Response rates were above 74% with 17 instructors with 512 total students (CTA n = 316, CI n = 56 and AP n = 140), the gender was 65.9% male and 34.1% female students. The table 5-20 and table 5-21 shows the percentage of the three groups with the gender, Figure 5-7 show the distribution for course about the three groups.

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	AP	140	27,3	27,3	27,3
	CTA	316	61,7	61,7	89,1
	CI	56	10,9	10,9	100,0
	Total	512	100,0	100,0	

Table 5-20 Frequency Learning styles & teaching styles

Contingency Table IdCourse * Sex

		Sex		
		f	m	Total
IdCourse	1	38	102	140
	2	117	199	316
	3	20	36	56
Total		175	337	512

Table 5-21 Learning styles & teaching styles

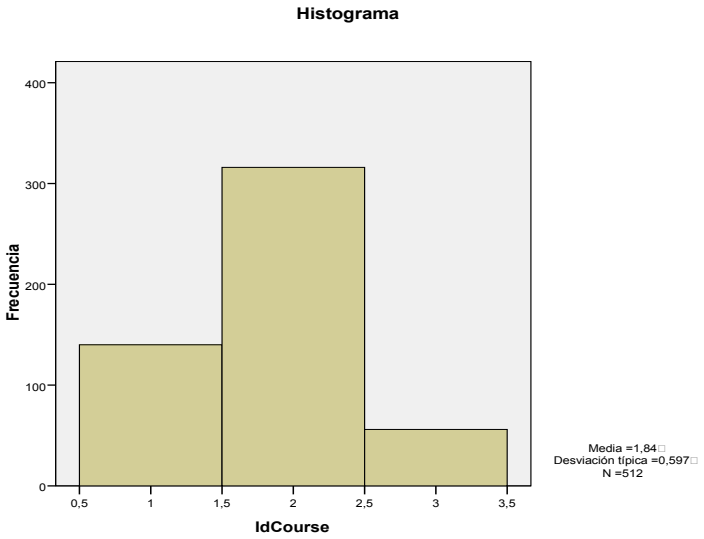


Figure 5-7 Dstribution for three groups

5.4.10 Teaching Styles and Course Grades

These results suggest that the students work alone have better performance that in cooperative group, as shows in table 5-22.

		grade	AbstractAply	UnderstRote	IndCoop	EnactiveSimbolic
grade	Pearson Correlation	1	-,081	,024	,225(**)	,019
	Sig. (bilateral)		,066	,584	,000	,670
	N	512	512	512	512	512
AbstractAply	Pearson Correlation	-,081	1	-,071	,041	-,298(**)
	Sig. (bilateral)	,066		,109	,354	,000
	N	512	512	512	512	512
UnderstRote	Pearson Correlation	,024	-,071	1	,011	,409(**)
	Sig. (bilateral)	,584	,109		,802	,000
	N	512	512	512	512	512
IndCoop	Pearson Correlation	,225(**)	,041	,011	1	-,230(**)
	Sig. (bilateral)	,000	,354	,802		,000
	N	512	512	512	512	512
EnactiveSimbolic	Pearson Correlation	,019	-,298(**)	,409(**)	-,230(**)	1
	Sig. (bilateral)	,670	,000	,000	,000	
	N	512	512	512	512	512

** Significative correlation at level 0,01 (bilateral).

Table 5-22 Correlation teaching styles & course performance

5.4.11 Teaching styles and learning styles

The comparison of teaching styles and learning styles (see figure 5-23) also resulted in some interesting relationships. Sensitive learners tend to gain better understanding when they are practical, don´t like courses without an immediate link to the real world (Franzoni et al., 2008), hence the concept representation - abstract and Cognitive Processing— symbolic were a good correlation to get a better understanding of the course contents. Visual-verbal hence the concept Representation—varies from abstract than applied. We will discuss more on these results in the next section.

		act-ref	sns-int	vis-vrb	seq-glob	Abstract Aply	UnderstRote	IndCoop	Enactive Simbolic
act-ref	Pearson Correlation	1	,046	,192(**)	,019	-,041	,066	-,052	,071
	Sig. (bilateral)		,295	,000	,669	,349	,139	,242	,107
	N	512	512	512	512	512	512	512	512
sns-int	Pearson Correlation	,046	1	,119(**)	,260(**)	-,117(**)	,066	,023	,132(**)
	Sig. (bilateral)	,295		,007	,000	,008	,134	,606	,003
	N	512	512	512	512	512	512	512	512
vis-vrb	Pearson Correlation	,192(**)	,119(**)	1	-,006	-,099(*)	,020	,001	,029
	Sig. (bilateral)	,000	,007		,894	,024	,651	,985	,510
	N	512	512	512	512	512	512	512	512
seq-glob	Pearson Correlation	,019	,260(**)	-,006	1	-,058	,025	,066	,045
	Sig. (bilateral)	,669	,000	,894		,193	,574	,134	,309
	N	512	512	512	512	512	512	512	512
AbstractAply	Pearson Correlation	-,041	-,117(**)	-,099(*)	-,058	1	-,071	,041	-,298(**)
	Sig. (bilateral)	,349	,008	,024	,193		,109	,354	,000
	N	512	512	512	512	512	512	512	512
UnderstRote	Pearson Correlation	,066	,066	,020	,025	-,071	1	,011	,409(**)
	Sig. (bilateral)	,139	,134	,651	,574	,109		,802	,000
	N	512	512	512	512	512	512	512	512
IndCoop	Pearson Correlation	-,052	,023	,001	,066	,041	,011	1	-,230(**)
	Sig. (bilateral)	,242	,606	,985	,134	,354	,802		,000
	N	512	512	512	512	512	512	512	512
EnactiveSimbolic	Pearson Correlation	,071	,132(**)	,029	,045	-,298(**)	,409(**)	-,230(**)	1
	Sig. (bilateral)	,107	,003	,510	,309	,000	,000	,000	
	N	512	512	512	512	512	512	512	512

** Significative correlation at level 0,01 (bilateral). * Significative correlation at level 0,05 (bilateral).

Table 5-23 Correlation between teaching styles & learning styles

5.5 Implication on pedagogical design

The study presented here should allow the teacher to determine the most appropriate teaching strategy and course material. Different approaches can be used. A recommendable approach consists in clustering students with similar learning styles and using the appropriate teaching strategy and material for each of the groups. Usually, the teacher is not able to implement such an approach, due for example to course time constraints, unavailability of the appropriate resources, etc. Should this

be the case, another plausible approach consists of the identification of the "group average style" and the selection of the material accordingly. A third alternate approach (and perhaps the most recommendable one, should the resources allow it) consists of the use of different types of materials (thus targeting different styles) for a set of two or three learning units at a time. The selected material would be used on a rotational basis. This can be done with the integration of teams or groups of students having different learning styles. The adoption of this third approach allows the creation of team group skills for the students. In this situation the teacher might want to focus only on the teaching strategy that is representative of each category of learning style. This is illustrated in the following, overall recommendations are presented to select teaching strategy and prepare e-learning tool for each learning style.

Sensitive learning style: The content must be practical, courses must have an immediate connection with the real world, using concrete methods that are oriented towards facts and procedures that follow previously established techniques. The requested homework must be detailed, not global, including problem solving, laboratory exercises and concept memorization.

Intuitive learning style: The content must be innovative, oriented to theory and meanings, with abstractions and mathematical formulae, avoiding repetitive methods. The requested homework must include the discovery of relations and actions. The introduction of new concepts can be used but not as memorizing facts but as abstractions.

Visual learning style: The content must be a heavy on visual components. The requested homework must include actions to visualize, the information gathering must use visual representations, images must be used in order to make it easier for the students to remember the contents, and the teacher can request diagrams that summarize the homework.

Verbal learning style: The content must have a lot of oral and textual components. The requested homework must include written essays or oral presentations, the information gathering must use textual representations, texts must be used in order to make it easier for the students to remember the contents, and the teacher can request abstracts that summarize the homework.

Active Learning Style: Students tend to comprehend and assimilate new information when they practice using it (discussion, implementation, group presentations) and rather learn working with others. The content must be applicable. The requested homework must include work in groups.

