

Using Learning Styles to Enhance an E-Learning System

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Abstract: Nowadays there are new educational scenarios emerging along with technological breakthroughs in Information Technologies (IT), which allow us to modify the traditional teaching methods. Due to this situation, we ought to think about satisfying the growing educational needs using new didactic resources, new tools which will make teaching-learning environments more flexible, adding electronic media provided by communication networks and by informatics.

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 researchers. Better teaching-learning strategies can be elaborated to assimilate in an effective and more efficient way new information and knowledge.

In the following research, the challenge is to use the vast resources offered by informatics to create a suitable environment for the development of individuals with different skills. 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 work, a computer program is provided for instructional aid, in which two educational aspects that have been only partially integrated yet are incorporated in an educational environment: computer science and educational psychology (although both of them have been previously used in education).

Keywords: Learning Styles, Teaching Style, Electronic Media and Electronic Learning.

Introduction

There is a gap between the knowledge of what IT has to offer in order to optimize teaching-learning methods, and the way education is being accomplished. This has caused computer-aided education problems (such as administration, planning, teaching and investigation) are being approached almost exclusively by computer science specialists. While these people have great knowledge concerning their field, they are unaware of the fact that specific problems may arise when integrating new technologies to a process with educational ends. Even though computer-aided education has rapidly grown, it still presents strict limitations regarding its relationship with the teaching-learning processes and with the teaching tools generated by other disciplines such as those in educational psychology.

Moreover, the two deficiencies identified by Rosenberg are still present: a) the development of ITS ("Intelligent Tutoring Systems") in a teaching-learning environment still needs to be carried out, and b) the performance evaluation of the computational system in the assistance of teaching needs to be covered (Rosenberg, 1987). In most recent ITS's, only the first flaw has been taken into account, but in order to be able to determine the effectiveness of the teaching-learning process it is also necessary to consider the latter. This way the performance of the ITS's can be improved by adapting them more effectively to the students' needs and by enhancing their teaching strategies.

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 and didactic 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 work, a computer program is provided for instructional aid in which 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 and Soloman, 1993; Coffield et al., 2004). Learning styles have also been shown to have an impact on the effectiveness of online learning (Allert, 2003:134-138; Carver et al., 1999:33-38).

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.

Objective

The objective of this paper 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", a first semester course in Computing Engineering at the Instituto Tecnológico Autónomo de México (ITAM).

This study addressed the following research questions:

- Is there a relationship between the students' learning styles and the different ways of using the multimedia learning system?
- Is it helpful for a student in a course to learn and acquire knowledge using his or her particular learning style? If so, can we imagine a system which helps us to do that?
- How can we measure the suitability of such a system for the students' learning objectives and abilities?

This study addressed the following research objectives in a comparative mode:

- Determination of the factors, including the learning styles, contributing to success in an Introductory Programming course.
- Assessment of the association between learning styles and course performance.

The rest of the paper is organized as follows: The second section presents the architecture of the system that we propose and presents information about the instruments used to identify the different learning styles. The third section presents the study carried out to identify and contrast the learning styles for ITAM students, and lists the factors contributing to their success in introductory programming courses. Finally, the fourth section presents concluding remarks.

Methodology

- Create a system that, 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.

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.

Theory of Learning Styles

Definition of Learning Styles

The concept of learning style refers to the fact that each person has his/her own method or set of strategies for learning. 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 and 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.

The concept of learning style is very important since it expands our possibilities for action in education. It also helps students have more effective learning.

The models and theories about learning styles offer a conceptual framework to understand the student's behavior. But in real life the way information is elaborated and learned varies according to the context and the way each person studies and learns which in turn evolves and changes constantly.

The Felder-Silverman Model of Learning Styles

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 and Soloman, 1993). Each instrument classifies learning dispositions based on opinion surveys.

This study used the ILS. The ILS instrument is conveniently available on the Internet (Felder, 1998) and consists of 44 multiple-choice questions designed to separate the learning style affinities of an individual. ILS has also been used in several computer science and engineering studies (Allert, 2004: 385-389; Chamillard and Karalick , 1999: 291-295; Thomas, et al., 2002:33-37).

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

1. What type of information does the student prefer to perceive: sensory /external (sights, sounds, physical sensations), or intuitive/internal (possibilities, insights, hunches)?
2. Through which sensory channel is external information most effectively perceived: visual (pictures, diagrams, graphs, demonstrations), or auditory (words, sounds)?
3. With which organization of information 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)?

