An Interface Adaptation Model for LMSs According to Learning Styles

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Abstract: An LMS adapted to students' learning styles has the potential to promote more meaningful learning experiences. This work develops an interface adaptation model for LMSs based on Honey and Mumford's learning styles. Relevant characteristics of these styles are mapped and serve as basis for an Adaptation Model used for LMS interface prototyping regarding activist, reflector, theorist and pragmatic students. Information organization, navigation and presentation are among the aspects considered. A teacher module is also developed to help instructors create content adapted to different individuals.

1 INTRODUCTION

A Learning Management System (LMS) is a technological tool that serves as an intermediary in the teaching-learning process. However, a LMS has, in general, a standard interface, sometimes differentiated by profile (student, professor, administrative), although it is used by individuals who have different behaviors, attitudes, interests and motivations.

This creates the need to adapt LMS's to the particularities of students, in order to promote more meaningful learning experiences. Among the aspects for adapting an LMS, the theory of Learning Styles is of special interest in this work, specifying the preferences of individuals when learning new content. Knowledge of these styles makes it possible to understand and describe students' behavior in a learning situation, which favors the development of critical thinking (Coffield et al., 2004). The choice for learning styles is not unanimous, as pointed out by (Kirschner, 2017), however that is the approach used in this work.

In the literature, there are several studies that approach the adaptation of learning using student's learning styles as a parameter. Their contributions refer to adaptation at the level of resources, strategies, order of component presentation and system navigation. However, there is a lack of research including adaptation of color, screen layout, formatting, organization and arrangement of elements on the user interface. Also no research was identified that helps the teacher in content customization for different learning styles, as well as projects developed from the perspective of user experience (UX).

In this context, this research brings contributions in the area of adaptive learning by addressing two main actors of an LMS: the student and the teacher. Thus, we intend to motivate the student in their learning activities, customizing the LMS interface to their learning style in order to improve their performance. As for the teacher, we want to provide an environment that assists them in the production and customization of content to different learning styles, but that does not generate an additional workload in their already overloaded teaching routine.

This study aims to develop an interface adaptation model for LMS's using Honey and Mumford's theory of learning styles (Honey and Mumford, 1992) as a reference. To do so, we use as a starting point the mapping of the most relevant characteristics of the different learning styles, in order to determine how the interface elements will be adapted to the different student profiles.

From the interface adaptation model, prototypes

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of low-fidelity screens are produced for activist, reflector, theoretical and pragmatic students. Adaptations include techniques for adapting information, navigation and presentation. In addition, an interface prototype is implemented for the teacher, since he/she is responsible for creating and organizing the content available in the LMS.

This study complements the methodology we discussed in (Oliveira et al., 2020) where learning styles are used as a guideline to automatically recommend educational content to students of similar profiles by leveraging their learning style similarities.

Section 2 discusses the theory of Learning Styles under the perspective of Kolb, and Honey and Mumford's profile categorization. Section 3 discusses some aspects and strategies for LMS adaptation while Section 4 introduces the adaptation model used in this work. In Section 5, a comprehensive LMS interface prototyping is carried out considering different aspects within an LMS and their mapping to specific learning styles. Section 6 discusses teachers' role in this adaptive scenario and Section 7 sums up with conclusions and future work.

2 LEARNING STYLES

Personal behavior, reasoning process, forms of expression and strategies for carrying out tasks are some of the aspects in which human beings differ from one another. In this perspective, several scholars advocate that the learning process is not the same for everyone, so it is necessary to adapt it to people's particularities, such as their level of knowledge, motivation, cognitive style and learning style.

In a review carried out by (Coffield et al., 2004), 71 learning models were identified, divided into five categories. This work takes Honey and Mumford's theory as a reference, which extends Kolb's initial proposal.

2.1 Kolb and the Experiential Theory

For David Kolb, learning is a cycle of four stages: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE) (Kolb, 1976). This has been called an experiential learning model, a proposal emphasizing the relevance of experience and different skills during the process. It is observed that individuals show resourcefulness in certain stages, while they have significant inaptitude in others.

