Adaptation of Learning Object Interface based on Learning Style

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Abstract: Learning styles (LS) refer to the ways and forms that the student prefers to learn in the teaching and learning process. Each student has their own way of receiving and processing information, and bearing in mind the learning style is important to better understand their individual preferences and to understand why certain teaching methods and techniques work better for some students, while for others they do not. We believe that knowledge of these styles enables the possibility of making propositions for teaching, thus reorganizing teaching methods and techniques in order to allow learning that is adapted to the individual needs of the student. This would be possible through the creation of online educational resources adapted to the style of the student. In this context, this article presents the structure of a learning object interface adaptation based on the learning style. This should enable the creation of the adapted learning object according to the student's learning style, contributing to the increase of student's motivation in the use of a learning object as an educational resource.

1 INTRODUCTION

The learning style (LS) refers to a person's individual preferences, in relation to the ways and forms that they prefer to learn in the teaching and learning process. An investigation by Haider, Sinha and Chaudharyal (2010) indicates that pedagogical strategies related to the learner's learning style contribute to making learning easier. It also presents improvements in the learning process, if the educational material used by the learner matches their learning style.

Each LS contains specific characteristics that need to be collected and mapped in order to enable the adaptation of the educational material. This research considered as educational material the learning object (LO), so that the student benefits more from this resource that has been widely available in learning virtual environments.

The adaptation of the learning object interface considering the student's LS is one of the possibilities that allows the offering of digital educational resources adapted to students' individual learning preferences. In this case it is expected to obtain a greater motivation of the student with the use of this type of educational resource because the LO will be presented in a way that respects their individual preferences of learning.

There are several models of learning styles available in the literature that describe how to classify the student in a learning style as in (Felder and Silverman, 1988), (Kolb, 1984). These models classify students as to the form or manner that they prefer to perceive and process the information received when they are learning, so their individual learning preferences can be identified.

This research used the Felder-Silverman Learning Styles Model (FSLSM) (Felder and Silverman, 1988), because it is considered the most suitable to be used in educational environments, and a better match of their scales to the characteristics of learning materials (Akbulut and Cardak, 2012), (Truong, 2015).

In this perspective, this study proposes a structure of learning object interface adaptation based on the learning style to allow the creation of the LO adapted according to the learning style of the student, contributing to the increase of student motivation in the use of LO as an educational resource. This work makes the following contributions:

- Defines an association of the characteristics of LS with the most appropriate forms of presentation of the LO content for each LS of the Felder-Silverman model;

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- Creates a structure of adaptation of the learning object interface based on LS, from the in-depth research and analysis of the characteristics of the styles of the Felder-Silverman model to contribute to the creation of adapted LO to the LS;
- Analyzes the proposed structure to demonstrate the validity of the approaches used.

The text is structured as follows. Section 2 presents a theoretical basis. Section 3 presents related works. Section 4 describes the structure of the interface adaptation based on learning style. Section 5 presents an analysis and discussion of the work. In section 6, the final considerations and suggested future work are made.

2 LEARNING OBJECT (LO) AND LEARNING STYLES (LS)

LO can be understood as "[...] any digital resource that can be reused to support learning" (Wiley, 2001). They are produced by different institutions and researchers, and are usually cataloged in repositories.

LO in an overview can be understood as autonomous information segments that are intended for use in remote or face-to-face learning situations. It can also be considered as a resource that can assist the teacher in his teaching activity. This type of educational resource can contribute to the teaching and learning process of the students, since it is designed to meet a defined pedagogical objective. It is expected that LO could be adapted according to the student's different manners and ways of learning, which may characterize different profiles of learners. These different profiles can be identified through the learning styles (LS) of the students.

LS are student preferences and trends that define ways to receive, process, perceive, and organize the information (Felder and Silverman, 1988). In this work, we consider the cognitive dimension, that is, if the learning process and educational resources are appropriate to the style, the person will probably be more successful as a learner, and may be more motivated to use LO as an educational resource in the learning process.

