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Learning Object Interface Adapted to the Learner's 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 throughout the learning process. Therefore, knowing their LS is important to better understand their individual learning preferences, and also, understand why the use of some teaching methods and techniques give better results with some students, while others it does 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. Adapting learning 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 LS. The structure created should enable the creation of the adapted learning object according to the student's LS and contributes to the increase of student's motivation in the use of a learning object as an educational resource.

***Keywords*—**Adaptation, interface, learning object, learning style.

I. Introduction

THE 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. Reference [16] considers LS a composition of cognitive features and affective physiological factors that serve as relatively stable indicators of how a student perceives, interacts and responds to the learning environment. Reference [8] advocates LS as a characteristic and dominant preference in the way people receive and process information.

An investigation by [14] indicates that pedagogical strategies related to the learner's LS contribute to making learning easier. It also presents improvements in the learning process, if the educational material used by the learner matches their LS.

To 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.

In view of the creation of this LO, it is important to respect in addition to the physical, sensory and motor specificities of learners, the students' individual learning preferences, that is, LS.

The adaptation of the LO interface considering the student's LS is one of the possibilities that allows for 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 resources because the LO will be presented in a way that respects their individual preferences of learning.

There are several models of LS available in the literature that describes how to classify the student in an LS as in [8], [17], [15], [3], [10]. 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.

Reference [4] carried out an investigation of LS studies over the last 30 years up to 2003. They managed to identify 71 models of LS and categorize 13 of these as main models, considering three criteria: their theoretical importance, their widespread use, and their influence on other models of LS. Although many of these models are small adaptations of others, it is still considered a large number of models in the literature, and their styles can be used to define the profile of students in virtual learning environments, and therefore, be used as a criterion for the adaptation of educational materials.

This research used the Felder-Silverman Learning Styles Model (FSLSM) [8], 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 [12], [1], [9], [21].

In this perspective, this study proposes a structure of LO interface adaptation based on the LS to allow the creation of the LO adapted according to the LS 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;
- Creates a structure of adaptation of the LO 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;

The text is structured as follows. Section II presents a theoretical basis. Section III presents related works. Section IV describes the structure of the interface adaptation based on LS. Section V presents an analysis and discussion of the work. In Section VI, the final considerations and suggested future work are made.

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II. LO and LS

LO can be understood as "[...] any digital resource that can be reused to support learning" [22]. They are produced by different institutions and researchers, and are usually cataloged in repositories. A repository is a place, usually integrated with a learning system, in which the LOs are organized and stored in order to access the desired LO with greater accuracy, being access available for use or for reuse purposes in others.

LO should be thought of as gears of a much larger machine that comes to compose an LO system. This can be seen as a framework used to create and provide learning experiences that meet the educational needs of the students. They are designed to be flexible in order to provide the opportunity of being reused in several different environments [19].

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. Thus, with the use of LO as an educational resource, it is possible to apply strategies to work on diverse concepts that are part of the student's curriculum, which are difficult to be perceived or abstracted. 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 LS of the students.

LS are student preferences and trends that define ways to receive, process, perceive, and organize the information [8]. 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.

According to [11], the identification of LS is important in order to incite a link between teaching and the ways students prefer to learn. If so, students demonstrate better results and a stronger desire to learn. From the identification of LS, it is possible to understand individual learning preferences, and thus provide appropriate educational material to the style of student.

There are several LS models, which have been developed by various authors and can be used by educational systems to represent student styles [8], [15], [17]. LS are defined by these authors differently, influenced by different theories of learning psychology.

This research used the Felder-Silverman model [8], 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 [2], [12], [5].

The Felder-Silverman model [8] 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:

- Perception: "*sensory*" student learns facts, solves problems with established methods, is more detailed and methodical; While the "*intuitive*" prefers to discover possibilities and relationships, likes novelties and does not like repetition, prefers more concepts and theories and tends to be more theoretical.
- Retention: "*visual*" student more easily remembers what he saw, as figures, flowcharts, films and demonstrations, privileges the information he receives through images, diagrams, graphs and schemes; the "*verbal*" has more facility with words, written or oral explanations, privileges what is spoken and written.
- Processing: "*active*" student understands and retains information better by working in an active way, acting on something, discussing and applying concepts or explaining to others, likes teamwork more, tends to be more experimental; The "*reflective*" prefers first to reflect on the information received, likes to work more individually, tends to be more theoretical.
- Organization: "*sequential*" student learns in a linear way, in sequenced steps, step-by-step, follows logical paths to find solutions, presents analysis capacity; "*global*" learns in great leaps, assimilating the material almost randomly, without seeing the connections, to then understand the whole, able to solve complex problems, presents synthesis capacity.