Thus, Kolb proposes a *Learning Styles Inventory* (LSI) for the purpose of measuring the weaknesses

and strengths in this cycle and to identify learning styles (Kolb, 1976). In general terms, the above stages are organized as a Cartesian plan and four quadrants are determined referring to the styles identified by the LSI: divergent, assimilating, convergent and accommodating.

2.2 Honey and Mumford's Learning Styles

Kolb's learning cycle, associated with experiences in the management area, motivated Peter Honey and Alan Mumford to develop their own cycle and then the *Learning Styles Questionnaire* (LSQ) (Honey and Mumford, 1992) was born. In general terms, Honey and Mumford defined four learning styles, each one being directly related to two stages of Kolb's cycle. As Figure 1 shows, the four learning styles identified are activist, reflective, theoretical and pragmatic (Rosewell, 2005).
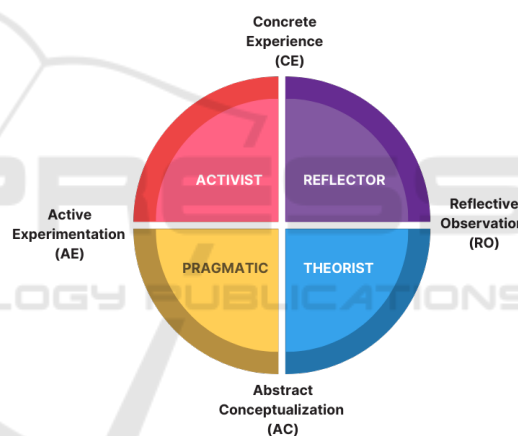
Figure 1: Honey and Mumford's Learning Styles.

3 LMS ADAPTATION ASPECTS

According to (Pereira et al., 2007), Learning Management Systems emerged as a technological tool to meet educational demands, both from schools and universities, and from the industry, positioning themselves as an intermediary between the educator and the student. Traditionally related to distance learning, LMSs have also been used as a support for face-to-face teaching, given the variety of resources available.

LMS resources can be classified into four main axes: information and documentation; communication; pedagogical and administrative management; and production (Pereira et al., 2007). In the 2020's, with the prominence of remote teaching due to the COVID-19 pandemic, virtual spaces sometimes be-

came the only alternative for maintaining academic activities, thus LMSs have established themselves as significant instruments for education as a whole.

LMS customization can help improve learning experience (Cossul et al., 2020; Thyagharajan and Nayak, 2007) and is based on criteria related to users' profiles. Among them, learning styles stand out, as they reveal relevant characteristics of individuals (Schmeck, 1998) and can be used to customize teaching strategies.

3.1 Adaptation Methodology

The methodology used to provide the adaptation model based on learning styles can be divided into three stages as shown in Figure 2:
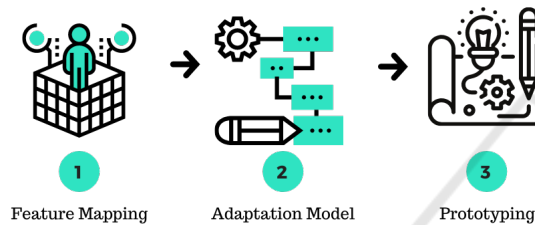

Figure 2: Proposed methodology.

The first step maps the most relevant characteristics of Honey and Mumford's learning styles. In the second step, we seek to determine how interface elements will be adapted. Finally, interface prototypes are developed according to the adaptation model.

Moreover, to carry out the adaptation of a system, such as an LMS, three components are needed: the user model, the domain model and the adaptation model (da Silva, 2017). The User (or Student) Model in learning systems represents the significant characteristics of the student, including learning styles. The Domain Model "specifies the conceptual design of an adaptive hypermedia application" (Aroyo et al., 2006), since it structures the material to be made available to the student. The Adaptation Model defines the adaptation semantics, i.e, it relates the data from the student model to the domain model in order to provide the desired adaptation.

In the case of the Adaptation Model, (da Silva, 2017) highlights the following items: Exploration Form (EF), Detailing Order (DO), Composition Order (CO) and Resources. EF refers to content structuring, which can be linear or networked. DO determines whether content should be presented from general to specific or vice versa. CO, in turn, establishes the order in which the elements of content are revealed to the student. Finally, resources refer to content to be made available to students.

