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Learning Objects Content Presentation Adaptation Model Considering Students' Learning Styles

Zenaide Carvalho da Silva, Andrey Ricardo Pimentel, Leandro Rodrigues Ferreira

Abstract**—**Learning styles (LSs) correspond to the individual preferences of a person regarding the modes and forms in which he/she prefers to learn throughout the teaching/learning process. The content presentation of learning objects (LOs) using knowledge about the students' LSs offers them digital educational resources tailored to their individual learning preferences. In this context, the most relevant characteristics of the LSs along with the most appropriate forms of LOs' content presentation were mapped and associated. Such was performed in order to define the composition of an adaptive model of LO's content presentation considering the LSs, which was called Adaptation of Content Presentation of Learning Objects Considering Learning Styles (ACPLOLS). LO prototypes were created with interfaces that were adapted to students' LSs. These prototypes were based on a model created for validation of the approaches that were used, which were established through experiments with the students. The results of subjective measures of students' emotional responses demonstrated that the ACPLOLS has reached the desired results in relation to the adequacy of the LOs interface, in accordance with the Felder-Silverman LSs Model.

Keywords**—**Adaptation, interface, learning styles, learning objects, students.

I. Introduction

LSs correspond to the students' preferences regarding ways in which they perceive, capture, organize, process and understand information [1]. Each style has specific features that need to be assessed and mapped, in order to enable the production of digital educational material adapted to students' needs. In the present study, the digital educational material considered was the LO, which can be defined as any entity, digital or not, that can be used, reused or referenced during the teaching process with technological support [2].

The best would be if the contents' presentation of LOs could be adapted according to the different ways in which students learn, featuring different profiles of students, which can be identified through their LSs. LSs were defined by multiple authors, such as [3]-[5].

During this research, ways of adapting the presentation of LOs based on the LSs were investigated and created. By adapting the LO to students' LSs, it is possible to contribute, indirectly, to increase their motivation while using the adapted LO as an educational resource.

Silva, Zenaide Carvalho da is with the Electrical Engineering and Computer Engineering Department, Federal University of South and Southeast of Para (UNIFESSPA). PO Box 100, Zip Code 68507-590, Maraba –PA, Brazil (e-mail: zenaide.silva@unifesspa.edu.br).

Pimentel, Andrey Ricardo, Ferreira, Leandro Rodrigues, are with the Informatics Department, Federal University of Parana (UFPR). PO Box 19.081, Zip Code 81531-980, Curitiba–PR, Brazil (e-mail: andrey@inf.ufpr.br, lrferreira@inf.ufpr.br).

There are several models of LSs available in the literature, which describe how to classify students into a style [1], [6]-[8]. This research used the Felder-Silverman model [1], for it is considered the most suitable in environments designed for education, as well as it presents a scale that fits best the learning material characteristics [9]-[12].

The process of adapting the content presentation of LOs can be made based on various criteria, occurs in various forms and use some parameters [13]. In this research, specifically, a model of content adaptation of LOs based on the LSs, named ACPLOLS, was created. The adaptation criterion was based on the mapping of the students' LSs and considered the interface and interaction aspects of the components that would be used in the adaptation of the LOs, in addition to the forms of content presentation. These components were defined in order to promote the adaptation of the LOs to the students' LSs, aiming to increase the motivation and satisfaction of the students while using LOs as educational resources. This research was conducted because few studies were found [3], [10] regarding the characteristics' mapping of the LSs models, in relation to interaction and interface elements that could be modified in the content presentation, concerning forms and formats, screen disposition, and navigation options.

The text is structured as follows: a) Section II presents the methods used to create the ACPLOLS; b) Section III presents the results obtained through the evaluation by means of experiments with students; c) Section IV discusses the results through the research and d) Section V exposes the final considerations.

II. Methods

A survey of the characteristics of the eight styles from the Felder-Silverman [1] model was conducted. This survey was conducted to identify important points that could be used to associate these features with the best ways to present the contents of the LOs, in order to adapt the interface to the preferences of each LS. Throughout the study and investigation of the presentation characteristics to the LOs regarding the sequencing, presentation, content form and format, and resources, which were assessed by means of an in-depth analysis of the styles properties of Felder-Silverman [1] model, it was possible to establish the parameters and attributes needed to define the adaptation model of LOs presentation based on LSs [14]. These parameters and attributes have been defined taking into consideration the elements that can be changed and/or adapted in the creation and composition of LOs.

The ACPLOLS was defined and composed respecting the principles of Cognitive Theory of Multimedia Learning - CTML[1] [15]. The principles of this theory help avoid the misuse of resources in various formats, which can lead to distraction and demotivation of the pupil and, consequently, failure in the learning process.

A. Mapping of the Relevant Characteristics of LSs

A detailed study of the Felder-Silverman LSs Model was conducted. Papers that used this model to identify students' styles were also consulted. The characteristics of the eight LSs present in the model were identified, in order to determine important points that could be used to make an association of these characteristics with the most appropriate ways to present the content of the LOs. This was done in order to adapt the interfaces of the objects to the preferences each style. Therefore, the four dimensions of the Felder-Silverman model were considered in the analysis for the definition of the characteristics of LOs presentation, namely: retention of information (how information is presented), perception of information (how information is perceived), information processing (how information is processed), and organization of information (how information is understood).