Reflexive learning style: Students observe and ponder experiences. Data are collected and analyzed thoroughly about before any conclusion is made. The content must be related with experiences. The requested homework must include personal work.

Sequential Learning Style: The content must be written orderly, step by step. The requested homework must consist of small orderly steps that are logically associated to the problems being solved. This allows content to be shown in steps (chapters).

Global learning style: The content must be written in big leaps, suddenly and almost randomly. Students can solve complex problems quickly and put things together in an innovative way but may have difficulties to explain how they did it. This allows seeing everything as a whole (Franzoni & Assar, 2009)

Blogs: Facilitate publication of knowledge, opportunities for subsequent reflection and analysis, and help teachers understand the relational and contextual basis of knowledge (Ferding &Trammell, 2008; Saeed & Yang,2008).

Wikis: Facilitate the creation of shared knowledge, dissemination of information, and group interaction (Augar et al., 2004).

Social bookmarks: Allow quick and easy access online resources (Asmus et al., 2008).

Podcasts: Provide an innovative way for people to improve communication, collaboration and social networking (Ractham & Zhang, 2006).

All of these features are key learning elements and make emerging tools appropriate for educational settings. However, to help students achieve the full cognitive development, lecturers need to be amongst the early adopters of these technologies by integrating then with the end user experience and learning styles (Saeed & Yang, 2008). We believe that above outcomes can serve as guideline for the lectures in choosing the right content and right technology for the right audience in their courses. Existing studies show that matching learning styles with teaching styles is advantageous to academic achievements (Smith & Dalton, 2005).

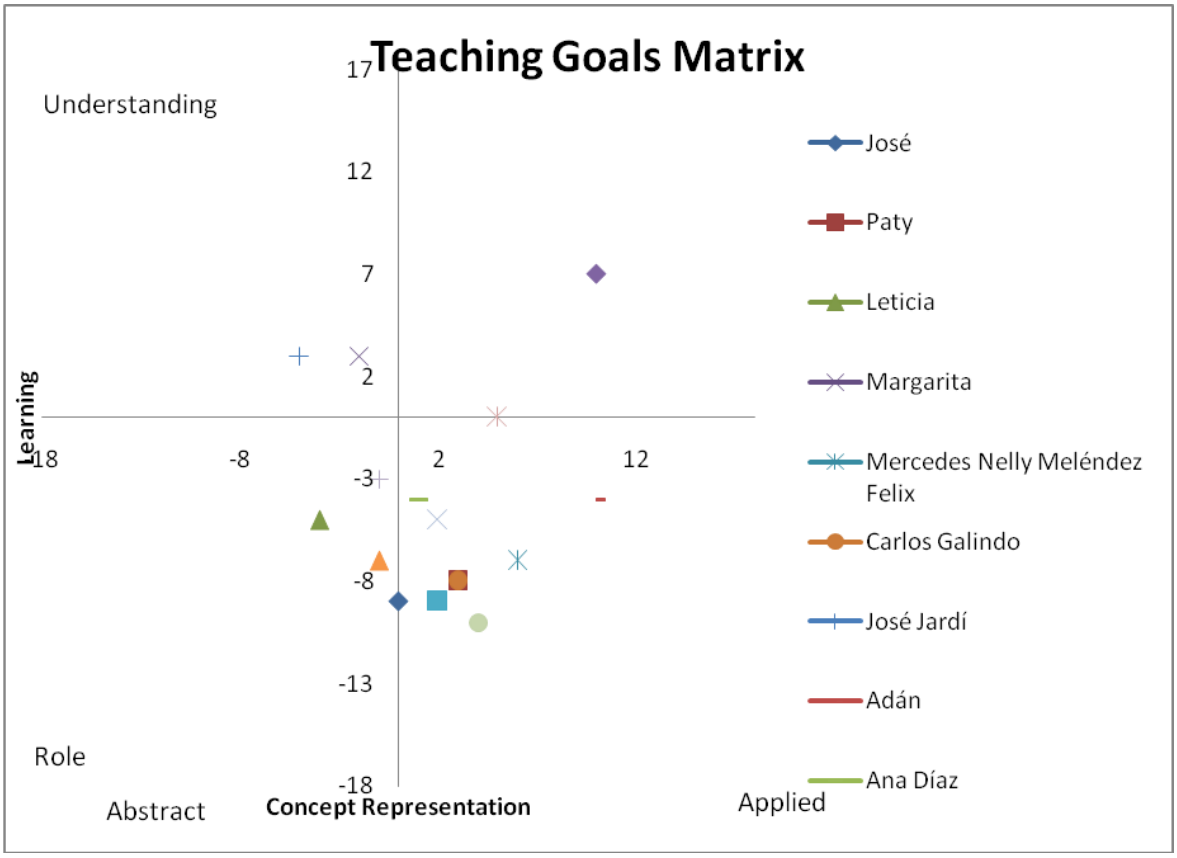


Figure 5-8 Teaching Goals Matrix Interpretation

Quadrant A = Instructor prefers rote learning to analysis (Example: Students memorize abstract facts, such as multiplication tables and atomic weights, through repetition.)

Quadrant B = Instructor prefers rote learning and focuses on practical applications (Example: Students learn practical facts about the real world, such as the available numerical apertures on fiber optics and the tensile strength of different sizes of nails.)

Quadrant C = Instructor prefers analysis to rote learning but does not focus on practical applications (Example: Students learn abstract processes, such as how to plot vectors representing forces on an unidentified object in an undefined space.)

Quadrant D = Instructor prefers analysis to rote learning and focuses on familiar applications (Example: Students are presented with real-world problems in which they use formulas and processes such as plotting designs for car parts using AutoCAD.)(webpage 2)

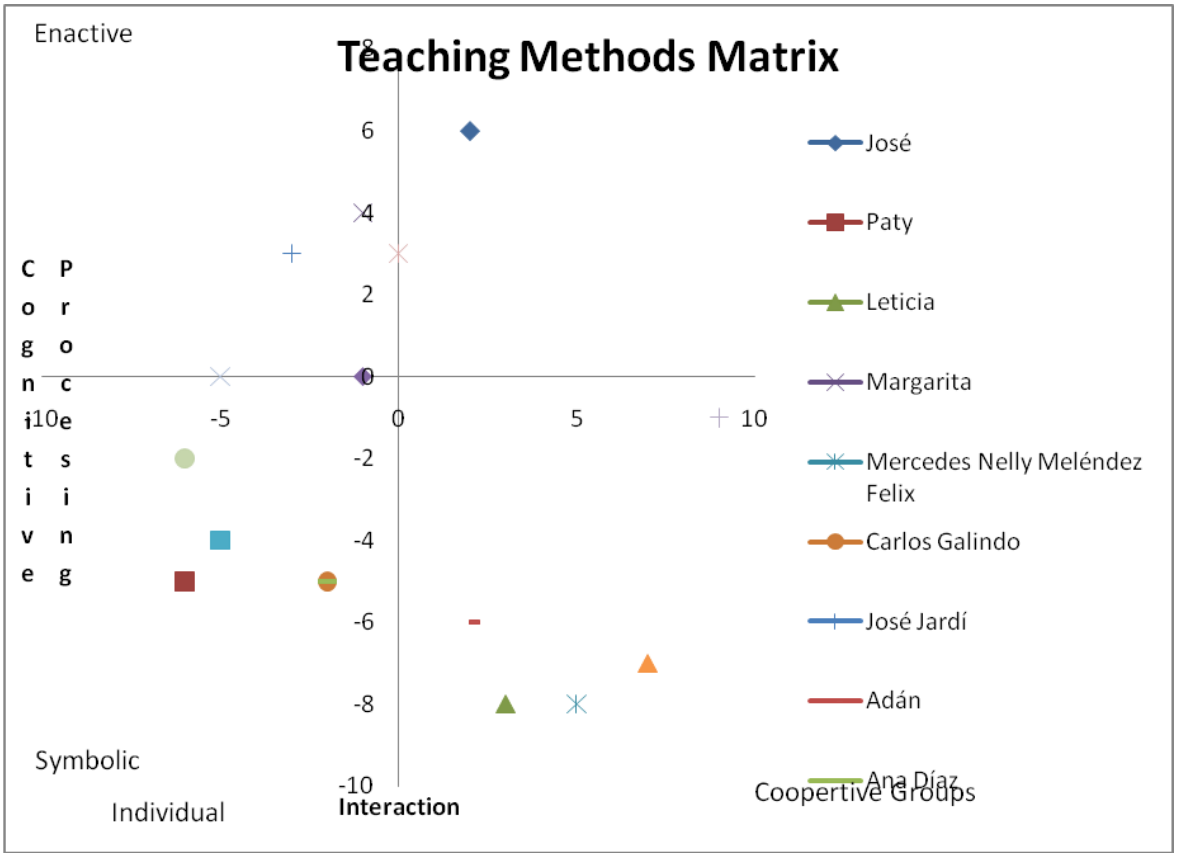


Figure 5-9 Teaching Methods Matrix Interpretation

Quadrant A= Instructor prefers to have student's process information via symbols and language and work as individuals (Example: Students listen to a lecture.)