4 ADAPTATION MODEL

In this research, the first step consists in mapping the most relevant characteristics of Honey and Mumford's learning styles, which will determine how the interface elements will be adapted. Eventually, prototypes of LMS interfaces customized for each learning style are developed.

By applying the characteristics of the student model as input parameter to the domain model, the Adaptation Model is obtained, which in this work includes activist, reflective, theoretical and pragmatic learning styles (Figure 3).
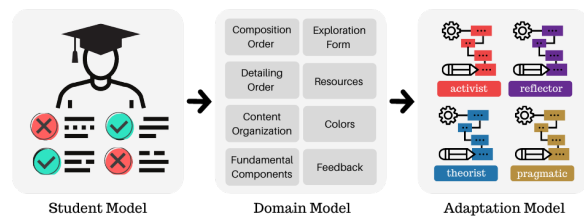

Figure 3: Student, Domain and Adaptation models.

In order to adapt the LMS interface, aspects such as Exploration form, Detailing order, Composition order, Resource types, Color palette, Feedback, Content organization, and Fundamental components are considered. Table 1 summarizes these characteristics organized by learning style as a contribution of this work.

In general, an activist student is characterized by a preference for embarking on new experiences and learning opportunities with an open mind, given their priority for participation, while, at the same time, their learning is compromised in situations that involve well-defined instructions and guidelines. Therefore, the network exploration form is established for this learning style.

Detailing order, in this case, is set from specific to general and composition order should be activity-based (Magoulas et al., 2003). These choices for DO and CO are defined because of students' preferences for the active experimentation and concrete experience stages of the experiential cycle, which indicate their understanding of the whole is enhanced by experiences and activities in specific situations.

In the case of a reflector, the experimentation form should be linear, since this student does not benefit from carrying out activities without proper preparation, therefore their exploration of the content should occur in stages. Detailing order is defined as general to specific, since they need a general overview to investigate and establish their own conclusions. Composition order is based on example (Magoulas et al.,

Table 1: Interface adaptation model.

	Activist	Reflector	Theorist	Pragmatic
Exploration Form	Network	Linear	Network	Linear
Detailing Order	Specific to General	General to Specific	General to Specific	Specific to General
Composition Order	Activity-based	Example-based	Theory-based	Exercise-based
Resources	Competition, Challenges, Films, Forum, Infographics, Games, and Mind Maps	Handouts, Digital Books, Papers, Documentaries, Films, Exercise lists, Podcasts, Riddles, Video lessons, and Webcasts	Handouts, Digital Books, Papers, Documentaries, Video lessons, Demo videos, and Webcasts	Documentaries, Films, Infographics, Games, Exercise lists, and Tutorials
Colors	Yellow, orange, red	Pink, brown, purple, green	Blue, gray	Crimson, yellow, green
Feedback	Individual vs Class	Self-analysis vs Grade	Timeline	Pie chart
Content Organization	Image and content title	Image, title and problem	Image, title and learning objectives	Image, title and applications
Fundamental Components	Forums and Last updates	Notices and Tasks	Last updates and Forums	Tasks and Forums

2003) due to the fact that their learning is better when allowed to observe the phenomena under study.

For the theorist, the form of exploration should be in a network, since they need to inquire, question and investigate. As their learning depends on their understanding of theories, detailing order is from general to specific and composition order is theory-based (Magoulas et al., 2003). For these students, the learning process is based on theories, models, concepts and facts. Recommended Resources are class notes, digital books, article, documentaries, videos, and webcasts.

Pragmatists have a linear exploration form, as they are more motivated when confronted with clear guidelines and procedures, thus learning in stages is more appropriate for them. They are more interested in practical benefits, so the detailing order should be from specific to general. Finally, exercise-based composition order is recommended (Magoulas et al., 2003), as they prefer learning the content by solving practical tasks. Since they need to visualize the application of the studied content, documentaries, movies, games, lists of exercises, tutorials, and infographics are recommended as educational resources.

5 INTERFACE PROTOTYPING

Based on the Adaptation Model, we prototyped three distinct screen layouts typically found in Learning Management Systems: student's view, course view, and content view.