This model uses the ILS (Index of Learning Styles) as a mensuration instrument to identify the LS based on FSLSM, which comprises 44 questions, 11 for each of the four dimensions described above. More details in [7]. In this research, it was considering that the style of the student has already been identified and the adaptation occurs from the knowledge of the style.

III. Related Works

Reference [13] in his PhD work carried out an expansion of the Learning Management Systems (LMS) to provide adaptability, incorporating LS according to the Felder-Silverman LS model. She created an automated approach to identify LS from students’ behavior and actions. This approach was designed, implemented and evaluated, demonstrating that it is adequate to identify LS. Also based on this approach, an autonomous tool for the automatic detection of LS in LMS was implemented. In addition, improvements were investigated in the automatic detection of LS, using additional information on students' cognitive traits, showing that there are relations between working and learning memory capacity, and styles, and that these relationships can provide additional information for the LS detection process. Moodle was used as a prototype to extend an LMS, making it possible to automatically generate and present courses according to students' LS. The results showed that the concept proposed to offer adapted courses was successful to support students in learning.

Reference [23] 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 FSLSM. Their experimental results showed that the proposed approach is capable of helping students to improve their performance in the learning process.

The work of [6] presented a proposal for an adaptive model to customize open learning environments based on the FSLSM. This model consists of two main agents to execute its functionalities; the identification agent is responsible for identifying the student's LS, monitoring certain patterns of behavior from the student with the LO, while the student interacts with learning materials; and the recommendation agent is responsible for providing adaptive navigation support based on the identified LS and preferences.

The works presented in this section used the LS 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.

IV. Adaptation of the Interface of the LO Based on LS

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 LO, raised from an in-depth analysis of the properties of the styles of the Felder-Silverman model [8], it was possible to establish the required parameters and attributes to define the structure so as to adapt the LO's interface based on the characteristics of the styles [20].

This structure was designed and composed respecting the principles of the Cognitive Theory of Multimedia Learning [18]. 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 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 Fig. 1. These elements were defined to create the interface adaptation of the LO, 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 IV; *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.