The actions and behaviors of students were assessed while they used a virtual learning environment. Based on this survey, the characteristics of LOs presentation for the styles of the four dimensions of the Felder-Silverman model were deducted: active and reflective (processing), intuitive and sensing (perception), sequential and global (organization), and visual and verbal (retention). The survey was based on the studies of [9], [11], [16]-[25], among other authors.

The characteristics of LOs presentation, deducted from the analysis of the actions and behaviors of students, were set to form an association with the interface elements of the LOs. This was done in order to establish the visual presentation of the content in a more planned and functional way, according to each LS. Considering that the interface layout is the art of manipulating the user's attention in order to convey meaning, sequence and interaction points [26], the following elements, based on [26], were created, organized and associated with the characteristics of the students' LSs:

- Control elements: commonly known as buttons, menus, navigation bars and icons, control elements are basic components in any user graphical interface. These are the elements that establish control over content and navigation. In this study, the Navigation Control Area, which establishes the navigation buttons, was defined, as well as the Tree of Content, which presents the content index in an order previously established. These two control items serve for students to navigate in the LOs' contents.
- Elements of composition: correspond to the organization of the components in order to generate meaning and order to the different visual factors of the interface, making them more harmonic. In this study, the Content Index, Content Area and Navigation Control Area, in which all the components constituting the LOs are arranged, were created. These components were manipulated in order to be organized according to the principles of CTML followed in this research.
- Elements of content: correspond to resources formed by texts and images, which are the items that compose the content of LOs. These elements are divided into 20 types of resources that, depending on the LS, can be used in relation to the composition of the LOs' contents, respecting the principles of CTML. According to [15], through the multimedia principle, "people learn more deeply from words and images than words alone", i.e., the contents will be composed of resources in the format of image and text.

B. Structure and Composition of the LOs' Content

In the definition of the adaptation structure of the LOs' content presentation, they are considered as being formed by elements of content composition, comprising the following steps:

- Summary (Sum): provides a general and clear overview of the content being addressed;
- Introduction (Int): comprised of a brief content for the presentation of the subject of a given field that is going to be studied;
- Development (Dev): comprised of a more comprehensive content, which contemplates the subject of a given field more completely;
- Activity (Act): consists of content for subject assimilation;
- Assessment (Ass): evaluation of the studied content of a given field.

The elements of content composition were organized regarding the parameters and attributes defined in the structuring of the LOs content presentation [27] and are based on the students LSs. They are outlined below:

- Exploration form (EF): defines how content may be structured regarding the students' EF. It may be in the form of a network (Net), consisting of a more random investigation that does not follow a script, or in a linear (Lin) manner, which consists of a more directed investigation, with a script to be followed.
- Composition order (CO): defines the organization of the steps used in the composition of the LOs contents, i.e., the order in which these stages are presented to the students. There are three COs defined, with the position of the step Summary being the only change between them: it may be at the beginning of the content composition, before the Activity step, or before the Assessment step.
  - order 1 - 1st Introduction, 2nd Development, 3rd Summary, 4th Activity, 5th Assessment;
  - order 2 - 1st Introduction, 2nd Development, 3rd Activity, 4th Summary, 5th Assessment;
  - order 3 - 1st Summary, 2nd Introduction, 3rd Development, 4th Activity, 5th Assessment.

[1] Multimedia learning is based on the hypothesis that "educational or instructional multimedia messages", which are conceived or generated from the way the human mind works, are more likely to achieve a more meaningful learning than others that are not.

- Detailing order (DO): establishes how the LOs contents can be presented in a level of particularities, which may be in two ways: a) specific-to-general (Spe-to-Gen), in which it begins in the specific part and proceeds to the general part, reaching a comprehension of the whole, and b) general-to-specific (Gen-to-Spe), in which it begins in the general part and proceeds to the specific part, also reaching a comprehension of the whole.
- Resource (R): defines what types of resources can be used in the elements of content composition for the LOs presentation. The resources used in the adaptation can be: Video (vid), Diagram (dia), Graph (gra), Picture (Pic), Narration (nar), Lecture (lec), Slide (sli), Self-assessment (sas), Table (Tab), Experiment (exp), Exercise (exe), Simulation (sim), Questionnaire (que), Scheme (sch), Animation (ani), Photo (pho), Web Page (wpa), Map (map), Demonstration (dem), Example (exa). A given content may be composed of more than one resource. The resources are classified regarding the presentation of the information as image and/or text. The resources were organized according to five CTML principles (multimedia, spatial contiguity, signaling, modality and temporal contiguity), which were applied in the adaptation of LOs to the eight styles of the Felder-Silverman model.

The overview of the parameters and attributes that were created based on the characteristics of LOs presentation regarding sequencing, presentation, and content and resources form can be visualized in Fig. 1. These elements were defined for the adaptation of the LOs presentation, which was based on the characteristics of the LSs.