A common template is used for all screens with five distinct elements: i) a header, ii) a navigation bar, iii) a footer, iv) a left sidebar, and v) the main content area. In (i), we find information identifying system and user profile. Item (ii) indicates where the user is located in the environment while the footer (iii) provides additional information. Items (iv) and (v) have a flexible layout adaptable to a specific learning style as directed by the Adaptation Model.

Since colors are important elements in a graphic representation, we chose to build palettes with five colors for each style, two of which are fixed and three are defined according to Table 1 and can be used as primary, secondary or tertiary colors. Thus, areas (ii) and (iii) as well as the details of areas (iv) and (v) are adapted accordingly.

Figure 4: Learning styles color palettes.

5.1 *My Courses* Screen Adaptation

My Courses module represents all courses a given student is enrolled in. The main area is divided into four

parts: a menu at the left side (1), a larger center top area (2), and two smaller areas at the center bottom (3 and 4) as shown in Figure 5.

The left sidebar (1) shows the same items for each of the learning styles. These items have the same symbols associated with their descriptions in order to ensure consistency and system patterns, thus enhancing users' action recognition and system usability (Nielsen and Molich, 1990).

The larger area (2) lists a student's in-progress courses while the two other areas are adaptable, reserved for components targeted to specific learning styles. For an activist profile, Forums and Latest Updates are prominent (Figure 5-a) while, for a reflector, Notices and Tasks are highlighted (Figure 5-d). For a theorist, Latest Updates and Forums are visible (Figure 5-c) while, for pragmatists, Tasks and Forums call their attention (Figure 5-b).

Besides interaction objects, the color palette is distinct for each learning style as shown above (Figure 4). This form of adaptation is compliant with the *page variants* technique since acreen layout and other visible components are presented in different ways for distinct users (Batista, 2008).

5.2 *Course* Screen Adaptation

In the *Courses* module screen (Figure 6), the left sidebar is divided into two regions: course menu items are displayed at the top two-thirds, and the student's performance is highlighted at the bottom one-third. Performance information is presented differently according to the learning style. The content of the main area varies in accordance with the Adaptation Model.

An activist obtains feedback on their performance through a bar graph that shows their individual statistics compared to the class average. Content, in turn, is presented with an image and title without any access restrictions (Figure 6-a).

For a reflector, performance feedback compares student self-analysis to the system's analysis over time. Content topics start with a question or problem for reflection purposes. Since learning style exploration pattern is linear, new topics are unlocked only upon completion of previous ones (Figure 6-d).

For a theorist, feedback is presented in a line chart so that they can visualize their performance over time. Ideally, this graph should be interactive in order to allow the student to explore specific mistakes or successes. Contents listed present an image, title and educational objective. As their form of exploration is networked, content can be acessed in any order (Figure 6-c).

A pragmatist has performance data presented as pie charts for a better understanding. Their form of exploration is linear, therefore certain navigation restrictions between content topics are imposed. Content list shows a title with an image and it highlights practical applications and benefits of the content (Figure 6-b).

5.3 *Content* Screen Adaptation

Last but not least, the *Content* module has been adapted considering Resources, Exploration Form, Detailing Order and Composition Order, as commented in Section 3.1. The Content screen shown in Figure 7 exhibits two areas on the left sidebar: the content navigation area (top) and additional resources (bottom). The main area on the right side is reserved for course content.

Content navigation area presents contents so that the student can understand the structure of the course. This area has been adapted according to the exploration form (EF). If EF is networked, the whole content will be readily available to the user for navigation purposes. If EF is linear, content will be released gradually according to student progress. In this case, Link Annotation navigation technique has been used. The content under study is highlighted in larger bold letters while other content not currently relevant appears in a lighter font.