There are several LS models, which have been developed by various authors and can be used by educational systems to represent student styles (Felder and Silverman 1988, Honey and Munford 2000, Kolb 1984). LS are defined by these authors differently, influenced by different theories of learning psychology.

This research used the Felder-Silverman model (Felder and Silverman, 1988), because it is considered the most suitable for use in educational environments, and better adapting its scales to the characteristics of learning materials. It is also widely used in the international context in research on the adaptation and customization of learning materials, as well as providing a good degree of adaptability to student profiles (Al-Azawei and Badii, 2014).

The Felder-Silverman model (1988) was developed by Professor Richard M. Felder and by psychologist Linda K. Silverman, and classifies students in scale number according to how each student perceives, retains, processes, and organizes information. In this way the student can be classified in four dimensions of the model: a) Perception (Sensory x Intuitive); b) Retention (Visual vs. Verbal); c) Processing (Active x Reflective) and d) Organization (Sequential vs. Global). The characteristics of students according to their LS for each dimension are more detailed in (Felder and Silverman, 1988).

This model uses the ILS (Index of Learning Styles) as a mensuration instrument to identify the LS based on FSLSM (Felder and Silverman Learning Style Model), which comprises forty four questions, eleven for each of the four dimensions described above. More details in (Felder and Soloman, 2006). In this research we consider that the style of the student has already been identified and the adaptation occurs from the knowledge of the style.

3 RELATED WORKS

Graf (2007) in her PhD work carried out an expansion of the Learning Management Systems (LMS) to provide adaptability, incorporating learning styles according to the Felder-Silverman learning style model. She created an automated approach to identify learning styles from students behavior and actions. This approach was designed, implemented and evaluated, demonstrating that it is adequate to identify learning styles. Moodle was used as a prototype to extend an LMS, making it possible to automatically generate and present courses according to students' learning styles. The results showed that the concept proposed to offer adapted courses was successful to support students in learning.

Yang, Hwang and Yang (2013) developed an adaptive learning system considering various dimensions of personalized characteristics, proposed

a customized presentation module for the development of adaptive learning systems based on the dependent/independent field cognitive style model and the LS of the Felder-Silverman learning style model. Their experimental results showed that the proposed approach is capable of helping students to improve their performance in the learning process.

The work of Fasihuddin, Skinner and Athauda (2014) presented a proposal for an adaptive model to customize open learning environments based on the Felder-Silverman learning style model. This model consists of two main agents to execute its functionalities; the identification agent is responsible for identifying the student's learning styles, monitoring certain patterns of behavior from student with the learning objects, while the student interacts with learning materials; and the recommendation agent is responsible for providing adaptive navigation support based on the identified learning styles and preferences.

The works presented in this section used the learning styles to adapt and/or customize the learning environments, or to adapt the presentation of the learning material. However, no further studies were found that explore how to use the characteristics of each style of the Felder-Silverman model, mapped in relation to aspects of format and order of LO contents to provide adaptation of the interface of this educational resource.

4 ADAPTATION OF THE INTERFACE OF THE LEARNING OBJECT BASED ON LEARNING STYLE

From the study and research on the "*presentation characteristics for LO*" with regard to sequencing, presentation and form/format of content and resources that compose the learning object, raised from an in-depth analysis of the properties of the styles of the Felder-Silverman model (Felder and Silverman, 1988). It was possible to establish the required parameters and attributes to define the structure so as to adapt the learning object's interface based on the characteristics of the styles (Silva and Pimentel, 2015).

This structure was designed and composed respecting the principles of the Cognitive Theory of Multimedia Learning (Mayer, 2005). The principles of this theory help to avoid the inappropriate use of resources in the most varied formats, which can lead to the student's distraction and lack of motivation in the use of this type of resource, which can cause failure in the learning process.