The simplified form of the LOs interface composition can be represented in the following formulation: StyleInterface (S) = (CO(x), DO(j), EF(k), R(r1, r2, ..., rn)), in which:

- S indicates the styles of the Felder-Silverman model, described in Subsection *A*;
- CO indicates the composition order in which the steps used in the content's composition are presented in the LOs;
- x may be 1, 2 or 3, which indicate, respectively, first, second and third composition orders;
- DO indicates the detailing order of each step of the LOs;
- j may be 1 = specific-to-general (spe-to-gen) or 2 = general-to-specific (gen-to-spe);
- EF indicates the exploration form that will be used in the LOs presentation;
- k may be 1 = network or 2 = linear;
- R indicates the resources that may be used in the composition of the LOs;
- ri are the resources that may be used in the LOs composition.

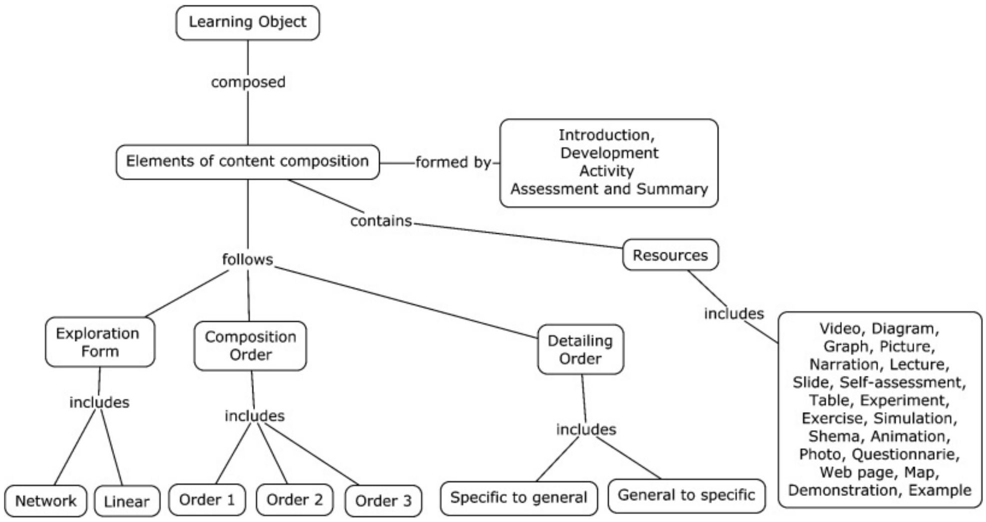

Fig. 1 Overview of LO structure [27]

Table I presents the attributes and parameters of the adaptation structure that were created, characterized with their respective values, in accordance with the adaptation rules for each style.

The parameters and attributes cited in the Table I were defined taking into account the elements that can be altered and/or adapted during the creation and composition of the LOs, in accordance with each LS. For example, students with an active style better retain and understand information while working actively, acting on something, discussing and applying concepts or explaining to others, and tend to be more experimental. Thus, the selected CO for them was order 2, for CO is an attribute that does not influence students' preference in the order in which the contents will be displayed in the LO. Therefore, the CO follows the order comprised of an introduction, followed by development, activity and summary, and ends up with an assessment. The resources for these students are not of much relevance as they are experimentalists, that is, they like to make/act, thus the LO needs to feature more the exercise resource, because these students like to practice. The defined EF for these students was network, since it is a more random way of exploring that does not follow any script. This makes it more suitable for students that like to apply/test, as they have more freedom to choose how to explore the LO content. In order to establish how the LO contents can be presented in a level of particularities, the selected CO for this style was Gen-to-Spe, for it allows the students to receive the general content of a certain subject without the need for too many details. That is because active students tend to reason more synthetically, which leaves them free to choose what they will or will not learn deeply.

TABLE I
ANALYSIS OF THE FELDER-SILVERMAN LSS MODEL (1988) REGARDING THE ATTRIBUTES AND PARAMETERS OF THE PROPOSED STRUCTURE [27]

Style	Exploration Form (EF)	Composition Order (CO)	Detailing Order (DO)	Resource (R)
Active	Network	2	General-to-Specific	Vid, Dia, Gra, Pic, Sas, Exe, Sim, Sch, Wpa, Map, Exa
Reflective	Linear	1	Specific-to-General	Dia, Gra, Lec, Sli, Sas, Tab, Exe, Sim, Sch, Ani, Wpa, Dem, Exa
Visual	Network	3	General-to-Specific	Vid, Dia, Gra, Pic, Sli, Sas, Tab, Exp, Exe, Sim, Ani, Pho, Wpa, Map, Demo, Exa
Verbal	Linear	3	Specific-to-General	Dia, Nar, Lec, Sli, Sas, Tab, Exe, Que, Wpa, Dem, Exa
Global	Network	3	General-to-Specific	Dia, Gra, Pic, Sli, Sas, Exp, Exe, Sch, Wpa, Map, Exa
Sequential	Linear	2	Specific-to-General	Dia, Gra, Pic, Nar, Lec, Sli, Sas, Exe, Sim, Que, Sch, Ani, Wpa, Dem, Exa
Sensing	Network	3	Specific-to-General	Vid, Gra, Nar, Sli, Sas, Tab, Exp, Exe, Que, Wpa, Map, Dem, Exa
Intuitive	Linear	1	General-to-Specific	Gra, Pic, Nar, Lec, Sli, Sas, Exe, Sim, Que, Ani, Pho, Exa

