Method for the Integration of the Didactic Strategy Model in Virtual Learning Platforms in the University Context: A Mechanism that Takes into Account the Professor's Work

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Abstract. The Learning Management Systems (LMS) have brought great benefits and changes in the way teachers and students interact in the teaching-learning process. However, it is evidenced that the LMSs are not capturing the professor's intentions to perform his work as a teacher, but they focus on providing technology; although useful, it makes the professor's work remain in the background. Likewise, the fact that the LMSs do not supply intuitive mechanisms for the customization of the teaching-learning process considering learning styles was also identified. Having in mind these detected problems, this article pretends to contribute with a possible solution through a method that allows the inclusion of a visual model of activity sequences defined as the didactic strategy model in LMS, so that the resources offered by the LMS are exploited, and the professor can focus on his work and the students' needs. The method is implemented through a concept test in the Moodle platform.

Keywords: Didactic strategy model · e-learning · LMS · Sequence of activities

1 Introduction

Currently, one of the most used technologies both in virtual and on-site education is the Learning Management System - LMS. An LMS is a software system generally installed on a web server, which is used to create, aprove, administrate, store, distribute, and manage virtual training activities [1]. These types of systems have brought benefits and changes in the way professors and students interact in the teaching-learning process, they facilitate the synchronous or asynchronous communication, help the space and time barriers to decrease, encourage collaborative learning, among many others. However, in order to take advantage of all these benefits, professors need to know the wide range of services and variety of LMS configurations in depth. So, it can be exploited for the achievement of its learing objectives. In this way, it is perceived that the professors are the ones who must adapt to the way the LMS work, and not the other way around. When the ICTs are used for the development of educational environments,

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there is a general principle: they must be in function of the pedagogical design, not backwards. That is to say, for using a video, animation, forum, e-mail, and so on, the pedagogical need must be considered [2]. This principle, general and essential, is not being thought of in the current virtual platforms since the profesor must solve his conflicts dealing with technology first; subsequently, thinking of his duties as a teacher.

To illustrate the problem presented, let us suppose the following scenario. Planning is the primary task that a profesor performs. This is the equivalent in the LMS environment to configuring the didactic activities weekly. However, when the profesor enters the LMS to do the planning in function of the didactic activities, he only encounters technological components that do not guide him on how to do the activity unless the professor has taken an intensive course in how to use and configure them to carry out the task sucessfully. The main problem that is seen in the LMSs is that they are not capturing the professor's intentions to perform his work as a teacher; instead, they are centered on providing technology; albeit useful, they make the professor's work to remain in the background.

The second focal problem of this research is related to learning styles. People learn differently according to the senses considered most useful when receiving, processing, and responding to the information retrieved from the medium. The differences between one and the others are the ones that make each person unique regarding the way, speed, ease, and/or difficulty to learn something [3]. Taking into account this cognitive principle, it would be expected that the LMSs would have the mechanisms to make the teaching process somewhat customizable. While it is true that the LMSs have tools that allow the creation of student groups and specific activities for them, the way how a course could be designed for student groups with different learning styles and needs is not very intuitive.

There is evidence of research in the literature that has dealt with learning styles and the adaptation to the LMSs. Such is the case of the works by Castellón [4] and Leris [5], who are focused on the customization of the learning process using the conditionals proposed by the Center of Innovation for the Information Society (CICEI) for Moodle platforms. The customization is achieved from a diagnostic evaluation of the student's learning style. Once his style is recognized, a determined presentation of the course previouly designed is assigned, and it adapts gradually according to the student's process. Although these proposals work efficiently on the student's side, they have deficiencies in relation to the professor's work due to their laborious implementation.