4. How does the student prefer to process information: actively (through engagement in physical activity or discussion), or reflectively (through introspection)?
5. How does the student progress towards understanding: sequentially (in continual steps), or globally (in large jumps, holistically)?

Table 1 shows the dimensions of the learning styles obtained through the previous questions.

Table 1: Felder dimensions

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

Sensitive students prefer facts, data and experimentation. They are patient with details, but don't like complications. Intuitive students prefer principles and theories; they get bored with details and accept complications.

For the visual learners it is easy to remember the things they see: diagrams, timelines, films, demonstrations. Verbal learners remember what they have heard, read or said.

Inductive learners prefer information that proceeds from particularities to generalities (Garcia et al., 2005:1-15), 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, 2005:329-340). 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.

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. 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.

The Index of Learning Styles is the tool that Felder 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. The test thus has 44 questions in total (Felder, 1998).

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 1 and Figure 2. Then, the technical diagram is depicted and its elements are explained.

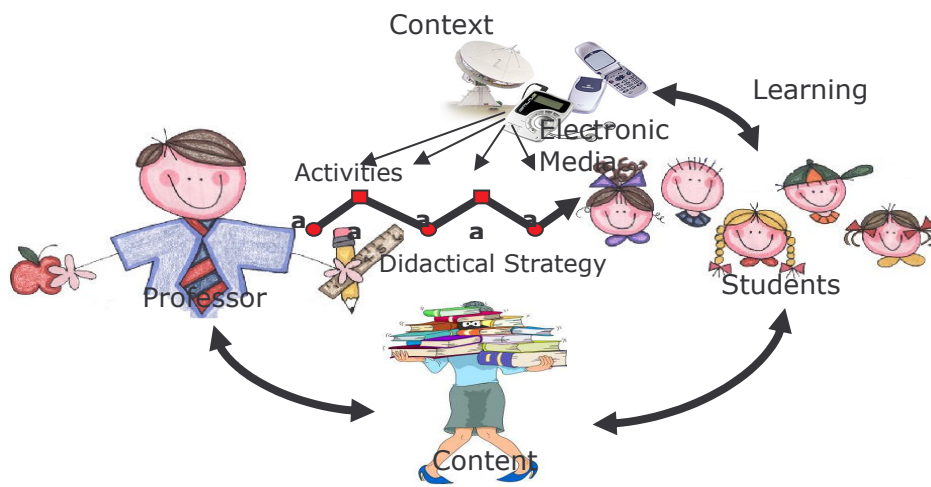


Figure 1: Functional diagram

Functional Diagram

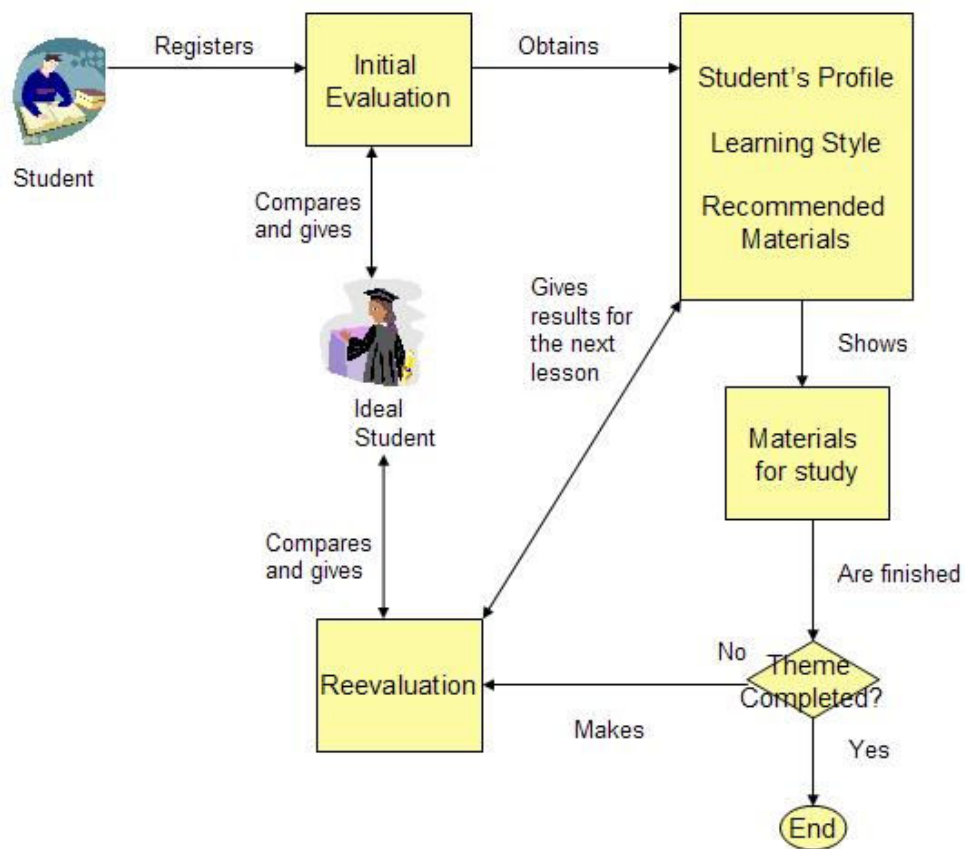


Figure 2: Functional Diagram

Explanation of Functional Diagram

The elements of the functional diagram (Figure 2) 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 system 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.

Technical Diagram

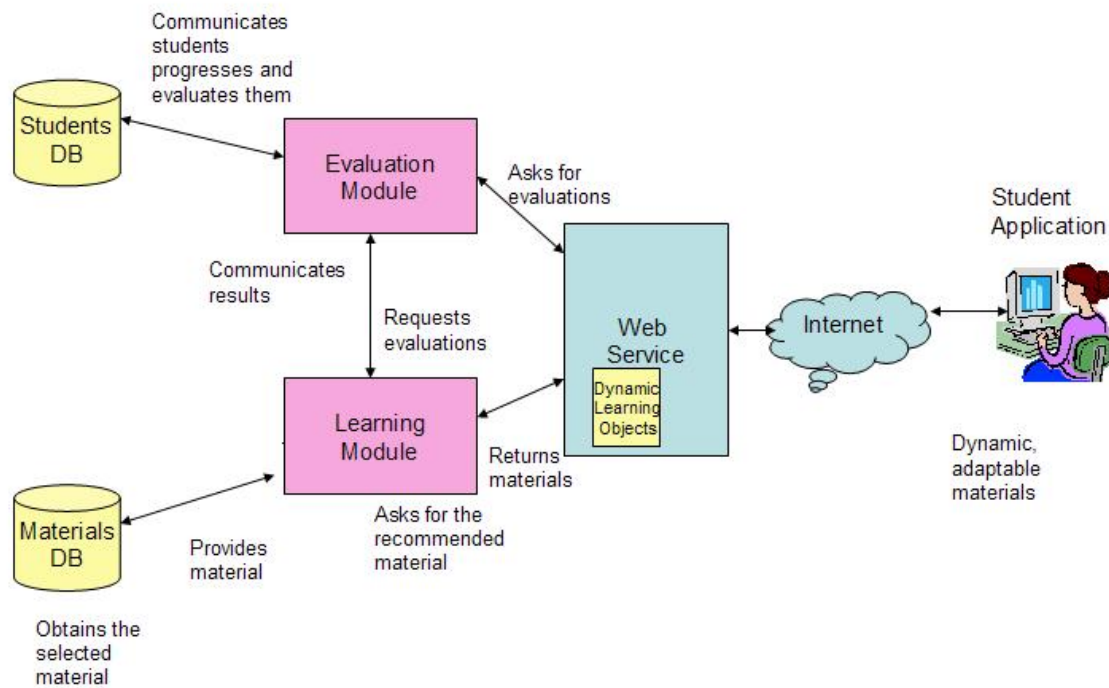


Figure 3: Technical Diagram

Explanation of Technical Diagram

The elements of the technical diagram (Figure 3) 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 were 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 that 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.

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*.

Results

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 visual and verbal dimensions, given that the system, for the visual dimension shows a picture or a table, while for the verbal dimension shows plain text. 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.

