

Lively Learning Framework of ISO / OSI Model and Data Communications

David L. La Red Martínez

Department of Computer, Northeast National University,
(3400) Corrientes, Argentina
Email: laredmartinez {at} gigared.com

Federico Agostini

Department of Computer, Northeast National University,
(3400) Corrientes, Argentina

Abstract — Main objective of this work was to develop an interactive environment of teaching and learning the data communication taking as a base the ISO/OSI model (International Organization for Standardization / Open System Interconnection) and the HFC net (Hybrid Fiber Coaxial). A theoretical framework was elaborated with basic concepts about communication protocols by using the ISO / OSI model and the active and passive elements that take part in the transmission of a message in a HFC net. Animations were made to allow the student study those concepts in an interactive and dynamic way. An interactive section was developed for the self-evaluation of the student. It was considered each of the process that take part in the treatment of the message, as the encapsulation, the codification of the digital information and the modulation to an analogue sign, as well as each of the elements that apply a treatment to the message inside the HFC net until it reaches its destination.

Data communication, ISO / OSI model, animations to teach, data communication protocols, transmission of information

I. INTRODUCTION

The number of learning resources available on the web has increased dramatically. A difficult task for students is to locate the learning materials that are appropriate to their requirements and needs [1].

It is a fact that the utilization of animations in the process of teaching and learning is more frequent. It contributes the improvement of that process, especially, in those themes that require a certain level of abstraction [2].

The animation is acquiring more and more importance in relationship to the educative contents. This technique, which assures moving images, helps the users visualize process, ideas or abstract concepts easily [3].

In various Argentina universities, in courses of data communications taught by the authors, has been the difficulty of students to understand the main concepts and abstractions of the ISO / OSI reference model.

As indicated in the previous paragraphs has motivated the development of a friendly environment for the learning of the ISO / OSI reference model and the main concepts of data communications.

This work will show a methodology to develop didactic animations, using as an example the realization of an animation to explain data communication concepts such as the ISO / OSI model, the data communications protocols and the signs transported by HFC nets, describing the treatment that the message receives.

This work has been organized in the following manner: section II describes the theoretical framework used, s. III listed some related work, s. IV outlined the objectives, s. V describes the development methodology, s. VI are discussed briefly the results, ending with the conclusions and references.

II. THEORETICAL FRAMEWORK

Learning theory

Taken into account the learning theory for the design of the use of media [4], the following aspects have been considered:

- Motivation: generating interest through an appropriate treatment of the information that is presented to the student; it should be relevant and meaningful.
- Learning objectives: each activity or learning unit should briefly introduce the purpose or objective that seeks to fulfil.
- Organization of content: the learning will be facilitated if the contents and procedures are organized into sequences with full meaning.
- Preparation of learning: you must previously set the level of students for whom educational material is being designed. Aspects such as the syntax of phrases or vocabulary and the grammar employed should be considered.
- Emotions: learning that involves emotions and personal feelings so much as intelligence, influences and is durable. You should try to create a positive predisposition towards learning.
- Participation and practice: learning requires effort and activity. Students should be aware that without effort and interest rarely learning takes place.

- Feedback and reinforcement: must report regularly to the student's progress, since this increases and encourages learning.
- Application: must try to make the student aware of the subsequent application.
- Individual differences: you must include factors such as intellectual skill, personality and learning style.

Learning Styles

Learning styles are the cognitive, affective and physiological traits that serve as relatively stable indicators, how students perceive interactions and respond to their environments of learning [5, 6, 7, 8].

This work has considered the model of Felder-Silverman, sorting styles from five dimensions [6]:

- What information preferably perceive students?: students are classified into sensitive (concrete, practical, prefer the facts or procedures), and intuitive (conceptual, innovative, opt for the theories).
- Through which mode the students more effectively perceive information?: in reference to the external information, there are students who prefer pictures, schemes, diagrams, graphics: Visual students; verbal students are decanted by written or spoken explanations.
- With what type of information organization prefers to work the student?: there are students who feel more comfortable if the information is organized in inductive way, i.e., when facts and observations are presented to them and then the principles or generalizations are inferred. There are others who understand better the information if themselves deducted the consequences and applications from the fundamentals or generalizations.
- How processes the student information?: there are students who learn to perform exercises, testing concepts, working with other students; they are active students. On the other hand, other students prefer to think alone about the concepts.
- How progresses the student in his learning?: some students need to go step by step, in a linear way, in a logical progression; they are the sequential. Other students need a comprehensive global vision, to advance learning.