C. Rules for Adapting the LOs Presentation

The attributes and parameters indicate how the LOs interface may change for students with different LSs. These changes occur in relation to:

- the sequence or order in which the elements of content composition of the LOs were organized in the part of the interface concerning the Content Index, respecting the three established COs, which change the order in which these elements will be placed in the organization of the LOs content;
- the types of resources that may be used in order to create the LOs, which are classified as text or image. Twenty types of resources were established, which were organized in the Content Area of the interface along with the textual part of the LOs. In the part of the interface concerning the Content Area, resources are organized respecting the five principles of CTML that were mentioned above;
- the manner in which the LOs content is being explored and the way in which the students may navigate through these contents, using the Navigation Control Area and/or the Content Index, which can happen either freely, randomly, not following any script, or in a controlled way, with a script to be followed, indicated by the EF attribute;
- the detailing level of the content's presentation and the manner in which they were approached, either by starting from the more specific part and proceeding to the more general part, or by starting in the more general part and proceeding to the more specific part.

Fig. 2 shows the wireframes of the display screens for the verbal and visual LOs, with the goal of demonstrating how these changes may occur in the adaptation of the interface. The adaptation rules were established in order to generate the interface changes regarding the styles, which were based on the aforementioned characteristics of LOs presentation.

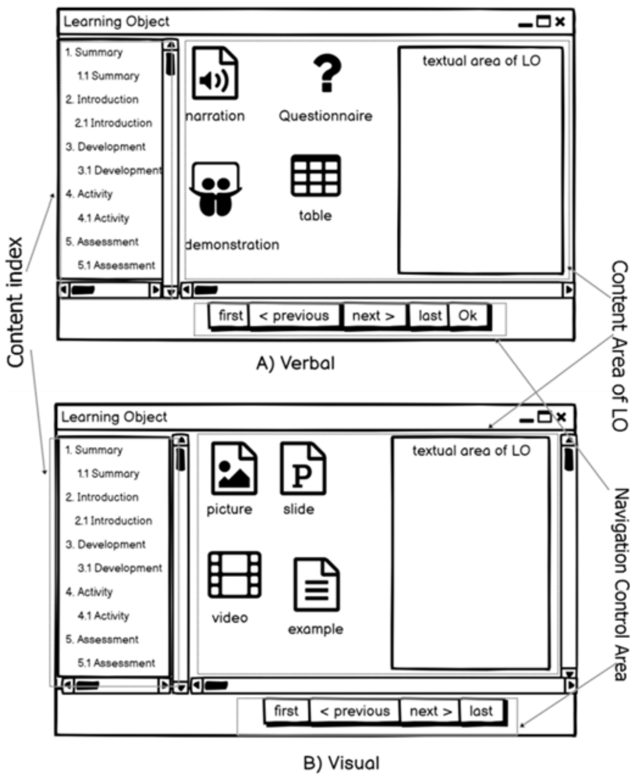

Fig. 2 Interface Wireframes of verbal and visual LO

The actions in each rule consist in completing the information for each parameter of the selected style. First, the allocation of the CO is made, then the allocation of the Rs, then the allocation of the EF, and finally, that of the DO. These actions follow the proposed model for filling in this information, in accordance with the adaptation rules adequate to each style. In the following example, we have the rule for the active style:

Rule Name = "Activestyle"
Conditions:

Style = "Active"
Actions:
a) Create a CO in the following order: "Introduction", "Development", "Activity", "Summary" and "Assessment";
b) Provide the following Rs: "Video", "Diagram", "Picture", "Graph", "Self-assessment", "Exercise", "Simulation", “Scheme”, “Web Page”, “Map” and “Example";
c) Indicate the EF "Network";
d) Indicate the DO "General to Specific".

Therefore, for each style of the Felder-Silverman model [1], the interface has undergone changes in order to adapt to the attributes and parameters. Such attributes and parameters were mapped based on the characteristics of each style, following the adaptation rules created in order to provide adapted LOs suited for students LSs.

D.Adaptation Structure of the LOs Interface

The elements that compose the interface are arranged according to the adaptation rules that were created to modify the elements considering the characteristics of each style. In the creation of this structure, the modeling aspects described below were taken into consideration.

As shown in Fig. 3, the Content Index consists of displaying the steps of the elements of content composition, and of their respective sub-steps, in a hierarchical tree structure, forming nodes for the stages and sub-steps. The Content Index is in accordance with the CO of the respective style.

Content Index items are made available according to the EF of the selected style. Thus, if the EF is linear (EF = linear), the subsequent item to the current sub-step will be made available only if the current step is completed, after clicking the OK button that appears on the screen. After the button is clicked on, it informs the system to make the next step/sub-step available, that is, it provides a more directed exploration of the LO.

In case the EF is network (EF = network), all items that include the step and/or sub-step, as well as the elements of the Navigation Control Area, are enabled, which allows a more random exploration of the LO.