Additional resources refer to materials that are complementary to student learning. They are indicated based on the types of resources recommended to their learning style and also based on the detailing order of these resources. For instance, an activist student could find a Mind Map, whose detailing is from specific to general. To a theorist, on the other hand, the LMS might recommend a paper discussing a certain content from a general to a more specific perspective,

The main area, or content area, presents content divided into Activity, Example, Exercise and Theory distributed in four tabs. Tag order is determined by the learning style composition order. For instance, a reflective student will see the sequence Example, Theory, Exercise and Activity (Figure 7-d). A theorist student, on the other hand, will find Theory, Example, Exercise and Activity, in conformance with their learning style (Figure 7-c). The exploration form dictates whether all tabs will be open for navigation (the case of activists and theorists) or will be gradually made available for reflectors and pragmatists (observe the padlocks on the tabs).
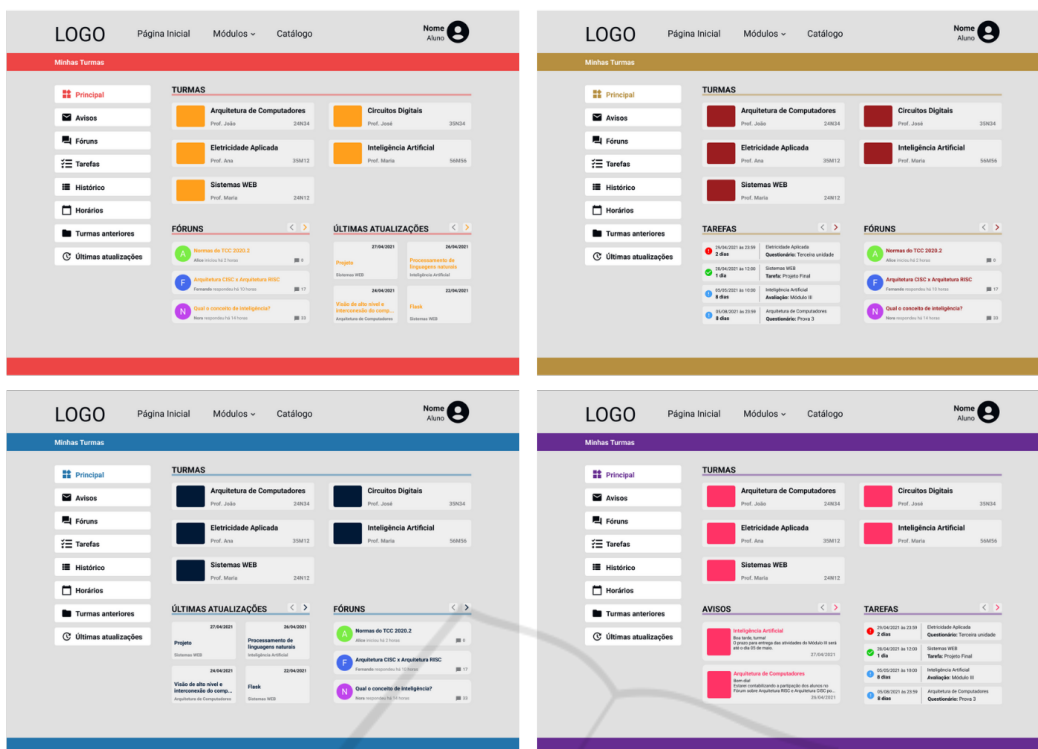
Figure 5: *My Courses* screen adapted to distinct learning styles.