In the definition of the structure we consider that in the creation of the LO it will be formed by "*elements of content composition* " that constitute the stages: Summary (*Sum*): provides an overview of the content that will be approached; Introduction (*Int*): composed of a brief content for presentation of the subject to be studied of a domain; Development (*Dev*): composed of a more comprehensive content that contemplates the subject of a domain in a more complete way; Activity (*Act*): formed by content to fix the subject; and, Assessment (*Ass*): assessment of the content covered by a domain. These "*elements of content composition*" are organized in relation to the parameters and attributes defined from the characteristics of the styles, and are described as follows:

- Resource (*R*): defines the types of resources that can be used in the elements of the content composition to present the LO. The resources assigned in the model can be: Video (*Vid*); or Diagram (*Dia*); or Graph (*Gra*); or Picture (*Pic*); or Narration (Nar); or Lecture (*Lec*); or Slide (*Sli*); or Self-Assessment (*Sas*); or Table (*Tab*); or Experiment (*Exp*); or Exercise (*Exe*); or Simulation (*Sim*); or Questionnaire (*Que*); or Scheme (*Sch*); or Animation (*Ani*); or Photo (*Pho*); or Web Page (*Wpa*); or Map (*Map*); or Demonstration (*Dem*); or Example (*Exa*).
- Exploration Form (*EF*): defines how the content can be structured in relation to the way it is explored by the student. It can be in Network (*Net*) - investigation more random, without following a script; or Linear (*Lin*) - more directed research, with a script to follow.
- Detailing Order (*DO*): establishes how the student prefers to approach the contents presented in the LO. It can be Specific-to-General (*Spe-t-Gen*): it begins in the specific part and proceeds to the general part for comprehension of a whole; or General-to-Specific (*Gen-t-Spe*): begins in the general part and proceeds to the specific part for comprehension of a whole.
- Composition Order (*CO*): defines the organization of the stages used in the composition of the

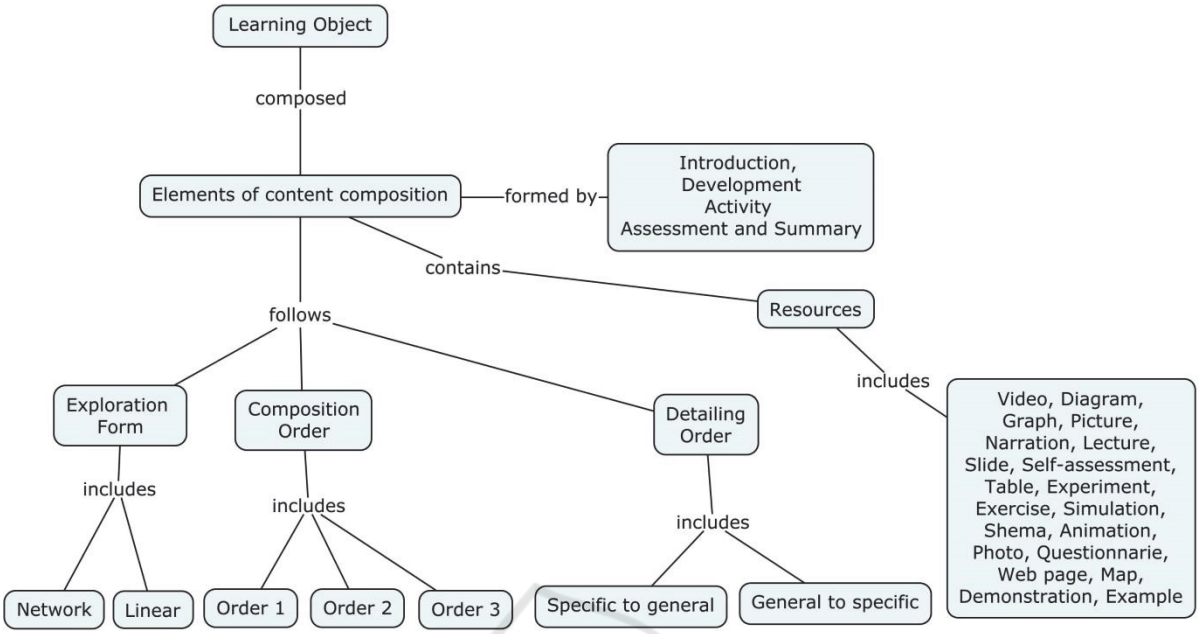

Figure 1: Overview of the LO structure.

