Journal of Universal Computer Science, vol. 15, no. 7 (2009), 1508-1525
submitted: 28/11/08, accepted: 28/3/09, appeared: 1/4/09 © J.UCS

Development of a Web Application for Management of Learning Styles

Rosa Silva
(Escola Secundária Ferreira de Castro, Oliveira de Azeméis, Portugal
rosa.silva@gmail.com)

António Andrade
(Universidade Católica Portuguesa, Porto, Portugal
aandrade@porto.ucp.pt)

Abstract: Information and Communication Technologies (ICT) permit the innovation of teaching and learning processes. ICT allow teachers to create or select and adjust contents that take advantage of the digital environment and interaction between peers. Teaching methodologies and strategies should be adjusted to the learning styles of students, offering them, in turn, the possibility to reflect about the way in which they might learn better. This article introduces a work of creation and validation of a web-based application, which aims to enhance the Management of Learning Styles (MLS) on the part of students and teachers, based on Felder-Soloman's Index of Learning Styles Questionnaire (ILS) and Honey-Mumford's Learning Styles Questionnaire (LSQ). The prototype has been validated and the results suggest its applicability and the relevance of the information this tool is capable of obtaining – reports on the learning styles profiles by student, teacher and class – with the objective of supporting them in the selection of strategies to improve teaching and learning, developing at the same time skills which will allow them to learn throughout their lives.

Keywords: Learning styles, Web-based Application
Categories: K.3.1

1 Introduction

Information and Communication Technologies (ICT) have brought on profound changes in pedagogical practices, some of which without great financial costs, from the exploration of teaching and learning methodologies supported by digital tools and social contents – on Web 2.0 – for communication through computer networks and, more recently, through portable devices.

This reality requires, therefore, a change in the educational paradigm, in view of more student-focused pedagogics, which makes use of research-action and induction methods and with a focus on curricula based on the process and experience-based learning. This new paradigm has, thus, to be framed by the constructivist theories and active learning methods. There is a need to discontinue the tendency to look at students in the classroom as a whole and pursue strategies for an "average" student, hoping that they will work with all of them, on the basis of an approach that is referred to in the literature as "one-size-fits all".

With this new educational paradigm, students and teachers will have to assume new roles. Teachers should guide the knowledge acquisition process of their students,

making decisions on the strategies and methodologies that they consider to be the most appropriate to the features of each student. Such choices are translated into an increase in responsibilities during the whole process of teaching and learning, mainly when facing changes in behaviour and attitude of each student vis-à-vis their own process of learning, while assuming a more active role in the building of their knowledge.

Therefore, there is a need to conceive learning environments which should be more personalized, differentiated and effective [see Morales, et al. 2007], and which contribute to strengthening the students' motivation and consider, by way of ICT exploration, a higher and more appropriate level of distribution, interaction and collaboration.

This possibility of taking advantage of ICT in order to diversify and personalize education and learning methodologies has led to renewed interest in the concept of *learning style*, also emerging as an answer to the need to adjust education methodologies to the young students of the so-called "Net Generation" [see Dede 2005].

However, the application of a learning styles questionnaire to a class, by a teacher, requires hard work, starting with the problem of selecting a questionnaire from among the models and theories that present perspectives which are sometimes contradictory. And the selection of the questionnaire is followed by the painstaking and monotonous work of processing the results obtained. This task may be automatized by means of a computer, allowing among other advantages the systematization of the different students in the classroom in what concerns learning styles in a relatively simple way.

For all this, it seemed appropriate to develop a Web-based application which would provide insights in the individual profile of learning styles with a view to attain the following objectives:

- Facilitate the application, gathering and processing of data obtained from learning styles questionnaires;
- Stimulate students and teachers to discuss and reflect on issues related to the practical application of learning styles, at the same time as they develop skills to support lifelong learning;
- Encourage teachers to systematize the diversity of learning styles of their students in order to support the selection of teaching and learning strategies and activities;
- Encourage teachers to diversify teaching and learning strategies and methodologies in order to cover needs in terms of their students' learning styles;
- Disseminate features of learning styles which will help students and teachers to get to know, understand and improve the teaching and learning process as a whole.

Below, and following a brief overview of the state-of-the-art of learning styles, follows a presentation of the computer system development methodology and description of the data gathering and analysis procedures that allowed the evaluation of the prototype designed in terms of *satisfaction* and *usefulness* of the tool for its potential users. Finally, the main conclusions of the study shall be synthesized.

2 Learning Styles

The idea that we learn in different ways is relatively consensual. However, the concept of *learning styles* has yet to be stabilized, as well as its diagnosis, which could enable the design of appropriate learning experiences, given the vast array of diagnostic theories, models and instruments one can find in any literature review, for example, [Cassidy 2004], [Coffield et al. 2004] and [Wilson 1998].

According to Keefe (1979), cit in [Swanson 1995], learning styles are «*the cognitive, affective, and physiological factors that serve as relatively stable indicators of how learners perceive, interact with, and to respond to the learning environment*». This is the definition that has gathered greater consensus, possibly for being the most comprehensive, and for having been validated and adopted by the National Association of Secondary School Principals. Still, this definition has been targeted with some criticism, such as the stability issue (and even the very existence) of the «*cognitive, affective, and physiological factors*», whether they are considered over time, or whenever they are used in different learning environments.

Furthermore there is a high degree of ambiguity when delimiting the concept of learning styles, which is frequently confused with the concepts of *cognitive styles*, *psychological types*, *learning strategies*, *learning preferences*, and even with *multiple intelligences*.

2.1 Theories, Models and Measures of Learning Styles

Given the diversity of learning styles theories, models and corresponding tools, several researchers have developed methodologies with a view to their operationalization.