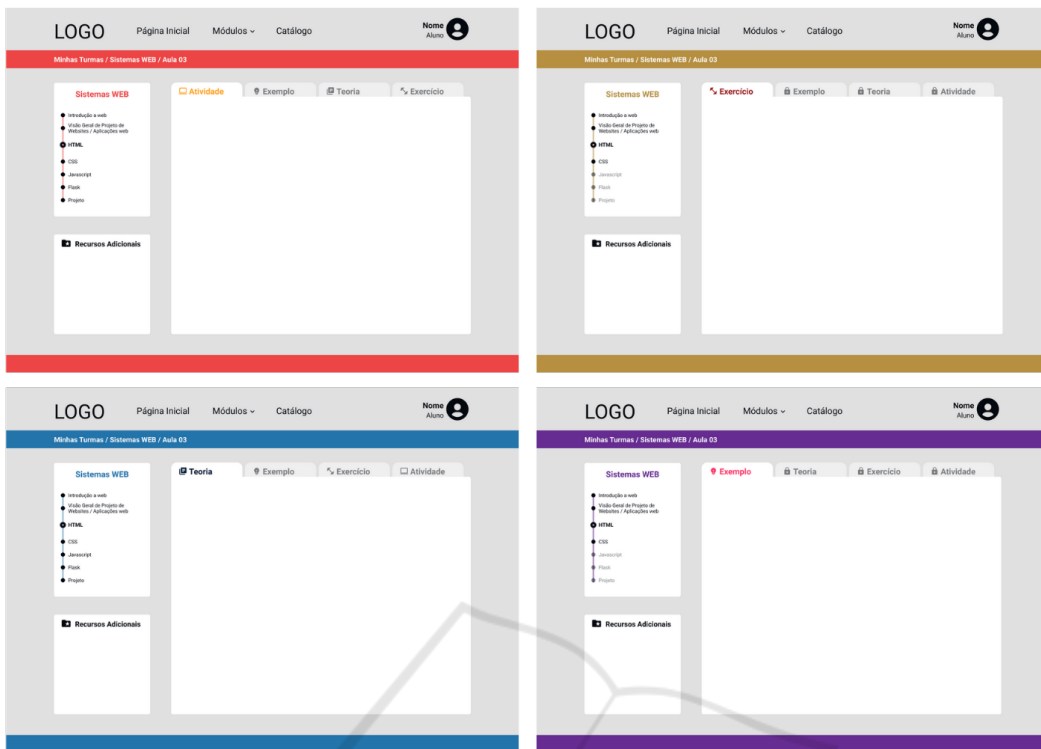Figure 6: *Course* screen adapted to distinct learning styles.

Figure 7: *Content* screen adapted to distinct learning styles.

6 TEACHER ROLE IN AN ADAPTABLE LMS

A Learning Management System can be characterized as an intermediary between the student and the teacher, since it mediates the teaching-learning process (Pereira et al., 2007).

The teaching practice in an LMS requires the teacher to be the author of the contents made available to the students. In the interface adaptation model proposed in this work, content is presented according to the specific Composition Order for the student's learning style, as well as complementary materials are recommended. The recommendation of these materials follows the criteria of the types of Resources indicated associated with the Detailing Order.

As seen above, different learning styles dictate different content selection, presentation, organization, exploration and so forth. Management of these different elements, specified in the adaptation model, should be carried out by the system, not by the teacher, whose role is to organize and provide content. The LMS will determine the target student and how this content will be shown and consumed.

In the adaptable LMS architecture proposed, the teacher should organize a *Lesson Plan* to serve as a road map for a given course. This plan is divided into three areas: general information, content, and teaching resources.

Teacher's *Course Management* screen (Figure 8) presents the content listing of a specific course assigned to an instructor. On the left sidebar, there is a menu similar to that of students with the insertion of a Class Profile item in order to present class preferences in terms of learning styles. This serves as a guideline for teachers when organizing course material.
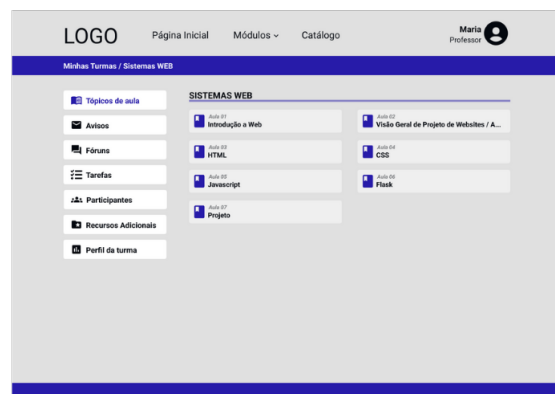

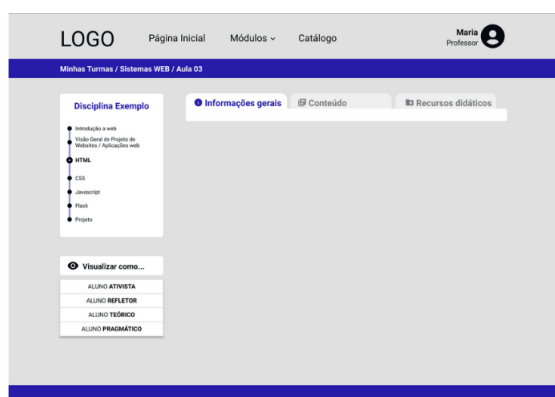Figure 8: *Course Management*: content selection.