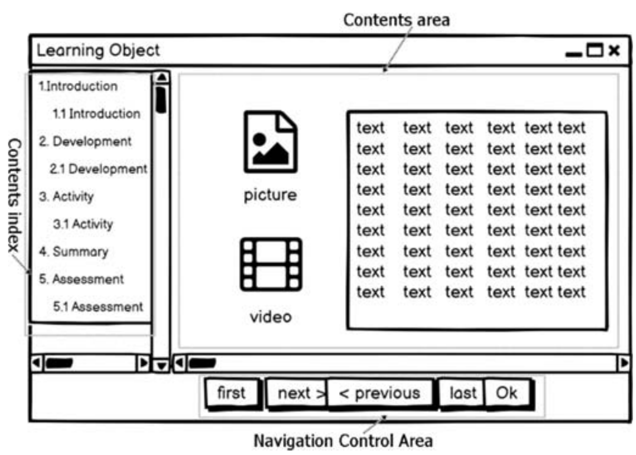

Fig. 3 Interface prototype screen for the verbal style

In the Navigation Control Area, it is worth noting that, for the verbal LO, there is an OK button for students to click on which allows them to proceed to the next item. As stated earlier, the EF for the verbal style is linear: as students’ access the contents, the other buttons are made available, which allows them to navigate through the LO contents.

In the Content Area, resources (video and picture), as well as texts, are organized according to the step/sub-step being accessed at the moment. In the Content Area, resources established for the verbal style were manipulated, which may or may not be modified for each step/sub-step of the LO. The interface changes for each of the styles of the Felder-Silverman model, in accordance with the attributes and parameters defined in the ACPLOLS model.

III. RESULTS

The evaluation of the ACPLOLS was conducted based on the students' point of view regarding the affective quality of the LOs interfaces during their interaction with the objects. The results obtained from the subjective measurement of the students' emotional responses to the LOs interfaces indicated if the ACPLOLS achieved the desired results regarding the adequacy of the objects’ interfaces, in accordance with the styles of the Felder and Silverman Learning Styles Model (FSLSM) [1].

According to [28], systems that evoke positive feelings of affection are more regularly used, easier to master and produce more harmonious results. In order to evaluate aspects related to the students’ emotional response, as well as their affective quality regarding the presentation adaptation of the LOs interfaces, the application of the Self-Assessment Manikin (SAM) questionnaire [29], [30] was employed as the empirical method of choice.

A. Description of the Evaluation Process

Initially, during the first stage, a test by means of online forms was conducted with the students that were selected to take part in the evaluation process, in order to identify their respective LSs. The aforementioned test used the Index of Learning Styles - ILS [31] of the FSLSM as the instrument for categorizing the LSs. The results of the tests (LS calculation) were processed through the system in order to generate a report with the characterization of the LSs and their respective preference levels (strong, moderate or light) for each of the four dimensions of the FSLSM.

Based on report of tests (LS calculation), during the second stage, the students were invited to participate in the evaluation of the LOs adapted to their LSs, in accordance with the ACPLOLS model. An online form was prepared for them, which contained evaluation instructions and explanations of how gain access to the LOs.

B. Participants

In the first stage, the sample for this experiment involved 184 students participating in Bachelor's degree courses in Information Systems, Electrical Engineering and Computer Engineering of the Electrical Engineering and Computer

Engineering of the Federal University of South and Southeast of Pará (UNIFESSPA – Universidade Federal Sul e Sudeste do Pará). All the students of these courses were invited to participate voluntarily in this research.

All 184 participating students were invited to fill out an online form to identify their LSs in accordance with the ILS of the FSLSM. As a result, a total of 127 students filled out the form in the first stage of the validation process. In the second stage, online forms were sent to these 127 students, inviting them to participate in the evaluation of the LOs adapted to their LSs, according to the ACPLOLS approach. Of all the 127 students, only one did not respond the form.

C. Result of the Application of the ILS Instrument

Table II presents the results obtained from the application of the online questionnaire (ILS), which was applied to identify the LSs of the students participating in the research, in relation to the styles identified in the FSLSM. It is possible to observe that there was no considerable predominance among dimensions' styles. However, if the absolute values were to be checked, the majority of the 126 students presented the visual style (20 students - 16%), followed by students presenting the sequential style (18 students - 14%). The processing dimension was the one that presented the least number of students (14 students - 11%) for each of its styles.

TABLE II
RESULTS OF THE ILS QUESTIONNAIRE FOR IDENTIFICATION OF THE STUDENTS' STYLES

Dimension	Style	Number of students	Percentage
Processing	Active	14	11%
	Reflective	14	11%
Perception	Sensing	15	12%
	Intuitive	15	12%
Retention	Visual	20	16%
	Verbal	15	12%
Organization	Sequential	18	14%
	Global	15	12%
Total		126	100%

During the planning of the ACPLOLS evaluation process, an average number of 10 students per style was established in order to proceed to the second stage. However, the results obtained in this first stage exceeded this estimate: for all styles of the Felder-Silverman model, a greater number of students was obtained, surpassing the initial expectations. The visual style was the one that presented the highest number among participating students.

D. Results of the Application of the SAM Instrument

The SAM questionnaire was applied to the students after they have visualized the LOs interfaces and have interacted with them. The three employed dimensions of the SAM were: Satisfaction (Sa), Motivation (Mo), and one's Feeling of control over the system (FC). Each one is represented in a scale with values ranging from 1 to 9, and the user had to choose the one that best reflected the intensity of their emotion. The three dimensions are equally important, so the same weights were considered for assessing the affective quality of the LO interfaces.