Curry (1983, 1987), cit in [Cassidy 2004], attempted to integrate learning styles models into four layers: Personality Models, Information Processing Models, Social Interaction Models and Instructional Preference Models. This metamodel, called The Onion Model, describes metaphorically the layers of an onion, presented here from the inside out, indicating that the Instructional Preference Models are based on learning aspects that are more susceptible to interactions with the environment, such that they are easier to observe and modify, whereas as we analyze the most inner layers, it gets more difficult to detect these aspects and they are less subject to changes.

Following a different approach, [Gordon and Bull 2004] presented the Metamodel of Four Quadrants, demonstrating that there are similarities between different models, by forming a "central core" of fundamental dimensions: Style α – Sequential and Practical, Style β – Intrapersonal and Argumentative, Style γ – Imaginative and Global, and Style δ – Logical and Analytical, which are bounded by a category that they have labelled "Resistant", as long as the model recognizes that the learning styles change over time, and with respect to the task that is being accomplished.

For this project, two learning styles instruments have been selected that can not only be adjusted to the metamodels presented, but also, as [De Bello 1990] suggests, have been subject to several validity and feasibility studies for the applications in which each model has been used: the Index of Learning Styles Questionnaire (ILS) and the Honey-Mumford Learning Styles Questionnaire (LSQ).

The ILS [see Felder and Soloman 1991] is a tool used to evaluate learning styles on the four scales of the Felder-Silverman Model: *Active/Reflexive*, *Sensorial/Intuitive*, *Visual/Verbal* and *Sequential/Global*. A second version was created in 1994, which was made freely available on the Internet in 1997, as long as it was used for educational purposes. Taking into consideration Curry's Metamodel, the ILS can be placed at the level of the Information Processing Models and Instructional Preferences Models, or, as previously mentioned, the external layers of Curry's Model, which are more easily observed and changeable, in order to improve the learning processes and results.

The LSQ is a learning styles questionnaire developed by Honey and Mumford (1992), cit in [Fernandes 2004], based on Kolb's Experimental Learning Model and his Learning Styles Model. It is an information processing model that considers Curry's Metamodel, and can be perfectly adjusted to the Gordon-Bull Model. With regard to other questionnaires, the LSQ has the advantage of having been adapted to the Portuguese population [see Fernandes 2004].

2.1.1 The Learning Styles Questionnaire by Honey-Mumford

The Learning Styles Questionnaire (LSQ) is a test with 80 items, used to classify learning styles: (i) *Active*, (ii) *Reflexive*, (iii) *Theoretical* and (iv) *Pragmatic*. The descriptions of each of these styles present many resemblances with the stages of the Kolb Model, such as *concrete experience*, *reflexive observation*, *abstract conceptualization* and *active experimentation*, respectively. In a very concise way, the major features of each style are as follows:

i) *Active* individuals like new experiences and challenges; they prefer to work in groups and resolve problems and discussions.
ii) *Reflexive* individuals like to watch, think and deliberate during activities; they can accomplish detailed tasks, but they do not like to feel pressured or time constrained.
iii) *Theoretical* individuals prefer to learn from models, concepts and theories; they like to analyze, evaluate and make use of logics.
iv) *Pragmatic* individuals prefer to study topics that are clearly connected with the real world; they like to have the opportunity to put into practice what they are learning.

Honey and Mumford, cit in [Fernandes 2004], sustain that the learning styles diagnosis should be used as a supplement to other information related to the individuals' different potentialities, in any organizational environment, which together guide them to improve their competencies.

According to this model, the preference for a learning style is considered to be strong, if the scores obtained fall in the group of the 30% with the highest scores as far as this style is concerned. Thus, each person can present from none to four learning styles with strong preference.

The scores presented on [Table 1] correspond to the adjustment standard of the LSQ to the Portuguese population, according to a study accomplished in 2002 by A. Fernandes.

Learning style	*Very high*	*High*	*Moderate*	*Low*	*Very low*
Active	13-20	11-12	7-10	4-6	0-3
Reflexive	18-20	15-17	12-14	9-11	0-8
Theoretical	16-20	14-15	11-13	8-10	0-7
Pragmatic	17-20	15-16	12-14	9-11	0-8

Table 1: LSQ Preference Standards, adjusted to the Portuguese population

2.1.2 Index of Learning Styles by Felder and Silverman

The Index of Learning Styles Questionnaire (ILS) is a tool based on the Felder and Silverman Learning Styles Model (1988, 1993), which was inspired in the Kolb Model in order to evaluate preferences in four dimensions: (i) *Processing—Active/Reflexive*, (ii) *Perception—Sensorial/Intuitive*, (iii) *Input—Visual/Verbal* and (iv) *Comprehension—Sequential/Global*.

For each of these dimensions, a scale is considered [see Figure 1], according to which the student can balance opposite styles or present moderate to strong preferences in one of the directions.

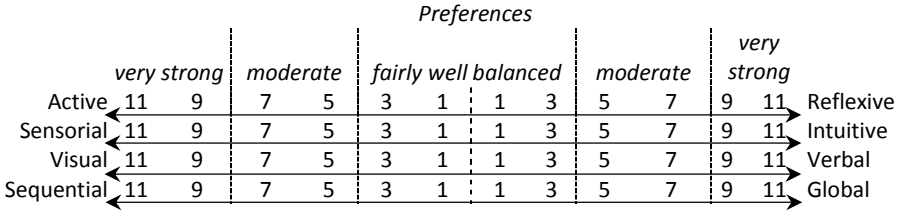


Figure 1: Felder-Silverman Scale

According to the Felder and Silverman Model, the major features associated with each dimension are:

i) *Active* individuals prefer to process information while accomplishing some kind of activity (by discussing, applying, explaining). They like to experiment things and work in group. The *Reflexive* individuals prefer to think, theorize and comprehend the basis of each subject before applying the new information. They prefer to work alone.