Quadrant B= Instructor prefers to have student's process information via symbols and language and work in groups (Example: Students discuss problems in groups.)

Quadrant C=Instructor prefers to have students learn through manipulative used individually. (Example: Working individually at computers, students explore physics principles by manipulating variables in interactive web-based applets.)

Quadrant D=Instructor prefers to have students learn through hands-on activities completed collaboratively (Example: team lab projects)(web page 2)

5.6 Conclusion

The work presented in this chapter answers to question 3: To which extent is it possible to validate and to generalize this framework? As an answer to this investigation we found that results concerning the application of the framework are the same, and don't depend on the degree program that the student selects. Also the framework is general and applies to students from different degree program. In addition the chapter presented three broad determinations. First, a great similarity in learning styles is present between teaching strategies and learning styles of the students, and a great similarity in learning styles is present between electronic media and learning styles of the students. Therefore, these results validate the framework and the answers to these materials for the students of all programs; hence we can suggest a modest generalization of the framework. We utilized the results to suggest other findings. Second, the similarity between learning styles of AP students and CTA students suggests the possibility of constructing pedagogical designs for courses but not for CI students. We have been successful in establishing several significant relationships and highlighting the tools preferences of various learner types, for example, the reflective style was significantly correlated with the preference of using vodcast and podcast which is in contrast with Saeed's study (Saeed & Yang, 2008) who report that the active-reflective did not give in any significant relationship when correlated with the tools preferences. Sequential-global scale was significantly correlated with the preference of using social bookmarks. These results suggest that reflective learners are correlated with global learners. These findings are also consistent with those reported by Alfonseca (Alfonseca et al., 2006), and may be used to form appropriate groups in programming assignments or projects. Third, the study outcomes clearly suggest that today's students are flexible in stretching their learning styles to accommodate varying teaching methods, including the use of emerging technologies. They further suggest that learning styles of today's learners facilitate them to experience emerging and varying technologies, while their learning preferences are not limited to a particular tool.

This study is part of our ongoing research on incorporating emerging e-learning tools in educational settings. To further strengthen our study results, we plan to conduct follow up studies in the usage of e-learning tools for different learning and teaching styles. This is an innovative idea that can help people have a better performance whilst learning. With the conclusion of this chapter we answer question 3.

Chapter 6

6 Concluding remarks

In this chapter we summarize the results of the previous chapters and give some pointers for future research.

6.1 Conclusions

In this dissertation we have studied the fields of learning styles, teaching styles and e-media and the possible connections between them. We started in chapter 1 by asking three research questions about these research areas and links between them. We will now summarize our findings and give the answers that we came up with in the different chapters of this thesis.

Technology is an increasingly influential factor in education. The basic principle of our research work is the creation of teaching methods and environments that use the vast resources offered by IT to adapt teaching material and strategies to the learner's skills and learning style. We use the Felder & Silverman (1988) model for defining learning style, together with an empirically built adaptation framework for matching e-media with combinations of teaching strategies and learning styles. We made two case studies to validate and generalize the framework. We made an overview of the potential of new e-media, we show that we can use new ways to create teaching material using available e-media and suggest that a personalization approach to education is relevant.

Research question 1: Is it helpful for a student in a course to learn and acquire knowledge using his/her particular learning style and e-media combined in a learning system? The answer to this research question is positive. In chapter 3 we showed that the basic system we have experimented with was satisfactory, we confirmed that it is an innovative idea that it can help people having a better performance whilst learning. We noticed that a student can learn more if the teaching is adapted to his/her learning style. The system was accepted positively by the students who participated in the test.

This experiment showed the viability of our approach and we conclude that it is possible to introduce personalization techniques based on learning styles and electronic media in educational environments. The system was positively appreciated by students even if the matching of the learning styles, with e-media and teaching strategies was limited to only two learning styles, to graphics and to only text and one teaching strategy.

The system's design is generic. We have used it to teach the C programming language, but we can easily replace this course material with other subject matter by modifying only the Materials Database, without the need to alter any other parts of the system.

Research question 2: Can we create a framework for integrating teaching strategies, learning styles and electronic media?

In chapter 4 we explained that the answer is to provide a structured framework to help in facilitating the learning process and personalizing the pedagogical resources. The chapter describes the development of an integrated framework combining learning styles, different teaching strategies and the corresponding appropriate electronic media.

We consider the recommendations on teaching strategies and electronic media that match a certain learning style as an important contribution to the field of pedagogical teaching methods. The evaluation of the student's learning style gives a strong insight about the student's ability to capture the teacher's message. The proposed framework offers a wide range of possibilities for building a course. Even if full personalization is not possible in face to face teaching, the teacher can develop different versions of the teaching material to fit to the learning styles of as many students as possible. It might happen that a teacher does not know the students' learning styles. Furthermore, he/she might not know either the appropriate educational strategies or instructional material for his/her courses. The presented framework is thus a useful tool to get a better knowledge of the wide variety of resources available to use in class.

This framework can be used in traditional face to face classes where the teacher can calculate the course's students' representative learning style to choose the suitable media as proposed by the adaptive teaching framework. It can also be used in distance learning courses. It is worth mentioning that combining teaching strategies with electronic media as proposed by our method doesn't act in an excluding way. It can be combined with any additional teaching approach and/or teaching resources. Because the adaptive framework is user friendly, the person implementing this method doesn't have to be an expert in information technology.

Research question 3: To which extent is it possible to validate and to generalize this framework?

The answer to this research question is also positive. We found that results concerning the application of the framework are the same and don't depend on the degree program that the student select. Also the framework is general and applies to students from different degree program. In chapter 5 we showed, with statistical methods, that a great similarity in learning styles is present between teaching strategies and also with

electronic media, this comparison contained almost all the matches founded with the Panel Delphi. These results validate the framework.

6.2 Future Work

In this dissertation we focus on one issue. It is incorporating learning styles, teaching strategies and electronic media in a framework tool that serves as a guide for teaching.

There are several possible extensions of our research. We outline them here:

The answer to research question 1 shows that not all dimensions of learning styles as used and we have limited usage of electronic media, so we want to extended the e-learning system for exploring the adaptation techniques using different electronic media. We can experiment the framework in the e-learning system for select and create the material for one computing course and then generalize for other courses.

In addition we could create a repository of different teaching material depends on the learning styles and research how can we do the automatically creation.

The answer to research question 2 was limited to the ITAM student population, and it would be good to extend our research to different populations to validate and justify the generally of the framework.

As another future direction we could consider the possibility of applying the framework to a variety of theories of learning styles and not only Felder & Silverman. More research is needed in order to decide whether new course material and tools should be designed.

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Appendix

Appendix A

Estilos de Aprendizaje

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Instrucciones: Seleccione la opción "a" o "b" para indicar su respuesta a cada pregunta. Si tanto "a" como "b" le parecen correctas, seleccione aquella que ocurra con más frecuencia.

