

Student Learning Styles Adaptation Method Based on Teaching Strategies and Electronic Media

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Abstract

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 [8]. 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. In this paper, we describe the design of a personalized teaching environment that is based on an adaptive taxonomy 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.

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, 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 use the new electronic media 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 [15-16], but

very few give an idea of which combinations of electronic media and learning styles are more effective than others. Beachman [1], 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 paper describes 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. Also, an implementation method is developed, in order to be able to properly use this taxonomy.

2. Related work

Recent investigations [5,11,12,13,14,20], try to integrate learning styles in the design of applications. This is not an easy process, however. The main difficulty is linking the learning styles with the hypermedia application. Most of the teaching systems that integrates learning styles are based on the premise that adapting the teaching strategies to the students learning styles will give better results [6,17,21]. Table 1 shows some of the systems found, their learning styles and the type of adaptation.

Table 1. LS and systems adaptation models [20]

System	Learning style and the adaptation Model
ARTHUR [11]	Visual-interactive, auditory-lecture and text styles. The adaptation is achieved by providing different media representations for each learner. <i>Auditory</i> representation is achieved using sounds and streaming audio. To appeal to <i>visual</i> and <i>kinesthetic</i> learners puzzles, animations, drag and drop examples and riddles are used.
CS388 [5]	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 [21]	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 [12]	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 [17]	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'
PHP Course [13]	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 Course [10]	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

This review shows that the different adaptations to learning style 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, our work is new and significantly different from the previous efforts done by others in the field.

3. Pedagogic Model

3.1. Learning Styles Model by Felder-Silverman

A learning style is defined as the characteristics, strengths and preferences in the way people receive and process information [8]. 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 [19]. The Felder and Silverman model was selected as the base of our taxonomy of adaptive teaching [8] because first, it has been successfully implemented in previous work when individually adapting the electronic learning material [5,13,17], second it has been approved by its author and other specialists [9,22], third it is user friendly and the results are easy to interpret, and fourth the number

of dimensions is controlled and can actually be implemented [17]. This model rates the student's learning style in a scale of five dimensions. Table 2 shows the learning styles dimensions [8]:

Table 2. Felder Dimensions

Dimension	Type
Perception	Sensitive(external agents), places, sounds, physical sensations
	Intuitive (internal), possibility, ideas, through hunches
Entry Channel	Visual (images, diagrams, graphics)
	Verbal(spoken words, sounds)
Organization	Inductive
	Deductive
Processing	Active through physical activities and discussions
	Reflexive through introspection
Understanding	Sequential with continuous steps
	Global through leaps and an integral approach

In 2002, Felder introduced the following changes to his model: he eliminated the inductive/deductive dimension due to pedagogical reasons, and he 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 our 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).

3.2. Teaching Strategies

Considering that pedagogy includes teaching and learning strategies, we explain the definitions for 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 [18].

Didactic teaching strategy 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 [18].

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 [7], who insists on the importance of teaching students by using methods that adapt to their conceptual preferences. Or Cabrero [4], who 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.

4. Adaptive Teaching Taxonomy

From the point of view of the 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 [5,8,11,13,17].

One usual definition of taxonomy is the following: "it is the science of orderly classification in natural history" [2]. Teaching taxonomy seeks to provide the foundations for a classification of the goals within a teaching system (i.e. classification of the desired behavior of the student). The proposed taxonomy consists on matching the different learning styles with the components and teaching strategies, it also suggests the suitable electronic media as a channel for its representation, thus personalizing it to every student.