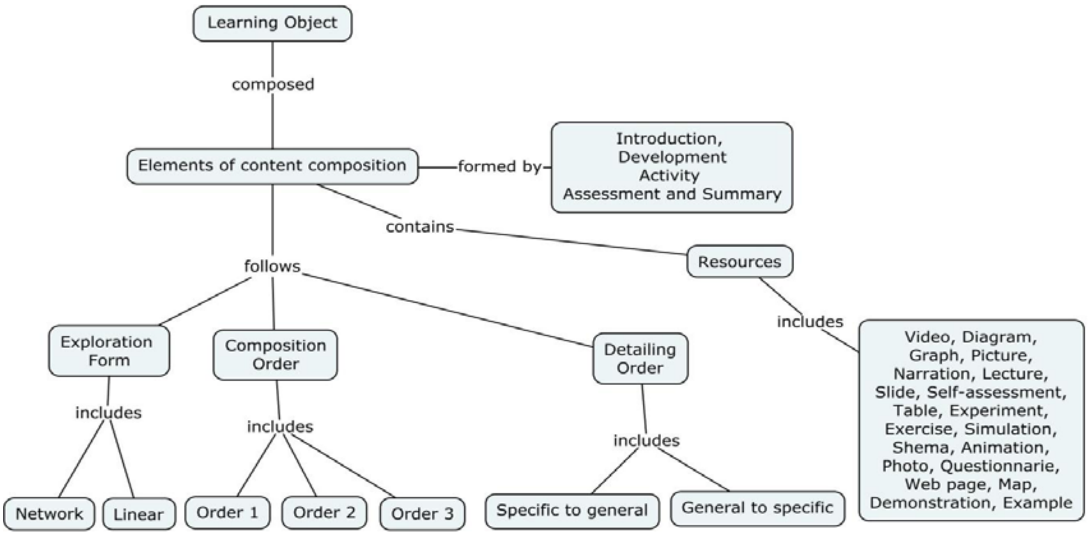

Fig. 1 Overview of the LO structure

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 LO as an educational resource, and consequently, can to enable improvements in learning. Therefore, we emphasize that styles preferences in the Felder-Silverman model can be mapped on a scale that classifies whether the student has a mild, moderate, or strong preference for each style. These preferences are identified through the LS measurement instrument, more details in [7]. Through this measurement instrument, three types of preferences can be identified for each of the styles that compose the four dimensions of the instrument's scale, described in Section II. They are: "*mild*" when the student scores on the scale between 1 and 3, in which case he/she has a mild preference between both styles of the scale dimension, so they will not have learning difficulties in an environment that favors one or other dimension style; "*moderate*" when the student scores on the scale between 5 and 7, in which case he/she presents a moderate preference for one of the styles of the dimension of the scale, so they may have learning difficulties in an environment that does not favor the styles of that dimension ; and "*strong*", when the student scores on the scale between 9 and 11, in which case he/she has a strong preference for one of the styles of the scale dimension, so they will have learning difficulties in an environment that does not favor the styles of that dimension [7].

Rules were created in relation to the attributes and parameters defined for interface adaptation for the following cases: when the preference is "*strong*" for a style of one of the dimensions of the scale, and "*mild*" and / or "moderate" preferences for the others Styles; And also when the preference is "*strong*" for two styles of more than one dimension of the scale, and "*mild*" and/or "*moderate*" preferences for the other styles.

In Fig. 2 we present an example of how these rules for the "*strong*" preference for more than one style, for the dimensions "*Information Processing* (active vs. reflexive)" and dimension "*Information Retention* (visual vs. verbal)".

In the example shown in Fig. 2, we observed that for a student with strongly "*Visual-Active*" style, the exploration form (*EF*) should be "*network*", that is, it should allow the student a more random investigation without following a script content of LO; the detailing order (*DO*) is "*general-to-specific*", so the contents of the LO must start in the general part and proceed to the specific part for comprehension of a whole; in the composition order (*CO*) can be "*order 2*" or "*order 3*", in which case the content stages follow one of these two orders, order 2 - 1st Introduction, 2nd Development, 3rd Activity, 4th Summary, 5th Assessment ; or order 3 - 1st Summary, 2nd Introduction, 3rd Development, 4th Activity, 5th Assessment; the resources (*R*) that can be used to compose the content are "*vid*", "*dia*", "*gra*", "*pic*", "*sli*", "*sas*", "*exa*", "*exp*", "*sim*", "*wpa*", "*map*", "*ani*", "*pho*", "*dem*" and "*tab*".

Table I presents the attributes and parameters of the proposed interface adaptation structure, defined with the values referring to the "*strong*" 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 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 I. 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.