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Firma alumno:

1. Entiendo mejor algo después de:
   - ● a) practicarlo
   - ○ b) pensar acerca de eso

2. Preferiría ser considerado:
   - ○ a) realista
   - ● b) innovador

3. Cuando pienso lo que hice ayer, es más probable que lo haga en base a:
   - ● a) una imagen
   - ○ b) palabras

4. Tiendo a:

- a) entender los detalles de un tema, pero no veo claramente su estructura completa
- b) entender la estructura completa, pero no veo claramente los detalles

5. Cuando aprendo algo nuevo, me ayuda:

- a) hablar acerca de eso
- b) pensar acerca de eso

6. Si fuera un profesor, preferiría enseñar un curso:

- a) que trata sobre hechos y situaciones de la vida real
- b) que trata de ideas y teorías

7. Prefiero obtener información nueva de:

- a) imágenes, diagramas, graficas, o mapas
- b) instrucciones escritas o información verbal

8. Una vez que entiendo:

- a) las partes, entiendo el tema completo
- b) el tema completo, comprendo como se integran las partes

9. En un grupo de estudio trabajando con material difícil, suelo:

- a) participar y contribuir con ideas
- b) sentarme y escuchar

10. Es más fácil para mí:

- a) aprender hechos
- b) aprender conceptos

11. En un libro con muchas imágenes y gráficas, suelo:

- a) observar y estudiar las imágenes y cuadros cuidadosamente
- b) enfocarme en el texto escrito

12. Cuando resuelvo problemas matemáticos:

- a) trabajo en las soluciones paso a paso
- b) Suelo obtener las soluciones, pero luego tengo dificultad para imaginarme los pasos para llegar a ellas

13. En las clases que he tomado:

- [x] a) Suelo conocer a muchos de los estudiantes
- [ ] b) No suelo conocer a la mayoría de los estudiantes

14. Al leer textos que no son de ficción, prefiero:

- [ ] a) aquellos que me enseñan hechos nuevos o me dicen como hacer algo
- [x] b) aquellos que me dan nuevas ideas en que pensar

15. Me gustan los maestros que:

- [x] a) usan muchos diagramas en el pizarrón
- [ ] b) toman mucho tiempo explicando

16. Cuando analizo una historia o novela:

- [x] a) pienso en los incidentes y trato de acomodarlos para obtener los temas
- [ ] b) se cuales son los temas al terminar de leer y luego tengo que regresar y encontrar los incidentes que los demuestran

17. Cuando inicio a resolver un problema de tarea, suelo:

- [ ] a) trabajar en la solución inmediatamente
- [x] b) tratar de entender todo el problema primero

18. Prefiero la idea de:

- [x] a) certeza
- [ ] b) teoría

19. Recuerdo mejor lo que:

- [x] a) veo
- [ ] b) oigo

20. Es mas importante para mi que un profesor:

- [ ] a) exponga el material en pasos secuenciales claros
- [x] b) me dé un panorama general y relacione el material con otras temas

21. Prefiero estudiar:

- [x] a) en grupo de estudio
- [ ] b) solo

22. Me considero:

- a) cuidadoso con los detalles de mi trabajo
- b) creativo en la forma en la que hago mi trabajo

23. Cuando pregunto por direcciones de un lugar nuevo, prefiero:

- a) un mapa
- b) instrucciones escritas

24. Aprendo:

- a) a un paso constante. Si estudio duro, lo entiendo
- b) en inicios y pausas. Me llego a confundir pero de repente lo entiendo

25. Prefiero primero:

- a) tratar de hacer algo y ver que sucede
- b) pensar en como voy a hacer algo

26. Cuando leo por diversión, me gustan los escritores que:

- a) son claros en lo que quieren decir
- b) dicen las cosas en forma creativa e interesante

27. Cuando en clase veo un diagrama o esquema, suelo recordar:

- a) la imagen
- b) lo que dijo el profesor acerca del diagrama o esquema

28. Cuando me presentan un cuerpo de información:

- a) me centro en los detalles y pierdo de vista la idea global
- b) trato de entender la idea global, antes de entender los detalles

29. Recuerdo mejor:

- a) algo que he hecho
- b) algo en lo que he pensado mucho

30. Cuando desarrollo una tarea, prefiero:

- a) dominar una forma de hacerla
- b) idear nuevas formas de hacerla

31. Cuando alguien me enseña datos, prefiero:

- [x] a) cuadros o gráficas
- [ ] b) textos que resuman los resultados

32. Cuando escribo un trabajo, primero quiero:

- [x] a) trabajar (pensar o escribir) en el comienzo del trabajo y progresar secuencialmente
- [ ] b) trabajar (pensar o escribir) en diferentes partes del trabajo y luego ordenarlas

33. Cuando trabajo en grupo, primero quiero:

- [x] a) tener una lluvia de ideas grupal para que todos contribuyan
- [ ] b) tener una lluvia de ideas individual y luego comparar la ideas en grupo

34. Considero que es mejor elogio llamar a alguien:

- [ ] a) sensible
- [x] b) imaginativo

35. Cuando conozco personas en una fiesta, suelo recordar:

- [x] a) como es su apariencia
- [ ] b) lo que dicen de sí mismos

36. Cuando aprendo un nuevo tema, prefiero:

- [ ] a) concentrarme en ese tema, para aprender lo mas que pueda de él
- [x] b) tratar de hacer conexiones entre ese tema y temas relacionadas

37. Soy considerado:

- [x] a) extrovertido
- [ ] b) reservado

38. Prefiero cursos que enfatizan:

- [x] a) material concreto (hechos, datos)
- [ ] b) material abstracto (conceptos, teorías)

39. Para diversión, prefiero:

- [ ] a) ver TV
- [x] b) leer un libro

40. Algunos profesores inician sus clases con un esbozo de lo que enseñarán. Esos esquemas son:

○ a) algo útiles para mi

● b) muy útiles para mi

41. La idea de hacer tarea grupal con una sola calificación para el equipo:

○ a) me parece bien

● b) no me parece bien

42. Cuando hago cálculos muy grandes:

● a) tiendo a repetir todos mis pasos y revisar mi trabajo cuidadosamente

○ b) encuentro cansado revisar mi trabajo y me tengo que esforzar para hacerlo

43. Tiendo a recordar lugares en donde he estado:

● a) fácilmente y con bastante exactitud

○ b) con dificultad y sin mucho detalle

44. Cuando resuelvo problemas en grupo, suelo:

○ a) pensar en los pasos para la solución de los problemas

● b) pensar en las posibles consecuencias o aplicaciones de la solución en un amplio rango de áreas

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Referencia: Felder, RM, and Silvermann, LK. 1988. Learning and Teaching Styles in Engineering Education. Engineering Education 78:674-681.
Texto adaptado por Ana Lidia Franzoni: Los estilos de aprendizaje y los medios electrónicos.(Estudio de caso), Proyecto de investigación 2008.

Appendix B

Questionnaire –

Humans have different ways of learning. Some can assimilate in a better way the knowledge received visually, auditory or through a certain sense, and this is why the traditional teaching styles generally tend to benefit one of these representation more than others. For example, the visual if everything is written on the blackboard without mayor auditory resources or, on the other hand, when only auditory explanations are used. In this sense, it is necessary to develop new means to deploy resources to support the learning process in a way that it not only suits the characteristics of a few, but that it adapts to the characteristics of each student. One effective way to ensure it (the learning materials can be designed for all types of students based on their learning styles) is by using multiple electronic media. Even though, there are many studies on the effectiveness of multimedia and learning styles in the educational systems (Najjar, 1996) (Liao, 1999), but very few give an idea of which combinations of electronic media and their learning styles are more effective than others. Beachman (2002), along with other researchers, based his investigations on the Dual Coding Theory (information is processed through one of two usually independent channels, while one channel processing verbal information such as text or audio, the other one processes visual information like diagrams, images, animations, etc.), concluding that a combination of the electronic media to expose class learning material helps to improve the learning results. This research is based on the development of learning styles integration taxonomy, teaching strategies and the proper implementation of electronic media to facilitate and personalize the learning process so that students have a better assimilation of knowledge.

To do this research, we ask your collaboration to answer the following questionnaire based on your experience. If you have doubts the any term definition please goes to the glossary at the end.