It is worth to note that students use some style of learning in a more or less common way, without excluding the possibility of alternate with other strategies.

A single individual can apply different strategies belonging to different learning styles, in different situations.

Learning styles are relatively stable, but they are not immutable.

Styles can change as students advance in their learning process and discover other forms or modes of learning.

The design of multimedia elements

Shall state the elements that must be considered in designing and making multimedia teaching materials.

- Contents

Content development will be determined by the learning styles of the students and the methodology to be used: discourse, one that presents a great influence of the traditional media; exploratory, that allows the user the ability to investigate without follow a fixed pattern, allowing a learning through trial and testing; simulations of environment, those who seek to create virtual environments that simulate real-life situations. Arise such environments and decision-making of the students is evaluated.

- Scrip

We must not forget that designing a multimedia application and the Organization of the contents must be a logic at the time of its presentation.

It can be differentiated between: script's contents, which refers to the Organization, structuring and modularization of the same; script of the application, which represents the functional organization of the same scheme, with aspects such as organization navigation and the linkages between the elements.

- Functional design

It will define the functionality of the application through an analysis of two aspects: navigation, which can be free, i.e. that the student has control over the application, or controlled, where will guide students through the learning path that we decide. The other essential aspect within the functional design is one that refers to the control and monitoring of the student, this includes control of itineraries, tracking exercises, the generation of reinforcements and assessments, among others.

- Graphic design

You must take into account that the aesthetic component is very relevant. It must strike a balance between aesthetics and effectiveness.

- Multimedia materials

They are the elements that configure the application: hypertext, images, animations, video, audio.

Animations

One of the key innovations that educational technology has made available is new forms of representations, such as animation, multimedia, and virtual reality [9]. Animations are a form of dynamic representation that display processes that change over time.

Animation is considered to be series of frames so each frame appears as an alternation of the previous one [10]. Typically, each frame exists only transiently to be replaced by subsequent frames, such that the dimension used to represent time in the representation is time.

Animations are used for a variety of reasons across a whole range of topics. They are often utilized when there is a need to show learners something not easily seen in the real world. More abstract representations can also be used to represent phenomena that are not inherently visual, such as a computer algorithm or stages in a mathematical solution [11].

An increasingly common use for animation is in animated agents, where lifelike characters are animated to include gesture and expression [12].

Many people believe that animations can help learners come to understand complex ideas more easily. However, the reasons cited for this beneficial effect tend to vary considerably. Some people believe that animations can help people learn because they are especially motivating [13].

Others people believe there are specific computational properties of animations that match the cognitive demands of a learning task [14].

In [15] its identifies three variants of animation: transformations, in which the properties of objects such as size, shape and colour alter; translation, in which objects move from one location to another; and transitions, in which objects disappear or appear.

The most extensive cognitive theory of the role of animation in learning is that of Richard Mayer [16]. His theory has three fundamental cognitive assumptions: 1) that there are two separate channels for processing visual and verbal representations; 2) that each of these channels can only actively process a limited amount of information at any one time; 3) that meaningful learning results from learners selecting, organizing and integrating new material with old in order to actively construct their own knowledge.

Cognitive Load Theory [17] pays specific attention to the way that memory resources are used in learning and it has been applied to research on learning with animation. Animations are considered in terms of three categories of cognitive load. Intrinsic cognitive load is the 'natural' load imposed by the information and consists of interacting elements that must be processed simultaneously to learn new material. Extraneous cognitive load is the load imposed by the form the instructional material takes. Germane cognitive load refers to the working memory resources required to acquire new information.

In [18] discusses two ways that animations might facilitate cognitive processing. The first he calls the enabling function of animation. Animations can provide additional information that cannot be displayed in pictures. This additional information allows for additional cognitive processing. The second is referred to as the facilitating function.

III. RELATED WORK

This section reviews approaches proposed in the literature.

According [19], e-learning delivers content through electronic information and communications technologies (ICTs). The use of these facilities, involves various methods that includes systematized feedback system, computer-based operation network, video conferencing and audio conferencing, internet worldwide websites and computer assisted instruction. The focus of e-learning methodologies is on both asynchronous and synchronous methodology. The three major e-learning tools are: curriculum tools, digital library tools and knowledge representation tools.