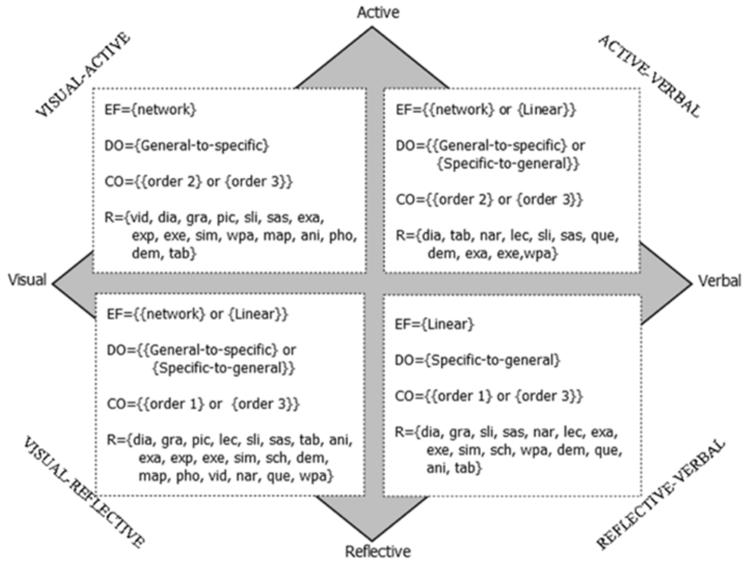

Fig. 2 Rules for the Information Processing and Retention dimensions

TABLE I
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

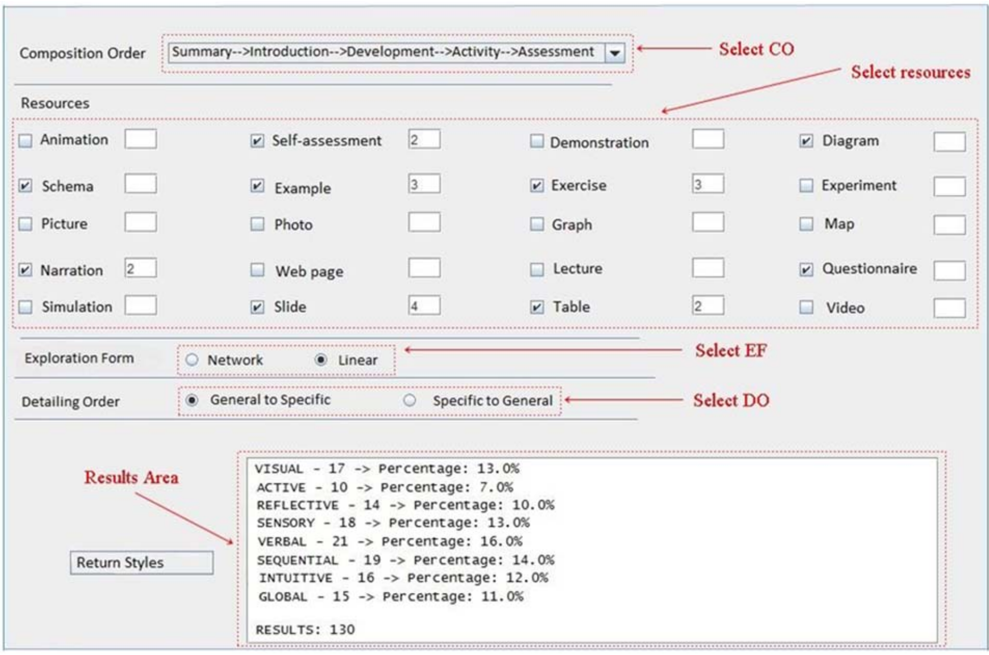

Fig. 3 Example of obtained results for the "Verbal" style

V. RESULTS AND DISCUSSION

The presentation and analysis of results cover the following topics:

A. Simulation of the styles identification based on the defined adaptation structure;
B. LO interface adaptation structure;

A. Simulation of Styles Identification

In order to verify if the attributes and parameters defined in the interface adaptation structure are in agreement with the styles, an experimental system that simulates if the acceptable values in the structure reflect the characteristics that identify the styles was created.

The simulation consists of filling in the information for each parameters and attributes group: Composition Order (*CO*), Resource (*R*), Exploration Form (*EF*) and Detailing Order (*DO*).

From the data filled in, the system will count which styles have certain information. For this, the production rules bases were modeled for each parameters and attributes group (*CO*, *R*, *EF* and *DO*, in this order), to execute the simulation and check the validity of the values. For example, if CO = "*order 1*" is reported, the "*Intuitive*" and "*Reflective*" styles will be identified and counted. For *Rs*, if you indicate that there are three "*Experiment*" type resources, the "*Visual*", "*Global*", "*Sensory*" and "*Active*" styles will be identified and counted three times, and so on.

Fig. 3 presents an example of the results from the parameters and attributes selection and filling, in this situation the "Verbal" style was the one that obtained more occurrences in relation to the selected values. As shown in Fig. 3, the *CO* = "*order 3*" was selected, which is formed by "*1st summary, 2nd introduction, 3rd development, 4th activity, 5th evaluation*", followed by selection of the number of *Rs* = "*schema*, *narration*(2), *self-assessment* (2), *example* (3), *slide* (4), *exercise* (3), *table* (2), *diagram*, *questionnaire*", and also selected the *EF* ="*linear*" and *DO* = "*specific-to-general*". From this selection, 130 occurrences were recorded resulting in a larger amount for the "*Verbal*" style totaling 21 occurrences for this style, which corresponds to 16% of the total occurrences performed according to the selected parameters and attributes.