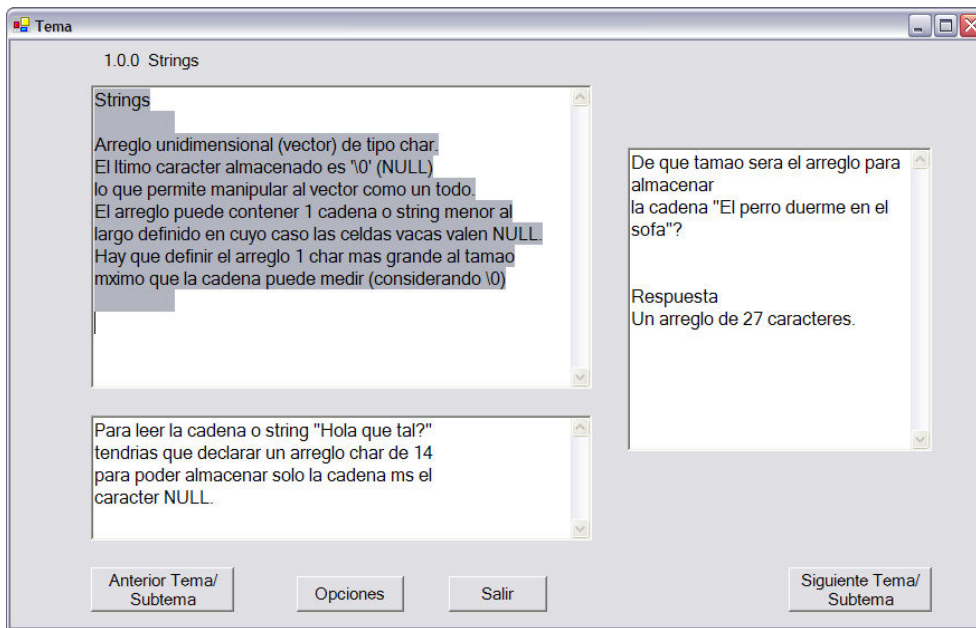


Figure 4: Theme for verbal students

Figure 4 shows the way a verbal student would see the information about a certain subject.

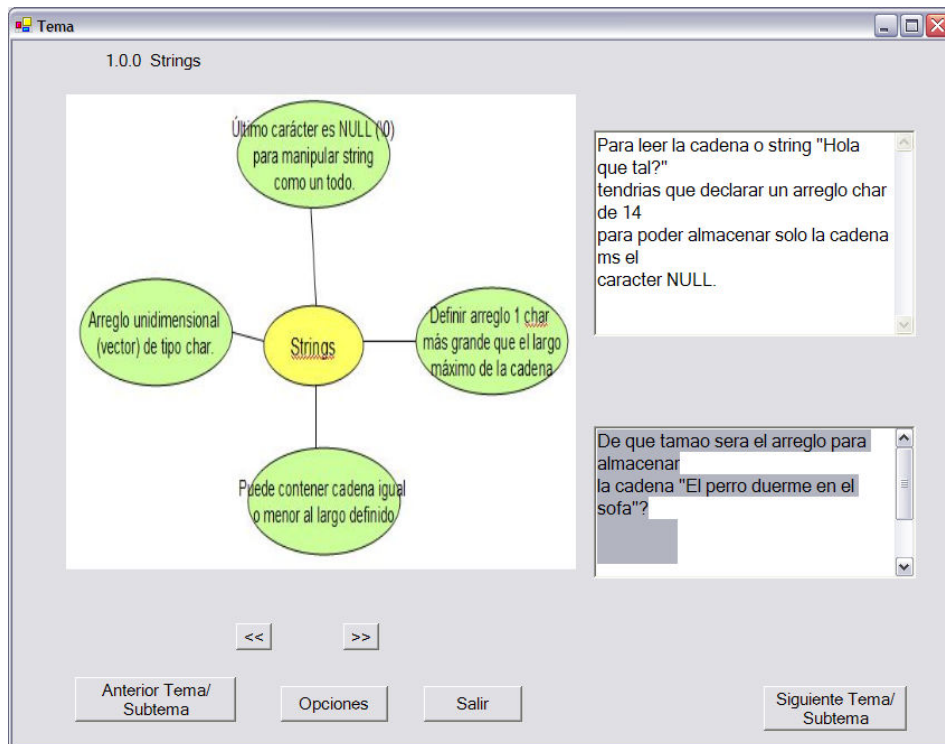


Figure 5: Theme for visual students

Figure 5 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 2:

Table 2: Felder test results

Group	Style	Number of students
S1	Active	16
	Reflexive	10
S2	Sensitive	16
	Intuitive	10
S3	Visual	22
	Verbal	4
S4	Sequential	16
	Global	10

Comparing the active and reflective dimensions, the majority of students was 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.

Conclusions

The use of a system with architecture similar to the one described in the second section 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 to other. Therefore, the use of several resources will help all kinds of students.

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.

There are many studies concerning nothing but learning styles; there are many tutoring systems without a pedagogical method (Gilbert et al., 2005:337). 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 my 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.

The idea behind this system is very important. It's all about creating and developing new alternatives for the students in a world where new information technologies are emerging and changing constantly. Hence we believe it's an innovative way to achieve the teaching-learning process.

In the future we want to enhance our system by expanding its course material to video and other formats, perform more experiments with more groups of students of differing characteristics in order to obtain more comparative results, and analyze the information accumulated in the student database in order to generate generic student models.

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