ii) *Sensorial* individuals prefer to select sensorial information (seeing, listening, touching). They easily memorize facts and like to accomplish activities with their own hands (lab, for example) and resolve problems through well-established methods. The *Intuitive* ones prefer to find out the relationships between concepts, they are usually innovators and do not like recurrent tasks. They feel more comfortable with abstraction and mathematical formulae.

iii) *Visual* individuals learn better if the information is presented visually (figures, diagrams, flowcharts, movies, timelines and demonstrations, etc.). The *Verbal* ones learn better if the information is presented verbally, that is in written or spoken words.

iv) *Sequential* individuals learn better in a linear way, i.e. in sequential stages, in which each step logically follows the previous one. The *Global* ones tend to learn in great steps, absorbing the information apparently without connexion, and, suddenly, he/she "gets it!". Generally, they can resolve difficult problems or they rearrange the information in an original way, after they have globally understood it, but they have difficulty in explaining how they got there.

According to [Felder and Soloman 2003], individuals are sometimes active and other times reflexive. Between these two opposed styles, preferences can be strong, moderate or low in any of the directions. The same happens with the rest of the style pairs.

However, according to this model, when presenting strong preference towards a certain style, a particular student might face a number of learning obstacles if the learning context suites the opposite style; furthermore, he/she will receive, assimilate and remember information better, if it is presented in compliance with his/her style. The ideal is to develop competences that permit balancing all styles.

This tool, although it has resulted from research in Engineering courses, presents several fidelity and validity studies, accomplished by the students from other fields of knowledge, such as for instance Economics [see Zywno 2003].

2.2 Pedagogy and Learning Styles

A majority of teachers agree that learning styles do exist and recognize the significant effect that learning styles have on the learning process as suggested by Vicent and Ross (2001), cit in [Gordon and Bull 2004].

[Miller 2001] reports that studies have confirmed that motivation and performance increase when education strategies are adjusted to the learning preferences and styles of the students. Similarly, [Fernandes 2004] points out that, notwithstanding the problem of precise and rigorous diagnosis, learning styles enable the design of study plans, didactics and strategies in compliance with the dominant learning style.

Several studies have shown that learning is more effective when the teaching style corresponds to the learning styles of students (*matching hypotheses*), when compared to circumstances where this is not the case, as described in [Felder and Brent 2005] and in [Hayes and Allinson 1993]. Zywno and Waalen (2001), cit in [Felder and Brent 2005], described the development and successful implementation of learning activities with hypermedia resources for students with learning styles less favoured by the traditional method.

However, this does not mean that teachers should only use strategies according to the students' learning styles, because this would hinder the development of skills within the other styles, which will prove to be very important as throughout their lives [see Felder and Brent 2005].

Additionally, teachers and technology should never force the student to follow a certain path, even if it appears to be the most appropriate to his/her learning style. They should only give recommendations and allow the student to have flexibility when choosing to follow alternative learning paths should he/she wish to do so [see Gordon and Bull 2004].

There are still a number of open questions on learning styles, which include:

- *The use of questionnaires.* Apart from questions related to the fragility of the validity and fidelity of the diagnostic tools, the learning style questionnaires seem to be too auspicious in order to evaluate such a complex construct (some questionnaires have about twelve questions). Therefore, opinions diverge as to the use of questionnaires, and it is suggested that teachers directly observe their students' behaviour in order to reach a diagnosis of their learning styles. This method is functional, but it requires more time and experience on the part of teachers than that necessary to use and to learn how to thoroughly interpret the results of a questionnaire. The method of evaluating learning styles by observation is being tested with success within LMS platforms, based on the navigation behaviour of students [see Vasilyeva et al. 2006].
- *The learning styles as labels.* In the opinion of some authors, identifying the learning styles of students might lead to the establishment of stereotypes and to an unduly generalization of the characteristics of a certain learning style. Additionally, they are concerned that teachers might tend to discriminate students who present a certain learning style, when relating that factor to his/her cognitive skills, or that students may think they are unable to learn because of their own particular style, instead of trying to just develop their potential. Other authors consider that no learning style is better than another, and it is necessary to respect the differences between students' learning styles despite the designations attributed.
- *The consistency of learning styles.* Another question on which researchers disagree is related to the consistency of learning styles. For some, learning styles are structural, that is, they are a group of characteristics that remain stable over time; while for others, learning styles are a process, so they change from state to state with each learning experience or situation [see Cassidy 2004]. For the former, learning styles are biologically determined, so they do not undergo any permanent change, much as eye or skin colour does not change, as says Kagan (1966), cit in [De Bello 1990]. Loo (1997), cit in [Cassidy 2004], have shown that we develop certain learning styles over time, but they remain the same for a relatively long period of time. According to [Cassidy 2004], the best view is to consider a more central position, that is, learning styles are versatile structures that remain stable for considerable periods of time, but they can change if there is a need to adjust in response to experiences or to meet the requirements of certain circumstances. According to [Fernandes 2004], learning styles have a genetic dimension, but are subject to interactions with the environment through training, reflection and changing strategies, becoming progressively more stable when individuals reach adulthood.
- *Matching/mismatching learning styles.* This correspondence between students' learning styles and *teaching style* is a technique that is called *matching*. Some authors defend, on the contrary, *mismatching* strategies in order to train students to develop their weakest styles. For example, the Honey-Mumford Model puts forward the Socratic ideal "know yourself", with the objective of reinforcing the dominating learning styles and training the underprivileged styles, in view of a proficient level within the four styles:

Active, Reflexive, Theoretical and Pragmatic, which are essential to good performance in our society today. The opinion of most of the authors is that one should try to help students capitalize their potential, while recommending that they develop their weakest styles whenever they resolve a certain problem or accomplish a certain task which may correspond to a certain learning style. Nevertheless, it is impossible to confirm this idea as «*deliberate mismatching has the status of an intuitively appealing argument which awaits empirical verification or refutation*» [see Coffield et al. 2004].