In the case of the occurrence of a tie between two or more styles, criteria for solving this are being investigated. Initially, we considered the definition of weights for the attributes and parameters of the structure. These weights would be established taking into account the characteristics of each style that were used in the definition of the adaptation structure. Thus, more relevant characteristics for a particular style could generate a greater weighting for the attributes and parameters, according to a scale, in which numerical values could be assigned to represent this weighting, for example, "*strong*" weight 3, "*moderate*" weight 2 and "*mild*" weight 1.

B. LO Interface Adaptation Structure

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 LO 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 finding 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: three for the quantity of sub-stages; five for the total levels of detailing; and five 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 six, the detailing order (*DO*) is "*general to specific*" and each stage has four sub-stages, each level has three sub-stages, being the last level with five 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 LO.

Resources assignment. Defines which resources will be displayed on the screen for each sub-stage in the content composition of the LO 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 two and five (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 two 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 the basis of styles that have a rule for each style defined in the interface adaptation structure were 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, as in the example below, we have the rule for the active style:

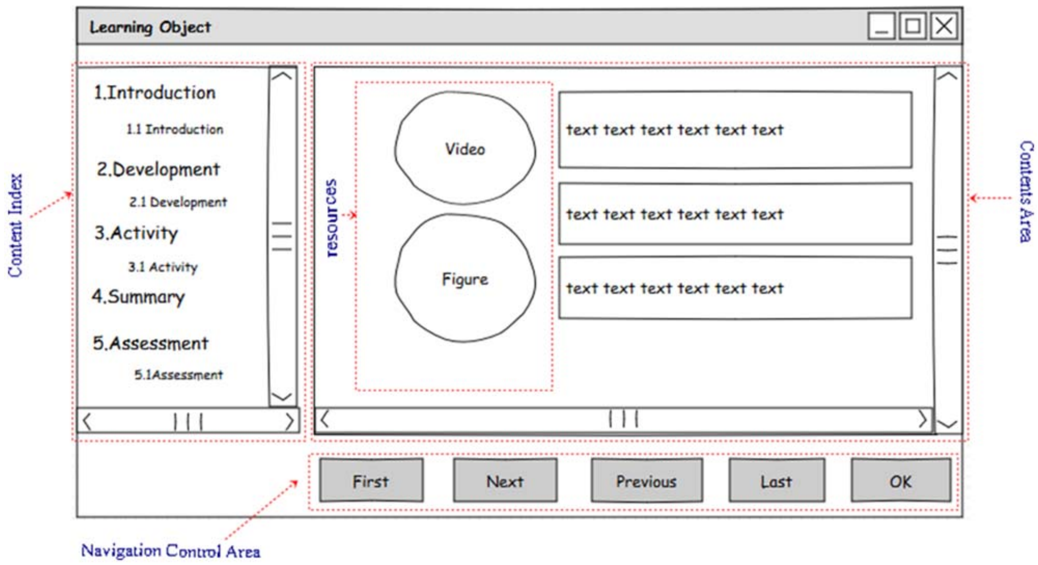

Fig. 4 Example of interface screen for the "Active" style

Rule Name = "*ActiveStyle*"
Conditions:
Style = "*Active*"
Actions:

1) Create an CO in the following order: "Introduction", "Development", "Activity", "Summary", and "Assessment";
2) Provide the following Rs: "Video", "Diagram", "Picture", "Graph", "Self-Assessment", "Exercise", "Simulation", "Schema", "Web page", "Map" e "Example";
3) Indicate the EF "Network";
4) And indicate the DO "General to specific".

In this case, as observed in Fig. 4, 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 LO 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 LO, providing an adapted and adequate LO to the students' LS.

VI. Conclusions

Considering the student's LS in the preparation and elaboration of educational material makes it possible to attend individual needs in relation to the mode and form he/she prefers to learn, contributing to a more adequate learning of their individual learning preferences.

In this context, 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 LO to his/her style can generate an increase in the motivation to use the LO as an educational resource, since the LO 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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