contents of an LO, that is, the order in which these stages will be presented to the student. There are three composition orders defined: *order 1* - 1st Introduction, 2nd Development, 3rd Summary, 4th Activity, 5th Assessment; *Order 2* - 1st Introduction, 2nd Development, 3rd Activity, 4th Summary, 5th Assessment; and *Order 3* - 1st Summary, 2nd Introduction, 3rd Development, 4th Activity, 5th Assessment.

The overview of the elements created from the "*presentation characteristics for LO*" in relation to the sequencing, presentation and form / format of content and resources that compose the LO can be visualized in figure 1. These elements were defined to create the interface adaptation of the learning object, based on the characteristics of the styles.

The simplified form of the composition of the LO interface adaptation can be represented in the formulation *StyleInterface* (S) = $\sum$(CO(x), DO(j), EF(k), R($r_1, r_2, .. ., r_n$)), where, S indicates the styles of the Felder-Silverman model, described in section 4; x can assume 1, 2 and 3, which indicates, respectively, first, second and third composition order ; j can assume 1 = "*specific-for-general*" and 2 = "*general-for-specific*"; k can assume 1 = "*network*" and 2 = "*linear*"; r_i are the resources that can be used in LO composition; *CO* indicates the order of composition that the stages used in the composition of the contents will be presented in LO; *DO* indicates the detailing order of each stage of LO; *EF* indicates the exploration form that will be used in the presentation of the LO; *R* indicates the resources that can be used in the composition of the LO.

So as to adapt the interface according to the styles of the Felder-Silverman model, it was necessary to investigate the characteristics and preferences of each style to define the most appropriate ways to modify the presentation of the LO to obtain an adapted interface to the style of the student. This is so because we believe that adapting the style-based LO interface can improve the student's motivation for using OA as an educational resource, and consequently can to enable improvements in learning.

Table 1 presents the attributes and parameters of the proposed interface adaptation structure, defined with the values referring to the preference according to the adaptation rules for each style.

The composition of the LO interface adaptation structure according to the styles was defined considering the following question *"How and what can be modified in the LO interface presentation for students with different learning styles?*". Thus, adaptation rules were created for the attributes and parameters defined in the structure, in relation to: sequence of the content composition elements of the OA (*composition order*); number and type of resources used to create LO (*resources*); the level of detail of the composition elements of LO content (*detailing order*); the way the student can explore

Table 1. Analysis of the styles of the Felder-Silverman model (1988) in relation to the attributes and parameters of the proposed structure.

Style	Exploration Form (EF)	Composition Order (CO)	Detailing Order (DO)	Resource (R)
Active	network	order 2	general-to-specific	vid, dia, gra, pic, sas, exe, sim, sch, wpa, map, exa
Reflective	linear	order 1	specific-to-general	dia, gra, lec, sli, sas, tab, exe, sim, sch,ani, wpa, dem, exa
Visual	network	order 3	general-to-specific	vid, dia, gra, pic, sli,sas, tab, exp, exe, sim, ani, fot, wpa, map, dem, exa
Verbal	linear	order 3	specific-to-general	dia, nar, lec, sli, sas, tab, exe, que, wpa, dem, exa
Global	network	order 3	general-to-specific	dia, gra, pic, sli, sas, exp, exe, sch, wpa, map, exa
Sequential	linear	order 2	specific-to-general	dia, gra, pic, nar, lec, sli,sas, exe, sim, que, sch, ani, wpa, dem, exa
Sensory	network	order 3	specific-to-general	vid, gra, nar, sli, sas, tab, exp, exe, que, wpa, map, dem, exa
Intuitive	linear	order 1	general-to-specific	gra, pic, nar, lec, sli, sas, exe, sim, que, ani, pho, exa

the LO contents (*exploration form*); besides the arrangement of these elements in the LO presentation. For each style, the LO interface is modified following the attributes and parameters presented in table 1. A prototype of the interface was created following the defined adaptation structure, in order to carry out an initial validation of the proposal, and will be discussed in the next section.