3 Web-Based Application for Managing Learning Styles

The Web-based application Management of Learning Styles (MLS) allows any registered user to get results automatically from two of the most well-known learning styles questionnaires: Felder-Soloman's Index of Learning Styles Questionnaire (ILS) and Honey-Mumford's Learning Styles Questionnaire (LSQ).

The development of MLS has followed the Object-Oriented Hypermedia Design Method (OOHDM) presented by [Schwabe and Rossi 1998]. This method permits the development of dynamic web-based applications phased in five stages: (A) Requirements Gathering; (B) Conceptual Design; (C) Navigational Design; (D) Abstract Interface Design; and (E) Implementation. Even though the model description suggests a linear sequential process, each stage can be executed several times during the life cycle of an application without a pre-established order as was the case with MLS.

Actor	***Action***
Student *Registered user*	System login Answer an ILS/LSQ questionnaire Visualize and print the results of the questionnaires answered Join a class by means of inserting a keyword provided by the teacher
Teacher *Registered user*	System login Create classes (a keyword is automatically generated and provided to the teacher, for each class) Answer an ILS/LSQ questionnaire Visualize and print the results of the questionnaires answered Visualize and print learning styles reports by class Visualize and print the learning styles report of each student in the class
User *Non-registered user*	Register as student or teacher Visualize the average scores attained by students and teachers (who answered any questionnaire) in each learning style, in each questionnaire Contact the administrator

Table 2: Actors and actions based on MLS application

During the first stage, the actors were identified, that is, the users who can interact with the system, and the requirements that the system needs to fulfil, namely the tasks the users intend to perform according to different profiles. [Table 2] lists the main tasks that allow us to get a general perspective of MLS actions.

The conceptual design stage identified the items to be implemented in the database as well as their respective attributes and the relationships between them. As for the conceptual model, which is part of the Entity-Relationship Diagram in [Figure 2], items include *student*, *teacher*, *class*, *questionnaire*, etc., which maintain different types of relationship between them, such as, for example, a teacher can have several classes, a student belongs to one class and a student can answer any of the questionnaires several times. The attributes of each item consist in its features. For example, the features of the item style consist in designation, description and strategy, which generalize facts such as in *visual* style, the student «*learns better if the information is presented visually: images, diagrams, flowcharts, movies, time lines and demonstrations, etc.*», for which reason it is suggested to the student to «*try to find diagrams, sketches, photographs, figures (…) or prepare a conceptual map*» to achieve better results [see Felder and Soloman 2003].

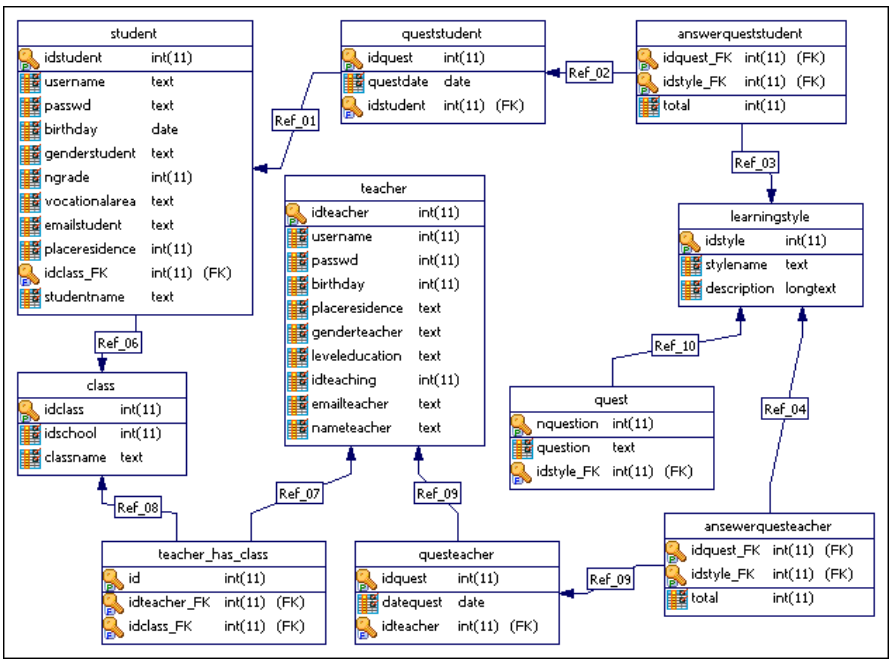


Figure 2: ER Diagram of the MLS database

While relationships between items sustained the design of the system's navigational design, the abstract interface was designed based on usability heuristics [see Nielsen 2003], shown in [Table 3].

Heuristic	***MLS design principles***
Visibility of system status	Visualization of relevant and vital information on each screen
Resemblance of the system with the real world	Use of simple and contextualized language regarding the learning styles diagnosis tools used
User control and freedom	Display of relevant information on learning styles, also to non-registered users
Consistency and standards	Invariance of the formatting rules and positioning of items in the whole application
Error prevention	Block, as far as possible, the insertion of invalid data into the system
Recognition instead of memorization	Use of an intuitive navigation scheme regarding the task to be performed
Flexibility and use efficiency	Direct access to all possible options in the context visualized on the screen
Aesthetics and minimalist design	Display of a simple interface
Support to users on error recognition, diagnosis and recovery	Display of error messages that can be interpreted by users and guide them towards problem solving
Help and documentation	Facilitation of system use, so that documentation does not have to be consulted

Table 3: Nielsen's Heuristics

During implementation, the coding of the programs that compose the application was created, tested and reformulated, based on Apache, PHP and PostgreSQL technologies.