[20] Presents the model of learning styles known as the model of Felder-Silverman, FLSM, compared with the Kolb model and the instrument of Herrmann, based on the specialization of the hemispheres of the brain, HBDI (Herrmann Brain Dominance Instrument). The world's leading thinking styles assessment tool, HBDI, is the assessment at the core of Herrmann International's Whole Brain Thinking approach.

[21] Introduces an online education platform that enables the teacher to organize teaching materials, assignment booklet release, classes scheduling, interactive communications with students and updated stop presses on the Web.

In [22] the following items are included: Learning Support Systems, Event and Learning Management, Computer Mediated Expert Communication, Learning Strategies, Course Structure and Objectives, Course Objectives, Course Development, Assignments, Focused Discussions, Effective Tutoring.

[23] Explores social networking technologies being used in higher education, their uses, extent of use, benefits and skills learners acquire from use of these technologies.

[24] Explores the relationship between the use of ICT, the accumulation of e-skills and innovation capacities of teachers. It explains that: innovative pedagogical usage of Information and Communication Technologies (ICT) can be considered as a proxy of the full exploitation of the possibilities of ICT in Higher Education (HE). Any public policy aiming at fostering these uses needs to take into account the role of training and especially training for innovative purposes. At the same time universities need to develop clear strategies in matter of ICT facilitations in order to improve innovative usage by allowing innovative HE to fully exploit their skills; HE Institutions should fully incorporate ICT in their own learning process by making processes more flexible, modifying attitudes and habits, and clarifying values.

[25] Aims to share the preliminary findings which have made easy the development of Personalized Learning Environment (PLE). It describes types of learning styles in PLE. PLE is a new concept in designing and developing an online learning. PLE is more focused on individual learning rather than the instructor, facilities, resources and tools. PLE has also played an active role in improving the effectiveness of learning. The integration of functions in the learning

environment is very important to ensure that the external conditions of learning are provided to students. Therefore the learning environment must be suitable according to their students learning styles, preferences and needs in learning.

[26] Examines innovations in graduate management educational delivery methods that have increased the quality of distance education by investigating the literature surrounding distance education with a focus on four major concepts and their association with modern education technologies. The first two concepts include dialogue and structure that have been used to describe and assess the quality of distance education programs. The second two concepts comprise students' ability to access courses and the flexibility that students have relative to their participation in courses. Involves a comparison of an innovative, parsimonious, online educational model with other methods of graduate management education.

[27] Presents a set of information and communication technologies developed with the goal to improve the practice of cued speech. They are based on three-dimensional graphics and are covering the entire end-to-end content chain: production, transmission and visualization. The research and development path takes into account high-quality animation, real-time constraints, personalization, user acceptability and, equally important, the easiness and feasibility of the deployment.

[28] Reports the development such Virtual Reality (VR) e-learning system in teaching automation technology courses. It also discusses how the e-learning system enhances the quality, scale, and breadth of technological education. It demonstrates a great enhancement in teaching effectiveness with ICT technologies.

IV. OBJECTIVES

The general objectives are:

- i) To develop an integrated environment to study the data communication protocols and the signals transported by the HFC nets, describing the treatment that the message receives.
- ii) That the student obtains solid knowledge about theoretical and practical aspects of the data communication using the ISO / OSI model, the available technological easiness and the involved resources.

The specific objectives are:

- i) To study the data communication protocols, precisely, the ISO / OSI model and the treatment that the message receives in the HFC nets.
- ii) To know the points of the HFC nets that takes part in the communicative process.
- iii) To study the concepts related with the HFC nets and the elements and process that take part in the data communication.
- iv) To make, by means of software Flash®, an animated application to describe the ISO / OSI model and the active and passive elements of a HFC net,

which allow the students make a self-learning process at his own pace, that includes a self-evaluating section to valid his learning.

V. DEVELOPMENT METHODOLOGY

It has started with a compilation of information from various bibliographical sources, including materials for the Teleprocessing and Distributed Systems course (currently Data Communications), books, papers, etc. [29, 30, 31, 32, 33, 34, 35, 36, 37, 38].

Enquiries were carried out to the students to relieve the difficulties encountered in attempting to learn the theoretical content and perform animations relating to these subjects in order to facilitate learning and provide a web questionnaire that will allow learners to self-assess themselves.