On the other hand, initiatives within the LMSs have been created pretending to be a mechanism to design didactic strategies, but they have only offered technology. Such is the case of the "Lesson" component used by Moodle and other LMSs. This component works for proposing activities that allow evaluating the student's progress since it presents content sequentially, assessing periodically if the student achieved the objectives or needs to reinforce the subjects [6]. Despite being a useful tool for the construction of sequences of activities, it has several limitations, among them: it does not have a graphic model that guides the professor in the construction of the strategy, the construction of sequence of pages is very complex for the users, the professor focuses on building content pages and solving problems related to the management of technology instead of devoting 100 percent to the his planning work. Likewise, there is the "LAMS" (Learning Activity Management Systems) project. LAMS, in addition to being a foundation, it is a learning sequence design tool that allows to build routes graphically where students can advance in relation to their achievements [7]. Despite the LAMS versatility and advantages, it also has several disadvantages in relation to what is proposed in this research work, namely: (i) LAMS is oriented to construct sequences and not processes, reason why the notation lacks elements that guide the didactic strategy as it is conceived in reality; (ii) as in other LMSs, LAMS focus on providing technological components that do not give an indication on the type of activity to which is attached, leaving again the professor's work in the background; and (iii) although LAMS can be intergrated with some LMSs like Moodle, the technical component it offers has a different interface, which affects the mental model that the users have in relation to the platform.

There are other proposals on the side of Educational Modeling Languages (EML) that have been integrated into LMS in practical cases such as the standard IMS-LD [8], PoEML [9], E2ML [10], CoUML [8], among others. To begin with, the main purpose of IMS-LD is to allow the creation of computer didactic unit models, so the development of didactic units can be controlled and supported by ICTs. On the other hand, the perspective-oriented educational modeling language (POEML) integrates workflow and groupware aspects into educational modeling and focuses on a separation of eleven different perspectives of educational practices. Also, E2ML is a simple design language coupled with a visual notation system consisting of multiple interrelated diagrams. It was developed as a thinking tool for instructional designers and for enhancing communication within large e-learning projects. Finally, CoUML stand for "Cooperative UML", indicating that its notation system is essentially an extension of the UML used to model cooperative activities and environments. All these proposals include a diagram to create activity sequences but the way in which they have been implemented has made the professor to focus on technology again, and not on his job.

Considering the aforementioned, this article pretends to contribute with a possible solution through a method of inclusion of a didactic strategy model that can be taken to computing, and integrate it with the LMSs in such a way as to capitalize on the resources that the LMSs offer, but avoiding the professor's work to remain in the background. In order to do this, this article presents the method of inclusion of the didactic strategy model in an LMS in Sect. 2, the development of every phase of the method in the subsequent sections, and its implementation in the Moodle platform. Finally, conclusions and future work are presented in Sect. 4.

2 The Method

This section presents the method used for the inclusion of the didactic strategy model for the university context and its ensuing use in a computational environment (see Fig. 1). The didactic strategy model is a graphic representation, which is conceived as a process that is comprised of learning activities and control actions carried out by the professor. In this way, the didactic strategy model constitutes a mechanism to plan and verify the progression of the process in which the sequence of activities that comprise it can be identified. Likewise, the model pretends to be and approximation to the achievement of didactic strategies design that adapt to specific student profiles.