5 RESULTS AND DISCUSSION

As mentioned earlier, in this research the preferences and characteristics of each style of the Felder-Silverman model were identified and mapped to "*LO presentation characteristics*". These characteristics were the basis for defining the LO interface adaptation structure of the according to each style. In the creation of the structure we considered some aspects of modeling described in the following components.

Assignment of Levels. The levels were created to demonstrate how the student prefers to approach the contents presented by the teacher in a learning object respecting the detailing order (*DO*) established for each style.

Quantity of Sub-stages. For each item of the composition order (*CO*) that corresponds to an LO stage, it is defined how many sub-stages will comprise each stage. The uniform pattern was adopted for all stages having the same quantity of sub-stages.

Number of Levels. Related to the detailing order (*DO*) of the content, which establishes how to approach the contents presented. If in a "*more general to specific*" or "*more specific to general*" form. The lowest value was adopted for "*more specific*" and the greater value for "*more general*". Each level will be evenly distributed according to the total amount of sub-stages of all stages, following the composition order (*CO*) definition for the selected style. The formula for find out how many sub-stages will be allocated for each level is represented by (stages * sub-stages / total levels), adding the rest of the division to the last level.

Amount of Resources on the Screen. Maximum quantity of resources allowed to appear on the screen for each sub-stage.

Standard values were defined for the components: 3 for the quantity of sub-stages; 5 for the total levels of detailing; and 5 for the maximum numbers of resources to display in the screen. In this case, these values are assigned if these components are not filled in or filled in incorrectly (informing

something that is not an integer). Also possible inconsistencies are controlled, for example, if the total levels are less than the number of sub-stages, the same quantity of sub-stages is assigned to the total levels.

After the assignment of these values, the organization of the total levels for the sub-stages is done through a staggering of the sub-stages. Firstly it is indicated which detailing order (*DO*) the selected style has. If it is the "*specific to general*" order the lowest level receives the lowest value (in this case, the value "1") and the highest level receives the highest value (that is, the value of the quantity of levels). If the order is "General to Specific" the opposite happens. Then, each sub-stage will receive a value, respecting the composition order (OC) of the style. That is, if the total of levels is equal to 6, the detailing order (*DO*) is "*general to specific*" and each stage has 4 sub-stages, each level has 3 sub-stages, being the last level with 5 sub-stages. The current sub-stage on the screen will display the level to which it belongs.

Content Index Display. It consists of displaying the stages and their respective sub-stages in an arrangement of a hierarchical tree, forming nodes for the stages and sub-stages and following the composition order (*CO*) belonging to the style. The items in this content index will be released according to the "*Exploration Form*" of the identified style. That is, if the exploration form is Linear (EF = "*Linear*"), the item subsequent to the current sub-stage will be released only if the current stage is completed, indicated by an "OK" button on the screen, which when clicked / selected informs the system to release next stage / sub-stage. Clicking on the "OK" button indicates the completion of the current stage / sub-stage in this case enables navigation to the next stage / sub-stage and / or returns to the completed stage / sub-stage, and / or to go to the first completed stage. If the exploration form is network (EF = "*Network*"), all items that include the stages and / or sub-stages as well as elements of the navigation control will be enabled for exploration at any time during the use of LO.

Navigation Control. Controls the display of the content index and navigation buttons, depending on the exploration form (*EF*) indicated by the identified style and the navigation flow between the sub-stages, following the composition order (*CO*) defined for the style. The navigation control must agree with the defined exploration form for the style. In this case, if the exploration form is network (EF = "*Network*"), all elements of the navigation control are enabled allowing the student to navigate in a non sequential or random way in the stages and sub-stages composed for the learning object.