For example, a PHP code extract is shown below for the function that enables inserting each calculated score in the database from the SQL command [see Figure 3].

```
67      function insert()
68      {
69          global $db;
70          $result = $db->query("insert into answeraluno(total, codestilo, codquest)
values(?,?,?)", array($this->total,$this->codestilo,$this->codquest));
71          if (PEAR::isError($result)) die($result->getDebugInfo());
72      }
73
```

Figure 3: Function that enables inserting the LSQ results in the database

The first version of the prototype has been individually tested in simulations by four students and four teachers from different education levels and with different computer-use knowledge who were invited to test the MLS. [Figure 4] illustrates the system interface, showing the average results obtained by the students (on the left) and teachers (on the right) who answered the LSQ questionnaire. It is possible to observe that the average scores are close, and that the highest value indicates

dominance in the reflexive style. Considering the adjustment standard to the Portuguese population, on average, students and teachers who used MLS show high preferences for the reflexive and pragmatic styles and moderate preferences for active and theoretical styles.

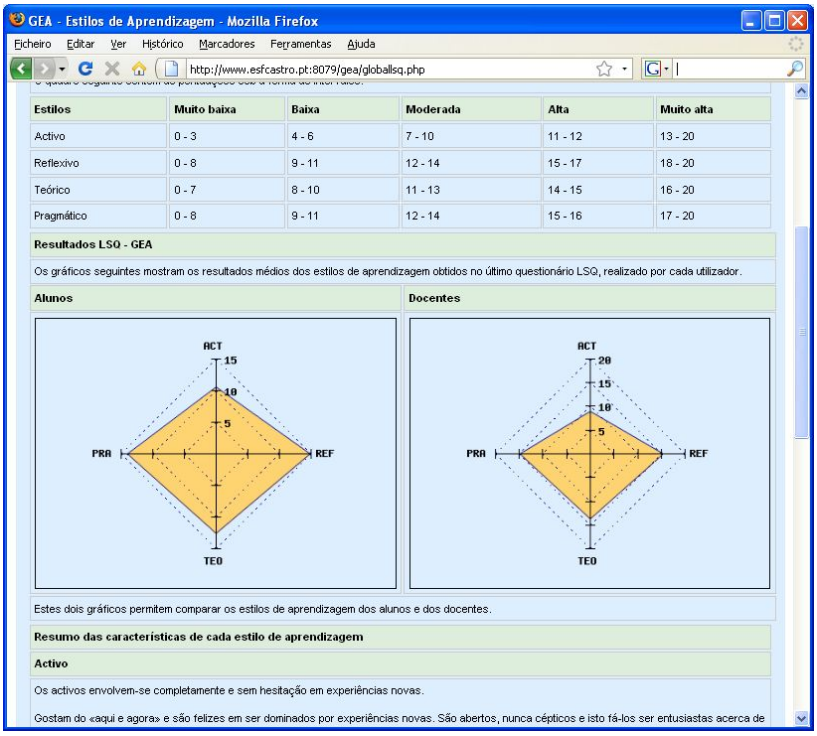


Figure 4: MLS system interface

Following the initial trial period, during which the application was temporarily available, MLS was installed in a server permanently connected to the Internet. The URL address of the MLS platform [Silva and Andrade 2007] was then sent to a Secondary School teacher and a Higher Education teacher, with the aim that they put it to the test with at least one class in a real learning context. Finally, MLS was disseminated, by e-mail, to 28 teachers in different academic areas and educational levels, even though MLS can be found in search engines on the Web.

3.1 Validation of the Application

MLS application is a prototype developed as part of a master's thesis [see Silva 2007]. It has been subjected to various exploratory and evaluation tests during the cyclic stages of system design and development, which were based on the OOHDM Model. These tests resulted in improvements to the prototype's running, but did not guarantee the compliance with the needs and *satisfaction* of its users in what concerns the operationalization of learning styles.

According [Andrade 2005] and [Tobar, et al. 2008], user satisfaction in the interaction with the product and its utility are critical factors to be considered in software design. These factors are governed by the guidelines set out in international standards regarding *usability* (ISO/DIS 9241:11, European Usability Support Centres). In this context and according to this standard, usability is defined as «*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*».

This section briefly describes the methods and tools used to evaluate the application in terms of «*effectiveness, efficiency and satisfaction*» of students and teachers, and which permitted the validation of the prototype created.

Thus, the validation of the MLS prototype corresponds to the potential for real use of the MLS platform, in a teaching and learning context, by means of a methodology that follows two guiding principles that complement each other. The first consists in exploring the application based on a usability test limited by the prototype evaluation criteria, which are appraised from the questionnaire surveys designed for students and teachers. The second one consists in the direct observation of the use of the tool based on data that are stored in a database that supports the application.

The MLS usability test included two questionnaires applied directly to students and teachers, with 10 items grouped into four parts, as follows: (I) Personal Data; (II) System Usability Scale; (III) Relevance of the Information; and (IV) System Effectiveness.

In what concerns the first part of the questionnaires, the information requested aimed to characterize the sample in terms of gender, age and educational level. The questionnaire for the teachers also asked about years of service.

As for the second part of the questionnaires, the SUS (System Usability Scale) usability test was used. The SUS is a standardized test from Digital Equipment Corporation, which includes only 10 items, but which provides solid results, even from small-sized samples [see Tullis and Stetson 2004]. Additionally, SUS is available for free and simple to use, and for each questionnaire, provides only one score from 0 to 100. Each SUS item covers different aspects of the user's reaction to the system. Only the first item does not fit the MLS to perfection, since the opinion about the meaning of frequency of use is subjective in the context of answering learning styles questionnaires. Still, the option was to preserve its structure intact based on the indication from the author himself [see Brooke 1996].