The results were obtained by adding the values of this assessment. Thus, it is possible to compare positive (circles 6 to 9 on the SAM scale), neutral (circle 5 on the SAM scale) and negative (circles 1 to 4 on the SAM scale) values for each dimension in relation to the evaluated LOs. These results provide a good indication of the students' reaction to the object under analysis, immediately highlighting their affective quality.

After the interaction of the students with the LOs adapted to their respective LSs, these students were asked to complete the SAM questionnaire and then evaluate the LOs with interfaces adapted to the styles opposite to theirs. After this interaction, the questionnaire was applied again. Therefore, active students, for example, evaluated the LO adapted to the active style and then the LO adapted to the reflective style. This procedure was performed for all styles of the Felder-Silverman model dimensions. Thus, a separate analysis of the results obtained in the evaluations with the SAM questionnaire was conducted for each of the two LOs analyzed by the students. Then, another analysis was performed comparing the results of the two evaluations.

The results obtained from the application of the SAM questionnaire regarding the LOs adapted to students' respective styles (as featured in the ACPLOLS) presented more positive (F+) than negative (F-) or neutral (Fn) feedbacks in the satisfaction, motivation and feeling of control dimensions of the SAM for all styles of the FSLSM, as shown in Table III. These results demonstrate that the majority of students were satisfied, motivated and in control of LOs adapted to their styles. Based on these results, it can be initially inferred that results regarding aspects of affective quality demonstrated that the LOs were adequate to the students' styles.

TABLE III
GENERAL RESULTS OF SAM FOR THE EIGHT STYLES OF FSLSM

Student	LO	Satisfaction			Motivation			Feeling of control		
		F+	Fn	F–	F+	Fn	F–	F+	Fn	F–
Active	Active	12	1	1	11	1	2	11	2	1
	Reflective	3	3	8	3	1	10	4	2	8
Reflective	Reflective	11	1	2	11	1	2	12	0	2
	Active	4	1	9	3	1	10	4	0	10
Sequential	Sequential	13	2	3	13	3	2	13	3	2
	Global	4	1	13	4	2	12	4	3	11
Global	Global	12	2	1	12	2	1	12	2	1
	Sequential	4	4	7	4	3	8	4	2	9
Visual	Visual	16	2	2	17	2	1	15	4	1
	Verbal	2	3	15	3	2	15	4	2	14
Verbal	Verbal	11	1	3	11	2	2	11	3	1
	Visual	3	3	9	3	2	10	2	6	7
Sensing	Sensing	12	2	1	10	3	2	10	1	4
	Intuitive	5	3	7	5	4	6	6	2	7
Intuitive	Intuitive	12	1	2	12	2	1	12	1	2
	Sensing	6	3	6	5	4	6	6	2	7

In a further analysis of the data in Table III, for active, reflective, sequential, global, verbal and visual students, the evaluation of the LOs adapted to the LSs opposed to theirs presented, in general, higher values of F- than of F+ or Fn for the three dimensions of the SAM. These results presented indications to support the affirmation that the reaction of these students to the LOs adapted to their opposing LSs was more negative, what shows that they did not feel motivated, satisfied or in control in relation to these LOs. Only for sensing and intuitive students F- did not surpass the F+ and Fn feedbacks. Therefore, in these two groups of students, this result may give indications that they were also pleased with the adaptations performed in the LOs that are adequate to the LSs opposed to theirs. This result may also indicate that the adaptations created for the LOs adapted to the correct style of the students and the LOs adapted to the style opposed to theirs did not modify these LOs sufficiently to evoke more negative reactions to the changes that did not please the students.

As mentioned earlier, students were expected to more positively evaluate LOs adapted to their styles and more negatively evaluate LOs adapted to their opposing styles. If this was to be confirmed, it would be possible to infer that the adaptation performed in the styles of each dimension of the FSLSM was able to reflect more accurately the characteristics of each style, by means of the ACPLOLS. Thus, a statistical analysis of the F- and F+ results given by students of a particular style, regarding the LO adapted to their opposite style, was conducted. This analysis was conducted for all LOs adapted to the eight styles of the four dimensions of the FSLSM. As to perform the statistical analysis, two hypotheses were initially defined:

- null (H0): the F+ and F- results of both the LO adapted to the style of the student and the LO adapted to his/her opposite style did not present significant differences.
- alternative (H1): the F+ and F- results of both the LO adapted to the style of the student and the LO adapted to his/her opposite style did present significant differences.

To evaluate whether the frequency differences of the F+ and F- feedbacks were significant, Fisher's exact test was used, with a confidence interval of 95% (α = 0.05). The significance level adopted throughout the statistical process was 5%. Values of p <= 0.05 were considered statistically significant.

Table IV presents the results of p-value regarding the frequency of F+ and F- feedbacks, both to the LOs adapted to the style of the student and to the LOs adapted to his/her opposite style.

By analyzing the results of the p-value, it was observed that, for active students, p-value was lower than 0.05 (p = 0.001683; p = 0.002416; p = 0.004711) in the three dimensions of SAM. A p-value lower than 0.05 (p < 0.05) in the three dimensions of SAM also occurred for students with reflective (p = 0.007710, p = 0.002416, p = 0.003165), (p = 0.001257, p = 0.000005, p = 0.000005), global (p = 0.006057, p = 0.003258, p = 0.001804), visual (p = 0.000005; p = 0.000002, p = 0.000027) and verbal (p = 0.008931, p = 0.002416, p = 0.002167) styles.