Resources Assignment. Defines which resources will be displayed on the screen for each sub-stage in the content composition of the learning object for the identified style. For each sub-step, a maximum number of resources to be displayed are randomly selected. This random number will be between 2 and 5 (default number). However, in order to guarantee the principles of the CTML (Cognitive Theory of Multimedia Learning), such as: multimedia (combination of resources in the image and text format) and spatial proximity (when a resource in the text format describes a resource in the visual format, these should be close), there is guarantee that at least 2 resources will be displayed in each sub-stage. This component is also responsible for ensuring that the principle of modality (for all animation resource one must use the narration resource rather than using a written text) is met.

In order to execute an initial validation of the work proposal, a prototype of the interface was defined and implemented to preliminarily analyze the interface structure defined. In the interface implementation, rules for basis of styles that has a rule for each style defined in the interface adaptation structure was created. The actions in each rule consist of completing the information of each parameter of the selected style. First, we will allocate the *CO*, then allocate the *Rs*, then the *EF* and finally the *DO*.

These actions obey the proposed modeling for this fill, according to appropriate adaptation rules to each style, in the example below, we have the rule for the active style:

Rule Name = *"ActiveStyle"*
Conditions:
Style = *"Active"*
Actions:
a) Create an *CO* in the following order: "*Introduction*", "*Development*", "*Activity*", "*Summary*", and "*Assessment*";
b) Provide the following *Rs*: *"Video", "Diagram", "Picture", "Graph", "Self-Assessment", "Exercise", "Simulation", "Schema", "Web page", "Map" e "Example";*
c) Indicate the *EF* "*Network*";
d) And indicate the *DO* "*General to specific*".

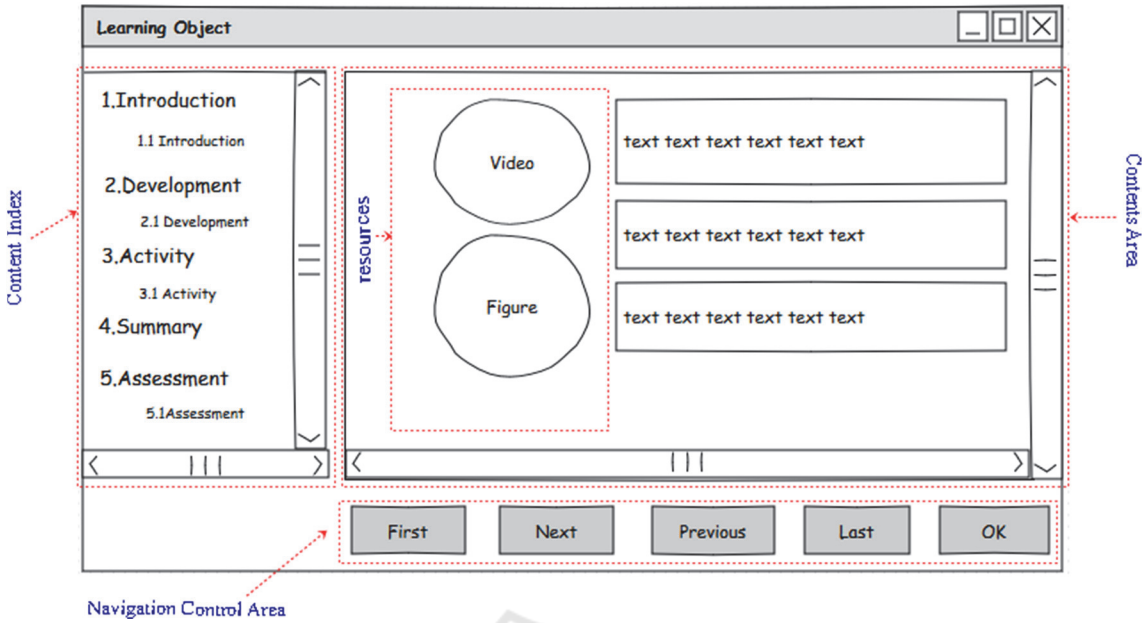

Figure 2: Example of interface screen for the "Active" style.