The third part of the questionnaires focused on the tool's utility in terms of the relevance of the information made available, for each of the questionnaires. This means that this part of the questionnaires aimed to check the relevance given to the information provided concerning the choice of the learning strategies in the case of students and the choice of teaching methodologies in the case of teachers. A five-point Likert scale was used (1 – I strongly disagree to 5 – I strongly agree) for the questions in this part of the questionnaires, except for the last question of the questionnaire designed for students, which focused on a potential preference for one of the questionnaires.

The last part of the questionnaires aimed to identify the potential weaknesses of the MLS application, which had been detected by users during the execution of specific tasks in the system. The first question of this part has also been assessed

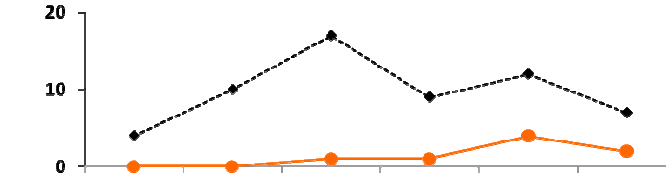
based on a five-point Likert scale (1–Never to 5–Always), and the last two questions required open answers with the aim of gathering difficulties, errors, comments and suggestions. To facilitate the analysis, the total score of the items was calculated, based on the same process used in SUS, which consists in the sum of the weights attributed, from 0 (most unfavourable) to 4 (most favourable) and further conversion to a scale from 0 to 100.

The questionnaires were made available online in digital format for a period of one month, 6 months after MLS was implemented. By making the questionnaire available on the Web, it was possible to obtain a more diversified sample of MLS users, which could be found practically all over the country.

The following section presents the results obtained in a user sample composed of 75 students and 11 teachers who corresponded to 19.0% and 19.6% respectively of the MLS users at that time.

3.2 The Study's Results

The first part of the questionnaires permitted the characterization of the random sample. From the 75 students, 45 are male (60.0%). With respect to age, the most frequent groups include people aged 30 years and over (50.7%), followed by the age group between 15 and 19 (33.3%). The teacher sample showed a female predomination (63.6%) and the age group ranged from 45 to 55 years (54.4%). With regard to educational level, the sample included mostly students and teachers from Secondary and Higher Education, in practically equal proportions (45.3% and 45.5%, respectively). The rest of the educational levels have small representativeness in this sample (one and three students, from the 2nd and 3rd Cycles of Primary Education [1], respectively, and one teacher from the 3rd Cycle of Primary Education). Teachers with 15 or more years of service predominate (72.8%).



	[0;50[	[50;60[	[60;70[	[70;80[	[80;90[	[90;100]
Students	4	10	17	9	12	7
Teachers	0	0	1	1	4	2

Figure 5: SUS Usability scale of MLS

The questions regarding the System Usability Scale (SUS), which compose the second part of the questionnaires, were answered by 59 of the 75 students (78.7%) and 8 of the 11 teachers (72.7%), and allowed the evaluation of the application with average scores of 69.2% (standard deviation of 14.1%) and 82.8% (standard deviation of 11.4%) by students and teachers, respectively. These results can be considered to be satisfactory, especially when considering the negative weight of the first item, as

[1] Education System in Portugal: 2nd Cycle – 5th and 6th grades; 3rd Cycle – 7th to 9th grades.

previously mentioned. [Figure 5] shows a distribution of the scores obtained under the SUS usability scale, for students and teachers.

Data from the third part of the student surveys show that about half of the students consider the information obtained in their individual learning styles reports relevant or very relevant, regardless of whether they were based on ILS (38.3%) or LSQ (40.5%). Besides, 44.4% consider them to be similar, despite the rest of the students give slight preference to the LSQ questionnaire (31.1%).

In relation to the questionnaires designed for teachers, results revealed some interest in the information obtained from the learning styles profile reports, both the individual report and the reports by student and class, whether based on ILS or LSQ, despite the fact that the sample was quite small and 36.4% of the teachers having failed to answer these questions.

[Figure 6] shows the students' opinions about learning styles.

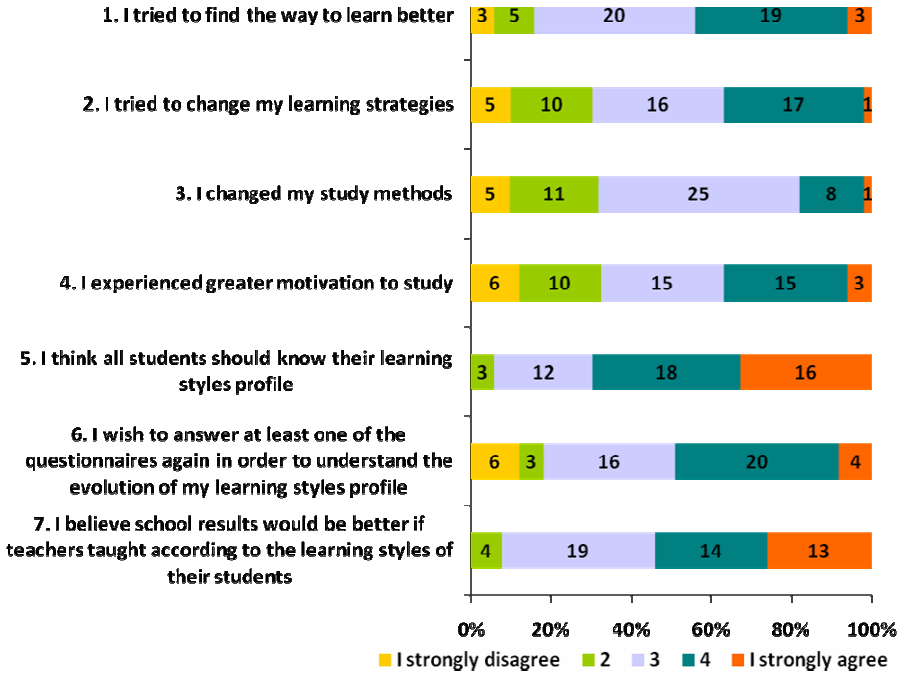
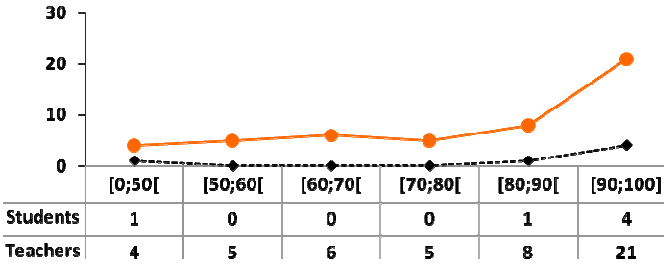