For sensing students, the p-value was lower than 0.05 only in the Sa dimension (p = 0.009977), and for the dimensions Mo (p = 0.070602) and FC (p = 0.172983), the p-value obtained was greater than 0.05 (p > 0.05). For intuitive students, the p-value was greater than 0.05 (p > 0.05) only in the Sa dimension (p = 0.061236), and for the dimensions Mo (p = 0.018307) and FC (p = 0.037315), the p-value obtained was lower than 0.05 (p < 0.05).

TABLE IV
FISHER'S EXACT TEST RESULTS

Student	LO	Satisfaction		Motivation		Feeling of control	
		F+	F–	F+	F–	F+	F–
Active	Active	12	1	11	2	11	1
	Reflective	3	8	3	10	4	8
	p-value	0.001683		0.002416		0.004711	
Reflective	Active	4	9	3	10	4	10
	Reflective	11	2	11	2	12	2
	p-value	0.007710		0.002416		0.003165	
Sequential	Sequential	13	3	13	2	13	2
	Global	4	13	4	12	4	11
	p-value	0.001214		0.000753		0.001255	
Global	Sequential	4	7	4	8	4	9
	Global	12	1	12	1	12	1
	p-value	0.006057		0.003258		0.001804	
Visual	Visual	16	2	17	1	15	1
	Verbal	2	15	3	15	4	14
	p-value	0.000005		0.000002		0.000027	
Verbal	Visual	3	9	3	10	2	7
	Verbal	11	3	11	2	11	1
	p-value	0.008931		0.002416		0.002167	
Sensing	Sensing	12	1	10	2	10	4
	Intuitive	5	7	5	6	6	7
	p-value	0.009977		0.070602		0.172983	
Intuitive	Sensing	6	6	5	6	6	7
	Intuitive	12	2	12	1	12	2
	p-value	0.061236		0.018307		0.037315	

In the descriptive analysis of the results obtained with Fisher's test, it is possible to conclude that the hypothesis H0 was a) rejected for active, reflective, sequential, global, visual and verbal students, in the three dimensions of SAM; b) rejected for sensing students in dimension Sa and c) rejected for intuitive students in dimensions Mo and FC. Such interpretation is based on the p-value, which in these cases were lower than 0.05. Therefore, for these cases, H1 is accepted, which indicates that the adaptation created for the LOs based on LSs had significant changes. This is evidenced by more positive reactions to the LOs adapted to the students' styles and more negative reactions regarding the LOs adapted to their opposing styles.

The results of the Fisher's test in which H0 was accepted (and, thus, H1 was rejected) were concerning the sensing students in the dimensions Mo (p = 0.070602) and FC (p = 0.172983), and the intuitive students only in the Sa (p = 0.061236), since the p-values obtained were greater than 0.05 (p > 0.05). In this case, when accepting H0, there are indications that adaptation created for the LOs based on sensing and intuitive styles failed to have significant changes that could be perceived by the sensing and intuitive students.

IV. Discussion

The results obtained through the application of the SAM questionnaire regarding LOs adapted to students' styles, according to the ACPLOLS, presented more F+ than F- or Fn, in the three dimensions of the SAM. The general F+ results were:

- Active LO: Sa = 86%, Mo = 79%, FC = 79%;
- Reflective LO: Sa = 79%, Mo = 79%, FC = 86%;
- Visual LO: Sa = 80%, 85%, Mo = FC = 75%;
- Verbal LO: Sa = 73%, Mo = 73%, FC = 73%;
- Global LO: Sa = 80%, Mo = 80%, FC = 80%;
- Sequential LO: Sa = 72%, Mo = 72%, FC = 72%;
- Sensing LO: Sa = 80%, Mo = 67%, FC = 67%;
- Intuitive LO: Sa = 80%, Mo = 80%, FC = 80%.

These results were a good indication of the students' reactions when interacting with the LOs adapted to their styles. This is evidence that the compositional elements of content composition structured regarding the EF, CO, Rs and DO defined in the ACPLOLS were suitable for all styles of the FSLSM, when evaluated by students identified with these styles.

The results obtained through the application of the SAM questionnaire regarding LOs adapted to their opposing styles, according to the ACPLOLS, were the expected: more F- than F+ or Fn, in the three dimensions, for the active, reflective, verbal and global LOs. For the visual LO, F- did not surpass F+ and Fn only in the FC dimension. For the sequential LO, F- did not surpass the F+ and Fn only in the Sa dimension. For the intuitive and sensing LOs, F- were did not surpass F+ and Fn in any of the three dimensions. The general results of F-, in percentage terms, were:

- Active LO: Sa = 64%, Mo = 71%, FC = 71%;
- Reflective LO: Sa = 58%, Mo = 72%, FC = 58%;
- Visual LO: Sa = 60%, Mo = 67%, FC = 47%;
- Verbal LO: Sa = 75%, Mo = 75%, FC = 70%;
- Global LO: Sa = 72%, Mo = 67%, FC = 61%;
- Sequential LO: Sa = 46%, Mo = 53%, FC = 60%;
- Sensing LO: Sa = 40%, Mo = 40%, FC = 47%;
- Intuitive LO: Sa = 47%, Mo = 40%, FC = 47%.