This project has been divided into three phases. The first of them applied to the collection and study of data communication protocols, as well as the inclusion (to be used as an example through the animation) of a HFC net [37, 38, 39]. The second is the construction of a website in Flash, which integrates the animations to obtain an interactive application to incorporate the theoretical contents studied; it explains the functioning and the sections that contain the application, each of the sections and the corresponding animations are explained in detail. The third phase consist of a web questionnaire, which allows students to perform the process of self-assessment of their programming [40, 41, 42, 19].

A. Stage 1

It has consisted in the collection of the theoretical contents that were used as sustenance for the realization of the animations:

- i) Survey of information.
- ii) Deepening of the theoretical framework referred to the subject. The sources were documents and tools from the subject, thesis and specialists in the subjects ISO / OSI model and HFC networks.
- iii) Analysis and evaluation of the most important challenges that are presented in the students to understand the theoretical contents.
- iv) Review and selection of the most important theoretical content to include in the animations.

B. Stage 2

It has consisted in the selection of the tools used to process, debug, and implement all necessary treatment for the development of the animations. Once the animations were developed, it was made the construction of a website in Flash to integrate these animations to obtain an interactive application. The methodology used for the development of the Flash application, it was divided into sub-stages:

- i) *Sub-step 1*: Analysis of the system:
 - Collection of information relating to the data communication protocols and the theoretical content of the topics covered in stage one to include in the application.

- Feasibility Analysis: the scope of the system and its capabilities were defined to delimit existing technological limitations.
- System Requirements Specification: the required capabilities, interfaces, and the benefits were explained in detail to be hosted on a web server.
- Documentation Review of tools and work environment.
- Tool Selection: to develop this application, certain tools were used to make animation, assemble application, edit images, audio and text to include them in the animations, and to create 3D objects we used the following programs, Adobe Flash, Adobe Photoshop, Adobe Illustrator, Swift 3D, Loquendo, audacity and the programming language Action Scripts.
- ii) *Sub-step 2: System Design:*
 - Designing of the prototype of animations.
 - Creation of pictures, videos, graphics.
 - Writing the script of the animations.
 - Animations representing each of the topics.
- iii) *Sub-step 3: The development of the system:*
 - Selection, correction, and debugging of external images, which would be included in the animations through Photoshop and Illustrator tools.
 - Creation of images and diagrams on the ISO / OSI model and the HFC networks through Photoshop and Illustrator tools.
 - Creation of 3D objects to include in the animations through the SWIFT 3D tool.
 - Development of animations with the Flash tool.
 - Creation of the texts and subsequent export of the audios to include in the animations through the Loquendo software, and its treatment with the audacity tool.
 - Testing and validation of the animations according to the expected results.
 - Designing of interfaces.
 - Initial Development of the application.
- iv) *Sub-step 4: Implementation: The implementation of feedback provided information that allowed us to refine the system to achieve the expected results:*
 - Testing and validation of the initial application according to expected results.
 - Settings and redefinition of the designing according to results observed.
 - Final Deployment of the application.

C. Stage 3

This stage is the complement to the other two stages; to complete the process of self-learning we have created a web questionnaire in PHP with MYSQL database that allows the student to self-assess himself by answering a set of questions for each topic. It consists of the study and requirements analysis, system needs, applicability of necessary resources, selection of the tool and possible programming languages.

i) *Sub-step 1: Analysis of the system:*

- Feasibility analysis: we will define the scope of the system and its capabilities to delimit them to existing technological limitations.
- System Requirements Specification. Detailing the required capabilities, interfaces, and the performance that must be obtained to be hosted on a web server.
- Documentation Review of tools and work environment.
- Selection of the theoretical content to include in the questionnaire (themes, questions and answers).
- Selection of tools. Tools used for the creation of the use cases, database, local server, etc. We used the following programs: Dreamweaver, XAMMP packages, MySQL, PHPMyadmin, StarUML and the following programming languages PHP, CSS and Javascripts.
- Use Case Diagram: used to understand the use of the system, it shows a set of cases and actors (an actor can be both a system such as a person) and their relations, that is, it shows who can do that and the relationships that exist between actions (use cases).

ii) *Sub-step 2: System Design:*

- Data model.
- Definition of users.
- Design of interfaces.

iii) *Sub-step 3: The development of the system:*

- Designing and development of the web application for the self-assessment questionnaire.
- User interface development.
- Development of the application.

iv) *Sub-step 4: Implementation: The implementation of feedback provided information that allowed us to refine the system to achieve the expected results:*

- Testing and validation of the initial application according to expected results.
- Settings and redefinition of the design according to the results observed.
- Final Deployment of the application.