Figure 6: Students' opinion about learning styles

It is worth mentioning that more than half agreed (or strongly agreed) that they tried to find a way to learning better (53.7%), as well as thinking that students should know their learning styles profile better (82.9%), and that school results would be better if teachers taught according to the learning styles of their students (65.9%). A slight lower percentage of students (43.9%) said that they tried to change their learning strategies and experienced greater motivation to study. However, only 22.0% of students said they had changed their study methods. When asked about the intention to answer any of the questionnaires again, in order to understand the

evolution of their individual learning styles profile, only 22.0% of the students disagreed or strongly disagreed with this idea.

The results obtained regarding the questions from the fourth and last part of the questionnaires, which are shown in [Figure 7], corroborate the very reasonable level of the application's effectiveness, since they reinforce that the majority of the respondents never experienced any difficulty in the use of the tool. On average, students appraised the system's effectiveness at 79.0% and teachers at 81.9%.



	[0;50[	[50;60[	[60;70[	[70;80[	[80;90[	[90;100]
Students	1	0	0	0	1	4
Teachers	4	5	6	5	8	21

Figure 7: Students' and teachers' opinion about the effectiveness of MLS use

These results obtained from the surveys are reinforced by the information given regarding the effective use of the MLS platform, between September 2006 and March 2007. During this period, 451 users have registered, 395 of which with a student profile and 56 with a teacher profile, and have answered 310 ILS questionnaires (295 with a student profile and 15 with a teacher profile) and 282 LSQ questionnaires (258 with a student profile and 24 with a teacher profile). 49 classes were created by 26 teachers, to which 348 students have been associated (88.1%).

Most of the MLS users during the seven months covered in this study were students (87.6%), as expected. The students' group shows that the most frequent age bracket comprehends 15 to 19 year old students (34.9%), closely followed by students aged over 30 years (32.9%), and lastly, students aged 20 to 24 (23.3%). The teachers' group shows that the most frequent brackets are those between 25 to 34 years (41.1%). The majority of the students are in Higher Education (63.5%) and the majority of the teachers teach in Secondary Schools (51.8%).

An analysis of the system data also allowed us to observe that the learning styles on the part of students and teachers are similar, as shown in [Table 4] and [Table 5] below.

LSQ	***Students***		***Teachers***	
Active	9.67	Moderate	9.35	Moderate
Reflexive	15.18	Strong	14.78	Strong
Theoretical	12.81	Moderate	13.39	Moderate
Practical	14.29	Strong	14.65	Strong

Table 4: Average scores obtained by LSQ

ILS	*Students*		*Teachers*	
Active	6.75	Weak	6.92	Weak
Reflexive	4.25		4.08	
Sensorial	7.31	Weak	7.15	Weak
Intuitive	3.69		3.85	
Visual	7.99	Moderate	8.46	Moderate
Verbal	3.01		2.54	
Sequential	6.20	Weak	5.92	Weak
Global	4.80		5.08	

Table 5: Average scores obtained by ILS

On average, ILS shows that students and teachers reveal a moderate preference for the visual style in detriment of the verbal style, and they are quite balanced regarding the rest of the scales; furthermore, LSQ shows that both groups present the reflexive style, as mentioned by [Fernandes 2004], as being the dominating style in academical spheres.

4 Conclusions

[Swanson 1995] and [Cassidy 2004] suggest – and which this study corroborates – the need to proceed with the research in the different areas of knowledge for the construction of a stable theoretical frame of learning styles. The progressive systemic movement of these studies facilitates the integration of concepts and the rationalization of means, particularly technological means which seek to contribute to teaching and learning processes.

The main contribution from the study is clear in the computer application for the Management of Learning Styles (MLS), insofar as it leads students and teachers to be more aware of the importance of considering the individual differences when looking for strategies to learn and teach better.

Notwithstanding the updates that can be continuously implemented in a software product, the results obtained during the prototype validation stage seem to indicate that the tool is useful for students and teachers, meeting the overarching goals underlying its creation.

During the seven-month observation period of MLS use, 451 users have registered and 310 ILS questionnaires and 282 LSQ questionnaires have been answered. Considering that the application was disseminated, by direct reference, to only 30 teachers and 4 students, these numbers suggest the adequacy of the prototype to the goals established.

As presented in [Figure 5], the system's usability is considered positive, according to the opinion of the MLS users, who answered the system usability evaluation questionnaires. The average of the scores obtained in SUS, based on the students' and teachers' answers (69.2% and 82.8%, respectively), as well on the items concerning system effectiveness evaluation (79.0% by students and 81.9% by teachers) confirms that the system is easy to use.