These results initially demonstrated that the expected results were not achieved only to the sensing and intuitive styles for the three dimensions of SAM. This indicated that the ACPLOLS was unable to present significant differences in the LO interface of these two styles. Therefore, to assess whether the observed difference in frequency of F+ and F- was significant for all LOs evaluated, we applied the Fisher's exact test, with 95% confidence level ($\alpha = 0.05$). The significance level adopted throughout the statistical process was 5%, and p-value <= 0.05 were considered statistically significant: If $p > 0.05$, H0 is accepted and H1 is rejected, and vice versa.

The results obtained with the Fisher test (see Table IV) demonstrated that the H0 hypothesis was rejected for the active, reflective, sequential, global, visual and verbal students in the three dimensions of SAM, as well as for the sensing students in dimension Sa and the intuitive students in the dimensions Mo and FC since, in these cases, the p-value was lower than 0,05. In addition, H1 was accepted, which indicates that the LS-based adaptations to the LOs succeeded in printing significant changes, evidenced by the more positive reactions to LOs tailored to student styles and the more negative reactions to LOs adapted to their opposing styles.

The results of the Fisher test in which H0 was accepted were for the sensing students in the dimensions Mo ($p = 0.070602$) and FC ($p = 0.172983$), and for the intuitive students in the Sa dimension ($p = 0.061236$), as the p-values obtained were higher than 0.05 ($p > 0.05$). In this case, when accepting H0, we have indications that the adaptation created for the LOs based on the sensing and intuitive styles failed to have significant changes or sufficient changes in the interface of the LOs, which could be perceived by the students of these styles and were able to generate more negative reactions if they were not pleasing to them.

The results obtained in the evaluation of the affective quality of the LOs, through the SAM instrument and Fisher's exact test, demonstrated that the adaptation performed in the LOs in accordance with the LSs was well accepted by students with styles on the dimensions: processing, organization and retention of information of the FSLSM. The adaptation was only not well accepted regarding perception, as explained previously. However, when considering the results of SAM to the LOs that were evaluated by the students for the adaptation of the LOs according to their styles, the results were positive for all LOs, indicating that the students reacted positively to the ACPLOLS.

The overall mean results of the subjective measures of the students' emotional responses indicated that ACPLOLS achieved the desired results regarding the adequacy of the LOs interfaces according to the styles of the FSLSM.

V. Conclusion

This research defined an adaptation of LOs content presentation that considered characteristics of the LSs (ACPLOLS) associated to aspects of interface and interaction. This adaptation sought to follow the principles of CTML, suitable to the students' LSs, and tried to meet the specific characteristics required of each LS.

In order to verify aspects related to the emotional response and the affective quality of the students regarding the adaptation of the presentation of the LOs interface, the three dimensions of the SAM questionnaire were evaluated, in order to verify the reactions of the students when interacting with the LOs adapted to their styles and LOs adapted to their opposing styles.

The results obtained through the application of the SAM questionnaire regarding LOs adapted to their styles, according to the ACPLOLS provided a good indication of the students' reactions when interacting with the LOs adapted to their styles. This demonstrates that the elements of content composition structured regarding the EF, CO, Rs and DO, defined in the ACPLOLS, were suitable for all styles of FSLSM, when evaluated by students identified with these styles. Therefore, it is expected that the ACPLOLS model may be more experienced, expanded and used in the educational field, in order to provide LOs better suited to students' individual learning preferences. We also expect that the results obtained with this research can have future contributions, in the sense of increasing the motivation and satisfaction of teachers and students in the use of LOs adapted to the LSs as educational resources.

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Zenaide Carvalho da Silva. PhD in Computer Science from the Federal University of Parana (2017). Master in Computer Science from the State University of Maringa (2004). Specialist in Software Engineering at the University of North Parana (1998). Graduated in Bachelor's degree in Informatics from the State University of Ponta Grossa (1994).

She is Adjunct Professor in the Bachelor's Degree in Information Systems at the Federal University of Southern and Southeastern of Para , working mainly in the areas of: Informatics in Education, conducting research on the development of tools and methodologies for the application of digital technology in Presence and distance educational spaces; And Software Engineering.

Leandro Rodrigues Ferreira. He holds a degree in Computer Science from the Federal University of Parana (2009). Master's Degree in Computer Science from the Federal University of Parana (2015). Has experience in the area of Information Systems, Database and Programming Languages.

Andrey Ricardo Pimentel. He holds a bachelor's degree in computer science from the Federal University of Parana (1994), a master's degree in computer science from the Federal University of Parana (1997) and a doctorate in electrical engineering and industrial informatics from the University Tecnologic Federal do Paraná (2007).

He is currently Associate Professor at the Federal University of Parana and a reviewer of the Brazilian Journal of Informatics in Education. Has experience in the area of Computer Science, with emphasis on Methodology and Computer Techniques. Working mainly in the following subjects:

Informatics in Education, Software Engineering, Object Orientation, Axiomatic Project Theory, Unified Process, Project Quality.