1. **Please select the electronic media that you don't know**

☐ Audioconference	☐ Lectures	☐ Digital magazines	☐ Digital newspapers
☐ Hypertext (web pages)	☐ eBooks	☐ Slideshows	☐ Readings
☐ Written text (Documents)	☐ Podcast	☐ Videoconference	☐ Videos
☐ Web seminars (broadcasts)	☐ Recorded live events	☐ Animations	☐ Graphics
☐ Movies	☐ Pictures	☐ Simulations	☐ Internet research
☐ Online learning communities	☐ Forums	☐ Weblog or blog	☐ Wikis
☐ Chat (Messenger)	☐ e-mail	☐ WebQuest	☐ Tutorial systems
☒ Course Legacy System	☒ Student Response System		

2. **Please select the electronic media that you have used or use in your classes**

☒ Audioconference	☐ Lectures	☒ Digital magazines	☒ Digital newspapers
☒ Hypertext (web pages)	☒ eBooks	☒ Slideshows	☐ Readings
☒ Written text (Documents)	☒ Podcast	☐ Videoconference	☒ Videos
☒ Web seminars (broadcasts)	☐ Recorded live events	☒ Animations	☐ Graphics
☒ Movies	☒ Pictures	☐ Simulations	☒ Internet research
☒ Online learning communities	☒ Forums	☒ Weblog or blog	☒ Wikis
☒ Chat (Messenger)	☒ e-mail	☐ WebQuest	☐ Tutorial systems
☐ Course Legacy System	☐ Student Response System		

3. **Please select electronic media usually employed for your daily work**

☐ Audioconference	☐ Lectures	☒ Digital magazines	☒ Digital newspapers
☒ Hypertext (web pages)	☐ eBooks	☒ Slideshows	☒ Readings
☒ Written text (Documents)	☐ Podcast	☐ Videoconference	☒ Videos
☐ Web seminars (broadcasts)	☐ Recorded live events	☐ Animations	☐ Graphics
☒ Movies	☐ Pictures	☐ Simulations	☒ Internet research
☒ Online learning communities	☐ Forums	☒ Weblog or blog	☒ Wikis
☒ Chat (Messenger)	☒ e-mail	☐ WebQuest	☐ Tutorial systems
☐ Course Legacy System	☐ Student Response System		

1. **Of the following list of electronic media please select which are completely favourable, favourable or unfavourable to integrate into your classes**

Electronic media	Completely favourable	Favourable	Unfavourable
Audio	☐	☒	☐
Audioconference	☐	☒	☐
Lectures	☐	☒	☐
Digital magazines	☒	☐	☐
Digital newspapers	☒	☐	☐
eBooks	☐	☒	☐
Hypertext (web pages)	☒	☐	☐
Readings	☐	☒	☐
Written text (Documents)	☒	☐	☐
Slideshows	☒	☐	☐
Podcast	☒	☐	☐
Recorded live events	☐	☐	☒
Videoconference	☐	☒	☐
Videos	☒	☐	☐
Web seminars (broadcasts)	☐	☐	☒
Animations	☐	☒	☐
Graphics	☒	☐	☐
Movies	☒	☐	☐
Pictures	☒	☐	☐
Simulations	☐	☐	☒
Internet research	☒	☐	☐
Forums	☐	☒	☐
Online learning communities	☐	☒	☐
Webblog or blog	☒	☐	☐
Wikis	☒	☐	☐
Chat (Messenger)	☐	☒	☐
e-mail	☒	☐	☐
Student Response System	☐	☐	☐
Tutorial systems	☐	☒	☐
WebQuest	☐	☐	☐
Course Legacy System	☐	☐	☐

2. **If you know some electronic media that are not mentioned please write it in the following lines**

1. **According to the learning style, please select the appropriate medium for representation**

Electronic media	Sensitive	Intuitive	Visual	Verbal	Active	Reflexive	Sequential	Global
Audio	1	0	0	1	0	1	0	0
Audioconference	1	0	1	1	0	1	0	0
Lectures	0	1	0	1	0	1	1	0
Digital magazines	0	0	1	1	0	1	0	0
Digital newspapers	0	0	1	1	0	1	0	0
eBooks	0	0	0	1	0	1	0	0
Hypertext (web pages)	0	0	1	0	1	0	1	1
Readings	0	0	0	1	0	1	0	0
Written text (Documents)	0	0	0	1	0	1	0	0
Slideshows	0	1	1	0	1	0	1	0
Podcast	1	0	0	0	1	0	0	0
Recorded live events	0	0	0	0	1	0	0	0
Videoconference	0	0	1	1	0	1	0	1
Videos	1	0	1	0	1	0	0	1
Web seminars (broadcasts)	0	0	0	1	0	1	0	0
Animations	1	0	1	0	1	0	0	0
Graphics	1	0	1	0	0	0	0	1
Movies	0	0	1	0	0	1	0	1
Pictures	0	0	1	0	0	1	0	0
Simulations	0	1	0	0	0	1	1	0
Internet research	0	1	1	0	1	0	1	1
Forums	0	0	0	1	0	1	0	0
Online learning communities	0	1	0	1	0	1	0	1
Webblog or blog	1	1	1	1	1	1	0	1
Wikis	0	1	0	1	0	0	0	1
Chat (Messenger)	0	0	0	1	1	0	0	0
e-mail	0	0	0	1	0	1	0	0
Student Response System	0	0	0	0	0	0	0	0
Tutorial systems	0	0	0	0	0	0	1	0
WebQuest	0	0	1	1	1	0	0	0
Course Legacy System	0	0	0	0	0	0	1	0

2. **Please select didactic strategies that you know**

☒ Games and simulations
☒ Learning based on problem solving
☒ Role playing
☒ Presentation
☒ Discussion panel
☒ Brainstorming

☒ Case study
☒ Question and answer method
☒ Project design method

1. **Please select didactic strategies that you have used in your classes**

☒ Games and simulations
☒ Learning based on problem solving
☒ Role playing
☒ Presentation
☒ Discussion panel
☐ Brainstorming
☐ Case study
☒ Question and answer method
☐ Project design method

2. **Of the following list of didactic strategies please select which are completely** favourable**, favourable or unfavourable to integrate into your classes**

Didactic strategies	**Completely favourable**	**Favourable**	**Unfavourable**
Games and simulations	☒	☐	☐
Learning based on problem solving	☒	☐	☐
Role playing	☒	☐	☐
Presentation	☒	☐	☐
Discussion panel	☒	☐	☐
Brainstorming	☒	☐	☐
Case study	☐	☐	☒
Question and answer method	☒	☐	☐
Project design method	☐	☒	☐

3. **If you know some didactic strategies that are not mentioned please write it in the following lines**

4. **According to the learning style, please select the appropriate didactic strategy representation**

Didactic strategies	**Sensitive**	**Intuitive**	**Visual**	**Verbal**	**Active**	**Reflexive**	**Sequential**	**Global**
Games and simulations	1	1	0	0	1	0	0	1
Learning based on problem solving	0	1	0	1	0	1	1	0
Role playing	0	1	1	1	1	0	0	1
Presentation	0	0	0	1	0	1	0	0
Discussion panel	0	1	0	1	0	0	0	0
Brainstorming	0	1	0	1	1	1	0	1
Case study	1	0	0	1	0	1	1	0
Question and answer method	0	0	0	1	0	1	1	0
Project design method	1	1	0	1	0	1	1	1