In this case, as observed in figure 2, the elements that make up the interface are arranged following the adaptation rules that were created to modify the elements according to the characteristics of each style. The "*Content Index*", which consists of displaying the stages and their respective sub-stages of the "*content composition elements*" in an arrangement of a hierarchical tree, forming nodes for the stages and sub-stages, and follows in accordance with the style *CO*. Items in the "Content Index" are released according to the *EF* of the selected style. That is, if *EF* is linear (EF = "*linear*"), the subsequent item to the current sub-stage will only be released if the current stage is completed, indicated by a button on the screen, which when clicked / selected informs the system to releasing next stage / sub-stage, that is, a more targeted exploration in LO. If *EF* is network (FE = "*network*"), all items that include the stages and / or sub-stages, as well as elements of the "*Navigation Control Area*" are enabled, so a more random exploration can be performed in the LO.

In the "*Content Area*" the resources that make up each sub-stage in the creation of OA content are displayed. To ensure that the principles of CTML, such as: multimedia (combination of resources in the image and text format); spatial proximity (when a resource in the text format describes a resource in visual format, these should be close), and the modality (for all the animation resource you must use the narration resource instead of using a written text) are met, it has been established that at least two features are displayed in each sub-step in the "*Content Area*".

The "*Detailing Order Indication*" is related to the levels that were created to demonstrate how the student prefers to approach the presented contents by the teacher in an LO, respecting the *DO* of each style. Thus if the *DO* is "*specific-to-general*" (DO = "*specific-to-general*"), the lowest level receives the smallest value (in this case the value "*1*") and the highest level receives the highest value (in this case the value of the quantity of defined levels), if the *DO* is "*general-to-specific*" (DO = "*general-to-specific*") the opposite happens. Therefore, the lowest value was adopted for "*more specific*" and the greater value for "*more general*".

The "*Navigation Control Area*" controls the display of the "*Content Index*" and the navigation buttons, according to the *EF* indicated by the informed style and the navigation flow between the sub-stages, following the *CO* defined for the style. As previously mentioned the "*Navigation Control Area*" must conform to the *EF* defined for the style. In this case, if *EF* is "*network*" (EF = "*network*"), all elements of the "*Navigation Control Area*" are enabled allowing the student to navigate non sequentially or randomly in the composite stages and sub-stages for LO. If *EF* is "*linear*" (EF = "*linear*"), navigation is sequential, i.e. step by step, the student needs to complete the current stage / sub-stage to proceed to the next stage / sub-stage.

Therefore for each style of the Felder-Silverman model the interface has undergone changes to adapt

according to the attributes and parameters mapped from the characteristics of each style, following the adaptation rules created for the styles in relation to sequencing, presentation and form / format of content and resources that make up a learning object, providing an adapted and adequate learning object to the students' learning style.

6 CONCLUSIONS

The creation of new forms/formats to present the LO contents taking into account the student's LS can generate a greater motivation from the student in the use of this type of educational resource, since the students would receive this adapted resource according to their individual learning preferences. Thus, we developed an interface that considered the characteristics and preferences of the LS, which were mapped in relation to the forms, formats, content sequencing, appropriate to each style that established the definition of the LO interface adaptation structure so that it is adapted to the student style. This structure was designed and composed respecting the principles of the Cognitive Theory of Multimedia Learning (CTML), since the principles of these theories help to avoid the inadequate use of resources in the most varied formats, that can lead to the student's distraction and demotivation in the use of this resources type and may cause failure in the learning process.

Therefore, this work brought contributions to the teaching and learning process by defining a LO interface adaption structure, according to the student's LS. This is so because we believe that the student who receives the adapted learning object to his/her style can generate an increase in the motivation to use the learning object as an educational resource, since the learning object will meet their individual learning preferences, and consequently may bring improvements in your learning process.

As future work we intend to conduct experiments with students using adapted LO to their style to measure the emotional response and motivation of the student in relation to the use of LO, and consequently to verify if there was an increase in learning.

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