VI. RESULTS

In this section it is explained and discussed the animations made to represent the ISO / OSI model [29], as well as the Flash application and the web questionnaire for self-evaluation. Described in visual form, the process of encapsulation of data messages when they are transmitted; the animations in this process is shown and while, is performed a more detailed description of the same, in audio, as a complement to the displayed (see Fig. 1).

The animations have been carried out with the Flash program, in which there were effects of movement and animation.

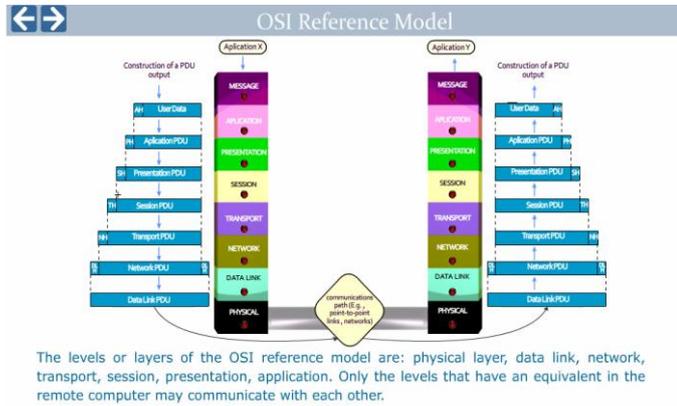


Figure 1. ISO/OSI Reference Model.

It has been worked with the program Photoshop and Illustrator to edit images, modify sizes, improve the quality, etc., adjusts the weight of the images according to the use of Flash on the internet. The Swift 3D program was used to generate the 3D objects that were embedded in Flash. For the generation of speech it was used the Loquendo software and for audio editing it was used the Audacity program. It represented the entire contents of the animations inside an executable file in Flash, while the survey was taken in PHP by using the program Dreamweaver.

When you start the application, it represents a real-life situation in which it is situated the HFC network (see Fig. 2, 3) together with its components in a city, from the onslaught of the user up to the bedside of the service provider. This helps to put the student in a specific type of network with its own characteristics, and better understand all the treatment it receives the message with that configuration.

It allows the user to navigate through various options and thus be able to understand the operation of the various parts that compose the HFC network more precisely and to learn about the operation of the ISO / OSI model, which is the main theme of this application. Start Section: it is the main part of the application, it represents the HFC network in real life, and there you can navigate and know its components (see Fig. 4).

In addition, you can access the test to complete the teaching-learning process, by answering a questionnaire on the content of everything developed. In this screen the user (depending on the level of access you have) can access the

administration panel of the questionnaire, or to the questionnaire itself.

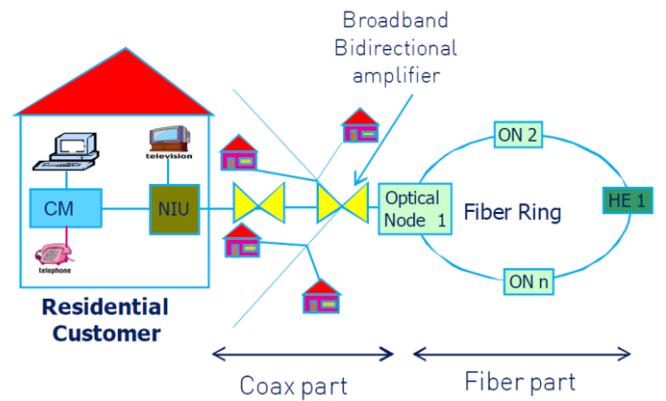


Figure 2. HFC network [39].

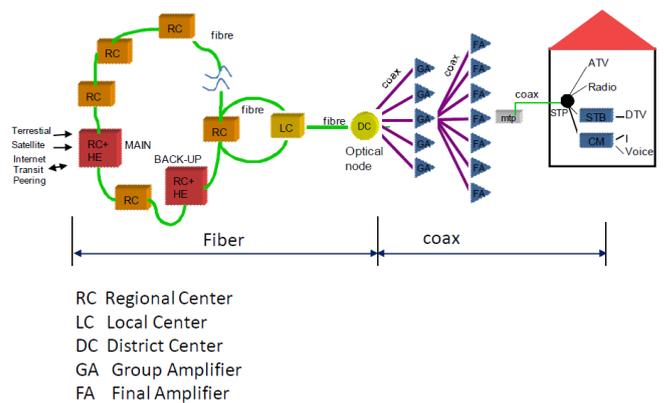


Figure 3. HFC network based on a star topology [39].