1. According to the didactic strategy, please select the appropriate electronic media representation

Electronic media / didactic strategy	Games and simulations	Learning based on problem solving	Role playing	Presentation	Discussion panel	Brainstorming	Case study	Question and answer method	Project design method
Animations	0	0	0	1	0	1	0	0	0
Chat (Messenger)	0	0	0	0	1	1	0	1	0
e-mail	0	1	0	0	0	0	1	1	1
Forums	0	1	0	0	1	0	0	0	0
Movies	1	1	1	1	1	0	1	0	0
Online learning communities	0	1	0	1	1	1	1	0	0
Pictures	0	0	0	1	0	1	1	1	0
Podcast	0	0	0	0	0	0	0	0	0
Searches on Internet	1	1	1	1	1	1	1	1	1
Simulations	1	0	1	0	0	0	0	0	0
Videos	0	0	0	1	1	1	1	1	0
Webblog or blog	1	1	1	1	1	1	0	0	1
WebQuest	0	1	0	0	0	1	0	1	0
Wikis	0	1	0	1	1	1	1	1	0
Digital magazines	0	1	0	1	1	1	1	1	1
Digital newspapers	0	1	0	1	1	1	1	1	1
e-books	0	0	0	1	1	1	1	1	1
Lectures	0	0	0	0	0	0	1	0	0
Recorded live events	0	0	0	0	0	0	1	1	0
Sistemas Tutoriales	0	1	0	0	0	0	0	0	1
written text (Documents)	0	1	0	1	1	1	1	1	1
Graphics	0	0	0	1	0	1	1	0	0
Slideshow (Presentaciones)	1	0	0	1	1	1	1	0	1
Videoconferencia	0	0	0	1	1	0	1	0	0
Audioconferencia	0	0	0	1	0	0	0	0	0
Audio	1	0	1	1	1	0	0	0	0
Course Legacy System	0	0	0	0	0	0	0	0	0
Web seminars (broadcasts)	0	0	0	1	0	0	1	0	0
Webblog or blog,	1	1	1	1	0	0	0	0	0
Wwikis	0	1	0	0	0	1	1	0	1
Chat (Messenger)	0	0	0	0	1	0	0	0	0
Hypertext (web pages)	1	1	1	1	1	1	1	0	0
Student Response System	1	0	0	1	0	1	0	1	0

GLOSSARY

Electronic Media

Electronic Media (Alphabetical Order)	Description
Animations	Animation is the rapid display of a sequence of images of 2-D artwork or model positions in order to create an illusion of movement
Audio	Sound that is capable of being heard
Audioconference	Audioconferencing uses telecommunications of audio to bring people at different sites together for a meeting. This can be as simple as a conversation between two people in private offices (point-to-point) or involve several sites (multi-point) with more than one person in large rooms at different sites.
Chat (Messenger)	Online chat can refer to any kind of communication over Internet, but is primarily meant to refer to direct one-on-one chat or text-based group chat (formally also known as synchronous conferencing), using tools such as instant messaging applications—computer programs, Internet Relay Chat and talkers. Instant messaging (IM) is a form of real-time communication between two or more people based on typed text. The text is conveyed via computers connected over a network such as the Internet
Course Legacy System	A legacy system is an old computer system or application program which continues to be used because the user (typically an organization) does not want to replace or redesign it
Digital magazines	Digital Magazine is an online magazine intended for professional web designers, web developers and those who practice Information architecture.
Digital newspapers	Digital Magazine is an online newspaper intended for professional web designers, web developers and those who practice Information architecture.
eBooks	An e-book (for *electronic book*: also *ebook*) is the digital media equivalent of a conventional printed book. Such documents are either read on personal computers, or on dedicated hardware devices known as *e-book readers* or *e-book devices*.
e-mail	E-mail, short for electronic mail and often abbreviated to *e-mail*, *email* or simply *mail*, is a store and forward method of composing, sending, storing, and receiving messages over electronic communication systems
Forums	An Internet forum is a web application for holding discussions and posting user generated content. Internet forums are also commonly referred to as Web forums, message boards, discussion boards, (electronic) discussion groups, discussion forums, bulletin boards, fora (the Latin plural) or simply forums. The terms "forum" and "board" may refer to the entire community or to a specific sub-forum dealing with a distinct topic. Messages within these sub-forums are then displayed either in chronological order or as threaded discussions
Graphics	Graphics are visual presentations on some surface, such as a wall, canvas, computer screen, paper, or stone to brand, inform, illustrate, or entertain. Examples are photographs, drawings, Line Art, graphs, diagrams, typography, numbers, symbols, geometric designs, maps, engineering drawings, or other images. Graphics often combine text, illustration, and color
Hypertext (web pages)	Hypertext most often refers to text on a computer that will lead the user to other, related information on demand. Hypertext represents a relatively recent innovation to user interfaces, which overcomes some of the limitations of written text. Rather than remaining static like traditional text, hypertext makes possible a dynamic organization of information through links and connections (called hyperlinks). Hypertext can be designed to perform various tasks; for instance when a user "clicks" on it or "hovers" over it, a bubble with a word definition may appear, a web page on a related subject may load, a video clip may run, or an application may open.
Internet research	Internet research is the practice of using the Internet, especially the World Wide Web, for research
Lectures	A lecture is an oral presentation intended to present information or teach people about a particular subject, for example by a university or college teacher
Movies	Film is a term that encompasses individual motion pictures, the field of film as an art form, and the motion picture industry. Films are produced by recording images from the world with cameras, or by creating images using animation techniques or special effects.

Electronic Media (Alphabetical Order)	Description
Online learning communities	An online learning community is a common place on the Internet that addresses the learning needs of its members through proactive and collaborative partnerships. Through social networking and computer-mediated communication, people work as a community to achieve a shared learning objective. Learning objectives may be proposed by an instructor or may arise out of discussions between participants that reflect personal interests. In an online community, people communicate via textual discussion (synchronous or asynchronous), audio, video, or other Internet-supported devices.
Pictures	In common usage, an image (from Latin *imago*) or picture is an artifact, usually two-dimensional, that has a similar appearance to some subject—usually a physical object or a person. Images may be two-dimensional, such as a photograph, screen display, and as well as a three-dimensional, such as a statue.
Podcast	A podcast is a collection of digital media files which is distributed over the Internet, often using syndication feeds, for playback on portable media players and personal computers. The term, like "radio", can refer either to the content itself or to the method by which it is syndicated; the latter is also termed podcasting. The host or author of a podcast is often called a podcaster. The term "podcast" is a portmanteau of the acronym "Pod" – standing for "Portable on Demand" – and "broadcast". The iPod name was coined with Pod, prefixed with the "i" commonly used by Apple for its products and services. The first podcasting scripts were developed for the iPod (see history of podcasting). These scripts allow podcasts to be automatically transferred to a mobile device after they are downloaded
Readings	Reading is the cognitive process of deriving meaning from written or printed text
Recorded live events	Record live events is a type of video recording system that works by using a digital rather than an analog video signal and recording daily events ith a *camera*, *video camera*, and *camcorder*.
Simulations	A simulation is an imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviors of a selected physical or abstract system.
Slideshows	Slideshow is a modern concatenation of "Slide Show". A slideshow is a display of a series of chosen images, which is done for artistic or instructional purposes. Slideshows are conducted by a presenter using an apparatus, such as a carousel slide projector, an overhead projector or in more recent years, a computer running presentation software.
Student Response System	A Student Response System (SRS) is a tool used to promote active learning in the classroom. Students respond to questions posed by the instructor using a small handheld keypad that looks like a TV remote control.
Tutorial systems	A tutorial systems is a document, software, or other media created for the purpose of instruction for any of a wide variety of tasks
Videoconference	Videoconferencing uses telecommunications of audio and video to bring people at different sites together for a meeting. This can be as simple as a conversation between two people in private offices (point-to-point) or involve several sites (multi-point) with more than one person in large rooms at different sites. Besides the audio and visual transmission of people, videoconferencing can be used to share documents, computer-displayed information, and whiteboards.
Videos	Video is the technology of electronically capturing, recording, processing, storing, transmitting, and reconstructing a sequence of still images representing scenes in motion. Video technology was first developed for television systems, but has been further developed in many formats to allow for consumer video recording. Video can also be viewed through the Internet as video clips or streaming media clips on computer monitors.
Web seminars (broadcasts)	Broadcasting is the distribution of audio and/or video signals which transmit programs to an audience. The audience may be the general public or a relatively large sub-audience, such as children or young adults

Electronic Media (Alphabetical Order)	Description
Webblog or blog	A blog (a portmanteau of web log) is a website where entries are commonly displayed in reverse chronological order. "Blog" can also be used as a verb, meaning to maintain or add content to a blog. Many blogs provide commentary or news on a particular subject; others function as more personal online diaries. A typical blog combines text, images, and links to other blogs, web pages, and other media related to its topic. The ability for readers to leave comments in an interactive format is an important part of many blogs. Most blogs are primarily textual, although some focus on art (artlog), photographs (photoblog), sketchblog, videos (vlog), music (MP3 blog), audio (podcasting) are part of a wider network of social media. Micro-blogging is another type of blogging which consists of blogs with very short posts.
WebQuest	A WebQuest is a learning activity used by educators. During this activity learners read, analyze, and synthesize information using the World Wide Web.
Wikis	wiki is software that allows users to create, edit, and link web pages easily. Wikis are often used to create collaborative websites and to power community websites. They are being installed by businesses to provide affordable and effective Intranets and for Knowledge Management. Ward Cunningham, developer of the first wiki, WikiWikiWeb, originally described it as "the simplest online database that could possibly work".One of the best known wikis is Wikipedia
Written text (Documents)	A document (noun) is a bounded physical representation of body of information designed with the capacity (and usually intent) to communicate.