Figure 9: *Course Management*: planning.

Also, the Planning screen in Figure 9 contains a lesson plan with a main area divided into three tabs referring to different aspects of a class. In addition, the sidebar has a content navigation area the teacher may use to organize course material. Finally, the teacher can choose how to visualize content on the perspective of different learning styles.

7 CONCLUSION

In this work, the characteristics of learning styles were mapped in relation to favorable and unfavorable learning situations, as well as aspects related to prioritization, problem-solving perspective, interaction, and personal preferences in relation to content. These characteristics, moreover, serve as parameters for the development of an LMS Adaptation Model.

The referred model was used for LMS interface prototyping for activist, reflector, theorist and pragmatic students. The proposed adaptations included content selection, navigation and presentation. In addition, it was provided a teacher interface, in the form of a lesson plan, to facilitate the organization of course material for different student profiles.

This resarch brings contributions to the area of adaptive learning in relation to strategies and resources for learning management environments. As future work, it is intended to validate the proposed approach by organizing real courses in an adaptable LMS.

REFERENCES

Aroyo, L., Dolog, P., Houben, G.-J., Kravcik, M., Naeve, A., Nilsson, M., and Wild, F. (2006). Interoperability in personalized adaptive learning. *Educational Technology & Society*, 9:4–18.

Batista, C. R. (2008). *Modelo e diretrizes para o processo de design de interface web adaptativa*. Programa de Pós-Graduação em Engenharia e Gestão do Conhecimento, Universidade Federal de Santa Catarina (UFSC), Florianopólis.

Coffield, F., Moseley, D., Hall, E., and Ecclestone, K. (2004). *Learning styles and pedagogy in post-16 learning: A systematic and critical review*. Learning and Skills Research Centre, Londres.

Cossul, D., Fagundes, B. J., Ferreira, G., Frozza, R., Silveira, W. A. N., Clavijo, M. L. T., and Orozco, W. J. G. (2020). Ambiente virtual de aprendizagem: uma abordagem baseada em mediação tecnológica personalizada. *Brazilian Journal of Development*, 6(12):101874–101888.

da Silva, Z. C. (2017). *Adaptação de apresentação de conteúdos de objeto de aprendizagem considerando estilos de aprendizagem*. Universidade Federal do Paraná, Setor de Ciências Exatas, Programa de PósGraduação em Informática, Curitiba.

Honey, P. and Mumford, A. (1992). The learning styles questionnaire. *Industrial and Commercial Training*, 24(7):10–13.

Kirschner, P. A. (2017). Stop propagating the learning styles myth. *Computers & Education*, 106:166–171.

Kolb, D. A. (1976). Management and the learning process. *California management review*, 18(3):21–31.

Magoulas, G., Papanikolaou, Y., and Grigoriadou, M. (2003). Adaptive web-based learning: accommodating individual differences through system's adaptation. *British journal of educational technology*, 34(4):511–527.

Nielsen, J. and Molich, R. (1990). Improving a human-computer dialogue. *Communications of the ACM*, 33(3):338–348.

Oliveira, A., Teixeira, M. M., and Neto, C. d. S. S. (2020). Recommendation of educational content to improve student performance: An approach based on learning styles. In *CSEDU (2)*, pages 359–365.

Pereira, A. T. C., Schmitt, V., and Dias, R. A. C. (2007). Ambientes virtuais de aprendizagem. In *Ambientes Virtuais de Aprendizagem em Diferentes Contextos*, chapter 1, pages 4–22. Editora Ciência Moderna Ltda, Rio de Janeiro.

Rosewell, J. (2005). Learning styles. *Times Educ. Suppl*, (4659):11–14.

Schmeck, R. R. (1998). *Individual differences and learning strategies*, chapter 10, pages 171–191. Academic Press.

Thyagharajan, K. and Nayak, R. (2007). Adaptive content creation for personalized e-learning using web services. *Journal of Applied Sciences Research*, 3(9):828–836.