Figure 4. Main Screen of the application.

If the user enters their data it becomes administrator, then you may enter to the panel with full access, to add, edit and delete any of the options.

If the user is teaching, then you can access the administration panel but you can only manage the issues and

options of your subject. Finally, if you access a user with level student, this may access the questionnaire, which provides the possibility of making a self-assessment of what has been learned, by answering a set of questions selected at random on the themes developed.

This allows students to detect flaws in their knowledge, transferring it to the corresponding theoretical contents.

OSI Layers Section: you can select each layer of the ISO / OSI model and get a description of the same.

Encapsulation Section: you can learn the operation of the ISO / OSI model, the process of encapsulation where the message each layer adds its own control information until you reach the physical layer, and then to be sent through the network (see Fig. 5).

OSI model Section: How it arises and evolves the OSI model; it is an introduction to the reference model from its inception.

Codification-Modulation Section: you can see the process by which the message that leaves from the application layer is transformed into frame and changes of state, the digital data of the frame are encoded, modulated and converted into an analog signal to be transmitted through the network (see Fig. 6).

Animations Section: Allows you to navigate through the various animations on the various topics; also provides a complete animation of all the treatment that you receive a message when a PC sends an e-mail to another. The animations represent this communication from the inside of the computer, from the instruction of "send", passing by the "encapsulated" in which each layer adds its own set of control data. A "robot" is responsible for adding to the "message", each header of each protocol layer to form the data to be sent through the physical layer. The animation shows how we pass from layer to layer and when it is ready to be sent over the network. It shows how in reality is visualization data, i.e., through voltage pulses, will be showing in a table in order to better understand what is actually being sent, strings of 0 and 1. The data are sent through the transmission medium in where there are other packages within the network that travel to your own destiny. After the frame arrives at its destination, shown the reverse process, i.e., as the "robot" within the destination machine disassembles the frames, and removes each header of the corresponding layer, as well until you can show the message in the application layer.

Staged development is accessible at the following link:

<http://www.lsiunne.com.ar/>

VII. CONCLUSIONS

Various tools have been integrated very satisfactorily during the realization of this work. It provided a very good visualization of the animated content in order understand better the scope of the ISO / OSI model and the details of the data transmission. In addition, it has been including a self-evaluation method where student can assess their knowledge

by means of questionnaires, on the content shown in the animations.



Figure 5. Encapsulation Screen section.

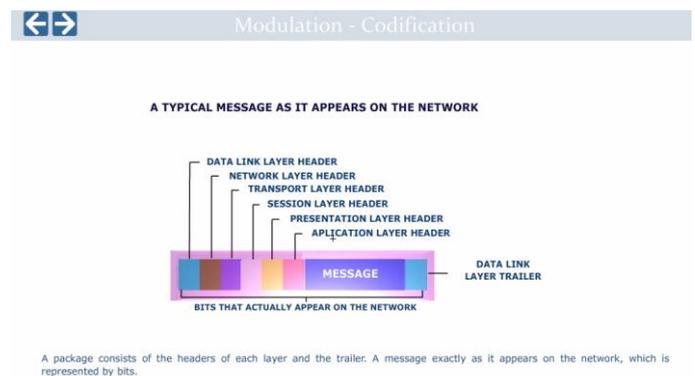


Figure 6. Codification-Modulation section.

This mechanism allows the student detects flaws in their knowledge, transferring it to the corresponding theoretical contents. In this work it has been chosen a type-specific configuration, as an example it has been used a HFC network, a NRZ encoding, an amplitude modulation, a type of modem and a transmission type guided tour.

The methodology developed is translatable to other knowledge areas, giving them a more practical approach and more profound of their respective contents to achieve a better process of learning for the students.

The questionnaire module is translatable to other knowledge areas, allowing any responsible for a chair manage their own students and the questions with their respective answers, everything from the administration interface.

Future Lines

It will continue on working, improving and expanding the animations and new mechanisms for self-evaluation to provide better methods of self-learning. It considers the possibility of adding mechanisms that allow us to obtain statistics on the results of the questionnaire, for information on the degree of difficulty of the questions, the amount of access, etc., and

consider alternatives to improve learning in the subjects that are more challenging for the students.

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