Appendix C

TEACHING STYLE INVENTORY

This inventory was designed by CORD to gauge your teaching preferences and styles. There are no right or wrong answers to these questions. Below, you will find twelve items, each of which contains four statements about ways you might respond in your teaching, through the way you might behave, think, or feel. Rank the four statements to reflect how well they describe the way you teach. Occasionally, you may feel that none of the statements describe you, or that all of the statements describe you. In these instances, you should force yourself to rank the statements the best way possible in order to get an accurate picture of your particular styles.

Please rank the statement that best describes your response with a "4". The next most descriptive statement should receive a "3," the next a "2," and finally, rank the least descriptive statement with a "1". The rankings should be recorded in the space next to the statement.

When I teach my class, I would be most likely to:

1.
4 A. Include student's life experiences or preexisting knowledge when I introduce a concept.

1 B. Incorporate reading assignments that provide the background for each concept introduced.

3 C. Require students to learn by doing creative problem solving exercises, laboratory activities, and projects.

2 D. Engage students in problems that are outside the realm of possibility to force them to think creatively.

2.
1 A. Suggest that students collaborate together on their assignments rather than compete.

2 B. Instill the relevant facts and procedures. When students cannot pass the state exam or do not have the prerequisite knowledge from my class in the next one they take, I have truly failed as a teacher.

4 C. Assign a wide variety of tasks that facilitate learning for understanding. Sometimes learning for understanding takes longer than the administration would like, or longer than I originally planned.

3 D. Cultivate scholarship and independent thinking/reasoning skills by providing optional assignments that can be done outside of class.

3.
2 A. Tie concepts to applications in the real world.

4 B. Institute a regularly scheduled time for skill building where students practice their use of problem solving.

3 C. Guide students in their desire to invent new methods for solving problems and/or representing data.

1 D. Introduce students to the possibility that for some problems there is no "right answer".

4.
4 A. Challenge students to reevaluate their own understanding by valuing the opinions of other students.

1 B. Supply students with the structure they need to recall and repeat the appropriate facts and procedures from memory to pass the end-of-unit or end-of-semester test.

3 C. Capitalize on student curiosity about unfamiliar situations.

2 D. Specify a certain amount of time in class for homework.

5.
1 A. Become concerned if I feel as though students are asking the question "Why do I have to learn this?"

2 B. Insist that students follow my lecture, and frequently question them during the lecture as a check of where I am. I may require that they take notes throughout.

4 C. Supply time for exploration and discovery where students have the opportunity to answer their "what if" questions.

3 D. Allow students to develop their own problem solution process.

6.
3 A. Illuminate students' misunderstandings by having them describe their thought processes and explain their ideas.

1 B. Provide a relatively complete content structure for students to memorize so that they can build upon this foundational knowledge later.

2 C. Present scenarios involving many concepts that provide material for class discussion about solutions and predictions.

4 D. Devote time to skill drills where each student works alone to deepen their understanding of a concept.

7.
4 A. Try to provide a rationale for learning that motivates students based upon relating what they are taught with what they know will help them later in life.

3 B. Provide many problems of the same type. I find that repetition and practice help my students better transfer their knowledge to new situations.

2 C. Introduce manipulatives or software, to permit students to represent concepts concretely.

1 D. Require that students commit facts to memory.

8.
1 A. Assign student roles for activities, such as equipment custodian, timer, measurer, recorder, evaluator, and observer.

2 B. Enforce accurate application of a solution procedure by using already learned responses to solving the problem or similar problems.

3 C. Foster creative problem solving that has some element of discovery embedded, forcing students to find the new rule or principle.

4 D. Walk around while students are working, speaking to them individually about my observations, or asking them questions about their problem-solving process or procedures.

9.
1 A. Help students understand that real life situations and scenarios cannot be carried out without an understanding of the knowledge I am providing.

3 B. Relate the method for solving a problem as explicitly as possible.

4 C. Encourage different approaches to problem solving that help students understand their reasoning skills and processes.

2 D. Present the facts first.

10.
1 A. Situate students in groups when assigning worksheets.

2 B. Amplify the importance of attaining the correct answer.

3 C. Assist students in moving gradually from representing information concretely to representing information symbolically.

4 D. Identify and point out during lecture the finer points in my problem solving methods that should be of assistance to all students.

11.

3 A. Scaffold upon previously understood concepts and knowledge that can be concretely examined based upon experiences at home, with friends, or activities students find interesting and valuable to them.

1 B. Frequently provide quizzes (as many as 1 per week) that help me understand how well my students are able to apply the problem solving methods they have been provided.

2 C. Establish activities that require collecting data, analysis of that data, making conclusions and predictions from it, followed by group reflection on the fundamental concepts involved in their data collection and analysis.

4 D. Ask open-ended questions that allow students to explore their ideas and creative thoughts in whatever direction they choose.

12.

3 A. Structure group activities that require students learn to use interpersonal skills.

2 B. Maintain the position that even though a problem may be solvable empirically, students must learn the analytical solution first before they begin to make such predictive solutions to problems.

4 C. Expand the ability of students to transfer their knowledge to new situations by incorporating project-based approaches.

1 D. Eliminate activities where the result is not distinctly attributable to individual students.

Appendix D

HERRAMIENTAS ELECTRÓNICAS DE APRENDIZAJE

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-Información Personal-
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Sección I
Por favor contesta las siguientes preguntas para ayudarnos a comprendor tu manejo del internet

1. ¿Cuál es su género
   masculino
   femenino
2. ¿Cuál es su edad?
   22
3. ¿Cuál es su ocupación?
   estudiante de tiempo completo
   estudiante de medio tiempo
   otro (por favor especifique abajo)

4. ¿Cuál es su grado escolar más alto completado?
   preparatoria
   TAFE
   universidad
   posgrado
   otro (por favor especifique)

   porfavor especifique el área de especialización

5. ¿Cuántas horas usas a la semana el Internet?
   5 - 10 horas
   10 - 15
   15 - 20
   más de 20 horas
6. ¿Para qué es lo que más utilizas el Internet? (escoge sólo una)
   trabajo
   estudio
   compartir información
   entretenimiento (m&uactue;sica/videos)
   comunicación con familia/amigos
   hacer contactos sociales
   colaboración
   autoaprendizaje
   otro (por favor especifique)

7. ¿Tienes acceseo un reproductor MP3?