This taxonomy is based on the four learning styles dimensions, $LSD_4 = \{LSD_1, LSD_2, LSD_3, LSD_4\}$, each dimension on learning styles type, $LST = \{(S,I),(Vi,Ve),(A,R),(Seq,G)\}$ and on their different combinations. In this case, there are 24 types of combinations: $LSC_{24} = \{(S,Vi,A,Seq), (S,Vi,A,G), (S,Vi,R,Seq), (S,Vi,R,G), (S,Ve,A,Seq), (S,Ve,A,G), (S,Ve,R,Seq), (S,Ve,R,G), (I,Vi,A,Seq), (I,Vi,A,G), (I,Vi,R,Seq), (I,Vi,R,G), (I,Ve,A,Seq), (I,Ve,A,G), (I,Ve,R,Seq), (I,Ve,R,G)\}$. Having this base in mind, teaching components are selected according to each learning style: $DS_n = \{DS_1, DS_2, \dots, DS_n\}$. Teaching strategies don't hold a one-to-one relationship with the learning styles, instead, it's a one-to-many relationship. There can be one or many teaching strategies that accommodate one learning style. In order to achieve the representation of knowledge, the appropriate electronic media for the teaching strategies is selected,

as well as for every learning style: $EM_n = \{EM_1, EM_2, \dots, EM_n\}$. Such electronic media doesn't hold a one-to-one relationship with the used strategies, but also a one-to-many relationship; for each learning style, there are one or many learning strategies that can be represented by one or many electronic media (see Figure 1).

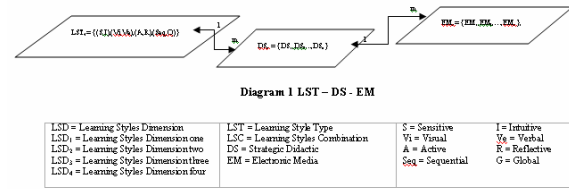


Figure 1. Relation Entity LST - DS - EM

In order to establish the relationship between the different dimensions, the teaching strategies' variables and the electronic media, a detailed review of the learning styles theory 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.

For example, for those with a sensitive style it was found that they prefer practical content and methods that allow the solution of problems. When selecting the appropriate strategies, these must give priority to such practical work (simulations and games, learning based on problems and role playing). Electronic media, in turn, should contribute to these priorities, animations, chats and forums (among others), are examples of media that allow the implementation of pragmatic solutions that can also be based on problems. Table 3 is the detailed taxonomy for one dimension.

Table 3. LSD₁ [Perception (Sensitive, Intuitive)]

Learning Style	Content	Method	Mean (characteristics)	Dialectic (teaching) Strategies	Electronic Media
Sensitive	Practical Don't like contents without an immediate link to the real world Giving examples, following by the expositions	Specific Facts and procedure oriented Enjoy problem solving by following well established procedures Patient when dealing with details Enjoy practical work Lab class	Practical Problem solving	Games and simulations Learning based on problem solving Role playing	Chat (Messenger) e-mail Forums Movies Online learning communities Pictures Podcast Internet research Simulations Videos Weblog or blog WebQuest Wiki
		Can memorize things easily Hands-on work Apply theory in practice	Hands-on work Experiments		
Intuitive	Conceptual, Abstract, Theoretical Innovative Oriented to theory and meaning interpretations that link the facts Enjoy working with abstract problems and mathematic formulations	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 Exposition before example	Theoretical Abstraction Math related	Presentation Discussion panel Brainstorming	Digital magazines Digital newspapers e-books e-mail Forums Lectures Online learning communities Pictures Recorded live events Simulations Tutorial systems WebQuest Wiki Written text (Documents)

Speaking of the intuitive style, since it prefers concepts, an exposition strategy is used, even though a discussion panel can also meet the requirements. On the other hand, considering that intuitive persons are innovators, a brainstorming session can also meet the

objective. If we associate these with the electronic media, we find that eBooks, readings and forums (among others), allow us to adapt these strategies.

There are three main phases for implementing this method: first, is the application of the Felder and Silverman learning styles questionnaire, second, the study plan is reviewed to set the course objectives. Bloom's taxonomy [2] helps to set the objectives by associating active verbs with the desired cognitive level, it allows us to classify the course information based on its categories and it also helps to elaborate evaluations (questionnaires). Next, is an example of how such levels can be evaluated through different types of questions. Table 4 associates the most used and recommended questions with the 6 cognitive levels.