Following the same direction, the surveys' results seem to indicate an interest in the matter of learning styles, especially as expressed by the students' opinions [see Figure 6], in their intention to change learning strategies and a stronger motivation to study (revealed by 43.9% of the students), by the fact that they know their profile, as well as in their belief that all students should be aware of that information (82.9%) and that teachers should teach in conformity with their students' learning styles (65.9%).

In short, the path undertaken served to frame and document the MLS, making it a sound tool and capable of contributing to the management of learning styles of students and teachers. Nevertheless, only by means of its integrated exploration in school information systems or in skill management systems will its potential be enhanced with respect to the reinforcement of e/b-learning methodologies efficiency, which better fit students' individual differences, and which produce more active, flexible and knowledge generating learning environments.

Acknowledgements

System Usability Scale (SUS) has been developed as a part of an engineering program on usability by Digital Equipment Co Ltd., Reading, United Kingdom.

References

[Andrade 2005] Andrade, A.M.: "*Ensino a Distância e e-learning*"; Instituto de Educação - Universidade Católica Portuguesa, Porto / Portugal (2005).

[Brooke 1996] Brooke, J.: "*SUS - A quick and dirty usability scale*"; UsabilityNet, Reading / United Kingdom (1996).

[Cassidy 2004] Cassidy, S.: "Learning Styles: An overview of theories, models, and measures"; *Educational Psychology*; *24*, 4 (2004), 419-444.

[Coffield et al. 2004] Coffield, F., Moseley, D., Hall, E. and Ecclestone, K.: "*Learning styles and pedagogy in post-16 learning: A systematic and critical review*"; London: Learning and Skills Research Centre (2004).

[De Bello 1990] De Bello, T.: "Comparison of Eleven Major Learning Styles Models: Variables, Appropriate Populations, Validity of Instrumentation and the Research Behind Them"; *Journal or Reading, Writing, and Learning Disabilities*; *6*, - (1990), 203-222.

[Dede 2005] Dede, C.: "Planning for Neomillennial Learning Styles: Implications for Investments in Technology and Faculty"; in Oblinger, D.G. and Oblinger, J.L. eds. *Educating the Net Generation*, EDUCAUSE (2005), 15.1-15.22.

[Felder and Soloman 2003] Felder, R. and Soloman, B.: "*Learning Styles and Strategies*" (2003).

[Felder and Brent 2005] Felder, R.M. and Brent, R.: "Understanding Student Differences"; *Journal of Engineering Education*; *94*, 1 (2005), 57-72.

[Felder and Soloman 1991] Felder, R.M. and Soloman, B.A.: "*Index of Learning Styles Questionnaire*" (1991).

[Fernandes 2004] Fernandes, A.A.: "*Didáctica das Tecnologias de Informação e Comunicação*"; Instituto de Educação - Universidade Católica Portuguesa, Lisboa / Portugal (2004a).

[Gordon and Bull 2004] Gordon, D. and Bull, G.: "The Nexus Explored: A Generalised Model of Learning Styles"; in *15th International Conference of Society of Information Technology & Teacher Education*, Atlanta, Georgia / USA (2004).

[Hayes and Allinson 1993] Hayes, J. and Allinson, C.W.: "Cognitive Style and the Theory and Practice of Individual and Collective Learning in Organizations"; *Human Relations*; *51*, 7 (1993), 847-871.

[Miller 2001] Miller, P.: "Learning Styles: The Multimedia of the Mind", Research Report, Calvin College, Computer Science Departament, U.S. (2001).

[Morales, et al. 2007] Morales, E.M., García-Peñalvo, F.J. and Barrón, Á. "Improving LO Quality through Instructional Design Based on an Ontological Model and Metadata"; Journal of Universal Computer Science; 13, 7 (2007), 970-979.

[Nielsen 2003] Nielsen, J.: "*Usability 101: Introduction to Usability*" (2003).

[Schwabe and Rossi 1998] Schwabe, D. and Rossi, G.: "An Object Oriented Approach to Web-Based Application Design"; *Theory and Practice of Object Systems*; *4*, 4 (1998), 207-225.

[Silva and Andrade 2007] Silva, R. and Andrade, A.: "Gestão de Estilos de Aprendizagem", (2007), URL: http://www.esfcastro.pt/gea/index.php.

[Silva 2007] Silva, R.: "*Desenvolvimento de uma Aplicação Web para Gestão de Estilos de Aprendizagem*"; Universidade Católica Portuguesa, Porto / Portugal (2007).

[Swanson 1995] Swanson, L.: "Learning Styles: A review of Literature"; *ERIC*; *N/A*, ED387067 (1995).

[Tobar, et al. 2008] Tobar, L.M., Andrés, P.M.L. and Lapena, E.L.: "WebA: A Tool for the Assistance in Design and Evaluation of Websites"; Journal of Universal Computer Science; 14, 9 (2008), 1496-1512.

[Tullis and Stetson 2004] Tullis, T.S. and Stetson, J.N.: "A Comparison of Questionnaires for Assessing Website Usability"; in *Usability Professionals' Association - UPA 2004*, Minneapolis, Minnesota / USA (2004).

[Vasilyeva et al. 2006] Vasilyeva, E., Pechenizkiy, M. and Puuronen, S.: "The Challenge of Feedback Personalization to Learning Styles in a Web-Based Learning System"; in *6th IEEE International Conference on Advanced Learning Technologies*, Kerkrade, The Netherlands (2006), IEEE Computer Society, 1143-1144.

[Wilson 1998] Wilson, V.A.: "*Learning How They Learn: A Review of the Literature on Learning Styles.*" (1998).

[Zywno 2003] Zywno, M.S.: "A Contribution to Validation of Score Meaning for Felder-Soloman's Index of Learning Styles"; in *American Society for Engineering Education Annual Conference and Exposition*, Nashville, Tennessee / USA (2003).