Si
No

8. Si tu respuesta fue "si", ¿qué tipo de reproductor MP3 tienes?
   reproductor portable (iPod, MP3/4 player)
   PC (escritorio o laptop)
   ambos

Sección II

Por favor contesta las siguientes preguntas acerca de tu experiencia con algunas modalidades emergentes del e-learning como *Blogs (p.e. Blogger o WordPress), Podcasts (p.e. grabaciones de audio y video), Wikis (p.e. Wikipedia)* y *Social Bookmarkings (p.e. del.icio.us o furl)*

9. ¿Cuál es tu experiencia con *blogs*?
   sin experiencia (pasa a P14)
   1-3 meses
   4-6 meses
   7-12 meses
   1-2 años
   más de 2 años

10. ¿Con qué frecuencia usas *blogs* por semana?
   1-3 veces
   4-6 veces
   7-10 veces
   más de 10 veces

11. ¿Qué tipo de *blogs* vistas más?
   personal
   noticias
   educativos
   ciencia y tecnlog'a
   fotográficos
   de videos
   otro (por favor especifique)

12. ¿Para qué es lo que más usas *blogs*? (elige sólo una)
   diario en línea
   educación
   colaboración grupal / contactos sociales
   compartir información e ideas
   autopromoción / autoaprendizaje
   entretenimiento
   otro (por favor especifique)

13. En tu opinión, ¿cuál es la mejor funcionalidad de los *blogs*? (elige sólo una)
   diario en línea
   educación
   colaboración grupal / contactos sociales
   compartir información e ideas
   autopromoción / autoaprendizaje
   entretenimiento
   otro (por favor especifique)

14. ¿Cuál es tu experiencia con *podcasts/vodcasts*?
   sin experiencia (pasa a P18)
   1-3 meses
   4-6 meses
   7-12 meses
   1-2 años
   más de 2 años

15. ¿Con qué frecuencia bajas *podcasts/vodcasts* por semana?

1-3 veces
4-6 veces
7-10 veces
más de 10 veces

16. ¿A qué tipo de *podcasts/vodcasts* te suscribes más? (elige sólo una)
música
películas
educativos
noticias
deportes
ciencia y tecnología
otro (por favor especifique)

17. En tu opinión, ¿cuál es la mejor funcionalidad de los *podcasts/vodcasts*? (elige sólo una)
entretenimiento
educación
almacenamiento de información
movilidad
colaboración grupal / almacenamiento de información
autopromoción / autoaprendizaje
otro (por favor especifique)

18. ¿Cuál es tu experiencia con *social bookmarks*?
sin experiencia (Q22)
1-3 meses
4-6 meses
7-12 meses
1-2 años
más de 2 años

19. ¿Con qué frecuencia usas *social bookmarks* por semana?
1-3 veces
4-6 veces
7-10 veces
más de 10 veces

20. ¿Qué tipo de sitios remarcas más usando *social bookmarks*? (elige sólo una)
música
películas
educativos
noticias
deportes
ciencia y tecnología
otro (por favor especifique)

21. En tu opinión, ¿cuál es la mejor funcionalidad de los *social bookmarks*? (elige sólo una)
almacenamiento en línea de mis bookmarks
contactos sociales
generación de conocimiento
compartir conocimiento
compartir intereses comunes
otro (por favor especifique)

22. ¿Cuál es tu experiencia con *wikis*?
sin experiencia (pasar a P22)
1-3 meses
4-6 meses
7-12 meses
1-2 años
más de 2 años

23. ¿Con qué frecuencia usas *wikis* por semana?
    - (1-3 veces)
    - 4-6 veces
    - 7-10 veces
    - más de 10 veces

24. ¿Qué tipo de *wikis* visitas más?
    - personal
    - noticias
    - (educativos)
    - entretenimiento
    - ciencia y tecnología
    - otro (por favor especifique)

25. ¿Para qué es lo que más usas *wikis*?
    - edición compartida
    - (educación)
    - colaboración grupal / almacenamiento de información
    - compartir información e ideas
    - autopromoción / autoaprendizaje
    - entretenimiento
    - otro (por favor especifique)

26. En tu opinión, ¿cuál es la mejor funcionalidad de los *wikis*?
    - edición compartida
    - (educación)
    - colaboración grupal / almacenamiento de información
    - compartir información e ideas
    - autopromoción / autoaprendizaje
    - entretenimiento
    - otro (por favor especifique)

Sección III

Por favor lee las siguientes oración y elige que tanto prefieres usar cada una de estas funcionalidades en las diferentes situaciones. Usando la escala provista escribe el número que más se adecúe en la caja de texto junto a cada oración (por favor introduce sólo números del **1** al **7**.

menos preferido 1 2 3 4 5 6 7 más preferido

27. Preferiría repasar un tema
    - 5 escuchando un *podcast* (grabación de audio) del tema
    - 4 viendo un *vodcast* (grabación de video) del tema
    - 6 discutiéndolo en un *blog*
    - 1 discutiéndolo en un *wiki*
    - 3 chateando con mis compañeros en *IM*
    - 2 platicando con mis compañeros en *IM*

28. Preferiría entregar un proyecto grupal a mi profesor:
    - 6 como un *podcast*
    - 7 como un *vodcast*
    - 3 por medio de un *blog*
    - 2 por medio de un *wiki*
    - 1 por medio de un correo electrónico
    - 4 por medio de un *Blackboard*
    - 5 *IM*

29. Preferiría tener una discusión con mi profesor a través de:

6 audio conferencia
7 video conferencia
3 *wiki*
5 *blog*
1 correo electrónico
4 *Blackboard*
2 *IM*

30. Preferiría tener una discusión grupal a través de:
6 audio conferencia
7 video conferencia
4 *wiki*
3 *blog*
2 correo electrónico
5 *Blackboard*
1 *IM*

31. Preferiría tener una discusión de estudio con mis compañeros a través de:
6 audio conferencia
7 video conferencia
3 *wiki*
2 *blog*
4 correo electrónico
5 *Blackboard*
1 *IM*

32. Preferiría que mi profesor se comunicara en horas de oficina a través de:
6 audio conferencia
7 video conferencia
3 *wiki*
4 *blog*
2 correo electrónico
5 *Blackboard*
1 *IM*

33. Preferiría recibir indicaciones dmi profesor a través de:
6 audio conferencia
7 video conferencia
4 *wiki*
3 *blog*
1 correo electrónico
5 *Blackboard*
2 *IM*

34. Preferiría almacenar mis resaltados en línea en:
6 audio conferencia
7 video conferencia
5 *wiki*
4 *blog*
2 correo electrónico
1 *Blackboard*
3 *IM*

Sección IV

Por favor contesta las siguientes preguntas acerca del uso en el futuro de estas herramientas de e-learning en la educación

35. Estás de acuerdo con el amplio uso de *Blogs, Podcast, Vodcast* y *Social Bookmarking* como

herramientas de aprendizaje?

Muy de acuerdo | Moderadamente de acuerdo | Ligeramente de acuerdo | Ni en acuerdo ni en desacuerdo | **Ligeramente en desacuerdo** | Moderadamente en desacuerdo | de

36. ¿Estás de acuerdo en que los *blogs* pueden ser usados como herramienta de aprendizaje?

Muy de acuerdo | Moderadamente de acuerdo | **Ligeramente de acuerdo** | Ni en acuerdo ni en desacuerdo | Ligeramente en desacuerdo | Moderadamente en desacuerdo | de

37. ¿Estás de acuerdo en que los *podcasts y vodcasts* pueden ser usados como herramienta de aprendizaje?

Muy de acuerdo | Moderadamente de acuerdo | Ligeramente de acuerdo | Ni en acuerdo ni en desacuerdo | Ligeramente en desacuerdo | **Moderadamente en desacuerdo** | de

38. ¿Estás de acuerdo en que los *social bookmarks* pueden ser usados como herramienta de aprendizaje?

Muy de acuerdo | Moderadamente de acuerdo | Ligeramente de acuerdo | **Ni en acuerdo ni en desacuerdo** | Ligeramente en desacuerdo | Moderadamente en desacuerdo | de

39. Podrías sugerir algunos usos de *blogs* en la educación? (100 caracteres máximo)

Proceso de como hacer tareas y trabajos

40. ¿Puedes sugerir algún uso de *podcasts* o *vodcasts* en educación? (100 caracteres m6aacute;ximo)

ver documentales o noticias

41. ¿Puedes sugerir algún uso de *social bookmarks* educación? (100 caracteres m6aacute;ximo)

no

42. ¿Puedes sugerir algún uso de *wikis* educación? (100 caracteres m6aacute;ximo)

subir trabajos hechas

Cuando termine de llenar el cuestionario por favor oprima "Enviar".

Enviar Limpiar Cuestionario

* las últimas 3 preguntas no se entienden bien si se piden sugerencias de usos o sugerencias de blogs, wikis que conozco.
NO conozco el significado de social backmarks y en algunas preguntas hubiera preferido llenar más de una opción