Table 4. Bloom's cognitive levels

Type of Question	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Brief Answer	✓					
Completing	✓	✓				
Multiple Option	✓	✓	✓	✓		
Matching	✓	✓				
Alternative Answer			✓	✓		
Arranging	✓					
Essay			✓	✓	✓	✓

In the third phase, a selection of the teaching strategies and electronic media is done according to the adaptive teaching taxonomy 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.

5. Example of method application

The Instituto Tecnológico Autónomo de México's Algorithms and Programs course (number COM11101) for first year engineering students was used to test the utility of the method. Only one segment of the course was used. Here is the test we did, following the previously explained phases. In the first phase the Felder and Silverman learning styles questionnaire was given to 26 students. The results are shown in Table 5.

Table 5. Results Felder and Silverman LSQ

Dimension	Learning Style	Number of Students
LSD ₁	Sensitive	16
	Intuitive	10
LSD ₂	Visual	22
	Verbal	4
LSD ₃	Active	16
	Reflexive	10
LSD ₄	Sequential	16
	Global	10

The results show that in the LSD₁ [Perception (Sensitive, Intuitive)], students are more sensible, while the most significant difference is in the LSD₂ [Entry Channel (Visual, Verbal)], where 22 students came out to be visual and only four were verbal. In the

case of LSD₃ [Processing (Active, Reflexive)], it was found that most of the students are active. Finally, LSD₄ [Understanding (Sequential, Global)], it shows that they are mostly sequential and since it is a traditional class, this will be taken as the ideal style of the class {(sensitive /Visual/ Active/ Sequential)}.

In the second phase 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.

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

The subjects of the course Algorithms and Programs, which are arranged based in the specific objectives described in Bloom's taxonomy. In this case, 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 taxonomy is done according to the results of the learning styles questionnaire, and also based on the ideal class style {(Sensitive/Visual/Active/Sequential)} The content 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. Table 6 describes the methodic strategy, that is, how the knowledge will be transmitted.

Table 6. Algorithms

SPECIFIC OBJECTIVE	Teaching Strategies and Electronic Media
1. - Identify places where algorithms will be used.	- Set examples using algorithms, Learning based on problem solving, Brainstorming + chats, forums, simulations, wikis
2.-Define Algorithms.	- Define algorithms using previous examples, Establish problems to be solved using algorithms, Role playing, Exposition, Questioning method, Discussion panel + Chats, wikis, eBooks, documents
3. - Solve simple problems using algorithms.	- Solve a problem using algorithms, Learning based on problem solving ,Discussion panel + Simulations, chats, webQuest

Even though this example deals with a physical class (seminar), it can be completely automated if the discussed set of rules is applied. This way, if a system is implemented, personalization of the learning process may be achieved.

6. Conclusions

This article describes the development of learning styles integration taxonomy, the different teaching strategies and the correct implementation of electronic media to facilitate and personalize the learning process, in a way that students have a better assimilation of knowledge, as well as a method to use such classification.

This method can be used on physical classes (seminar) where teachers can calculate the course's average learning style to choose the suitable media proposed by the adaptive teaching taxonomy, as well as like a catalyst to achieve an automatic personalization in the hypermedia systems. It is worth mentioning that combining teaching strategies with electronic media, doesn't act in an excluding way.

This work is based on the relationship between teaching and technologic components. Because the method and taxonomy is user friendly, the person implementing this method doesn't have to be information technology subject matter expert. We consider the recommendations on teaching strategies that match a certain learning style, as an important contribution to the subject. We hope that students learn in a more efficient and effective way.

A two phase evaluation of the method to test its efficiency will be done in the future. The first phase will deal with already developed educational software, and the second will be on a suited implemented system.

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