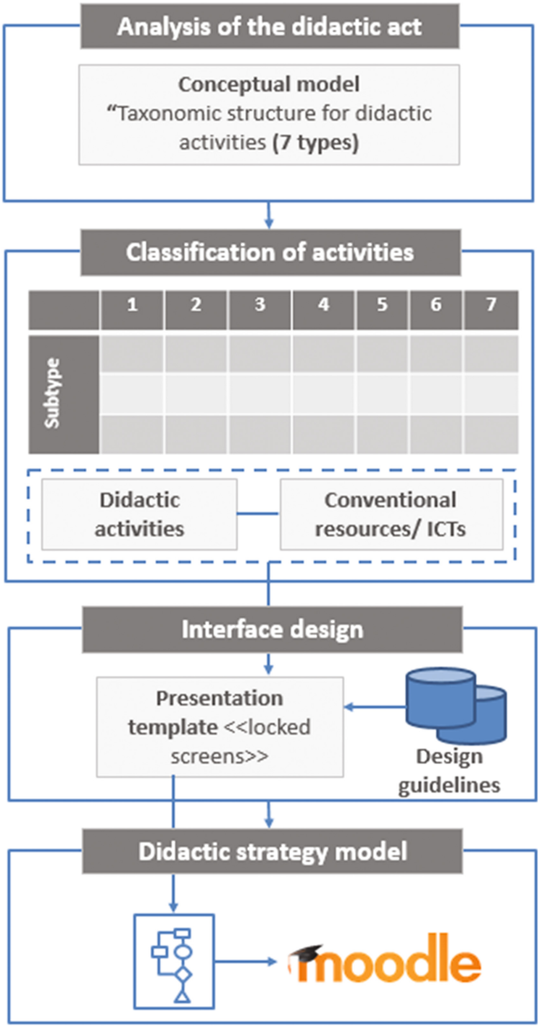

Fig. 1. Method for the construction of the didactic strategy model

In the teaching-learning process, to learn and to teach are considered didactic acts. For this reason, the method for the construction of the didactic strategy model begins with the theoretical study of the different conceptual models around the didactic act. For the purposes of this article, Marqués [11] conceptual model is presented, which shares common elements to other proposals presented by Meneses [12], Rodríguez [13] and others. Among the main elements of the didactic act are didactic activities, which according to Conole [14] are classified in seven main groups: assimilative, managerial, communicative, applicative, productive, experiential, and evaluative. In the second phase, Conole's taxonomic structure is used in order to classify the learning activities in the university teaching context, which were compiled by Marcelo [15]. Correspondingly, the activity subtypes are identified according to their nature along with the resources used by each activity, both the conventional as well as the technological-supported ones.

The classification of the resources used according to the activity constitutes the starting material for the third phase. In this phase, different interfaces are designed. They are associated to types and subtypes of didactic activities according to different combinations of resources that are supported on technology. Also, a series of design guidelines that promote the usability in the final interface are applied in this phase.

Finally, the didactic strategy model is specified in the fourth phase through the notation of the flow diagrams, and taken to the computational environment through a concept test in the Moodle platform.

In the following sections, each phase of the method for the inclusion of the didactic strategy model is developed.

3 Development of the Method Phases

This section presents the different phases that comprise the method for the inclusion of the didactic strategy.

3.1 Analysis of the Didactic Act

Teaching and learning are held as didactic acts. According to Marqués [11], the didactic act defines the performance of the teacher to facilitate the students' learning, and its nature is essentially comunicative. The didactic act is comprised by four basic elements: the teacher or tutor, the student, the contents, and the context (see Fig. 2).

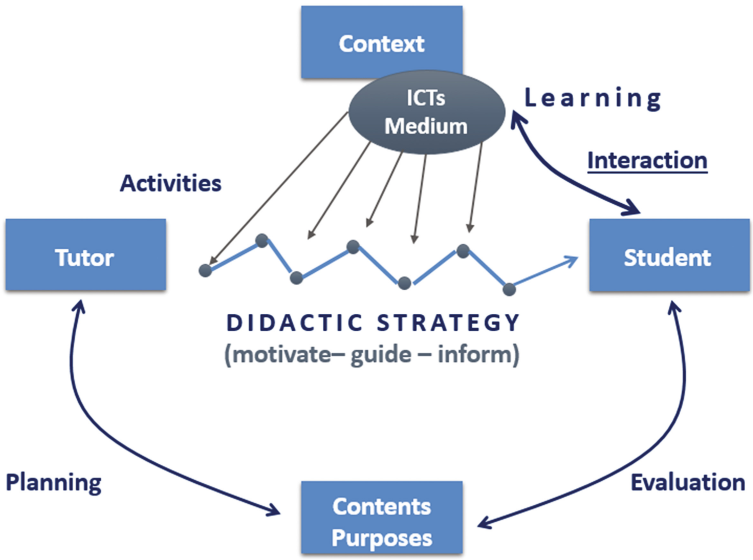

Fig. 2. Marqués didactic act

Teaching is particularized in didactic acts where the professor or tutor proposes multiple activities to the students to facilitate the desired learning. These activities are adapted to the students' characteristics, to the available resources, and to the contents to be studied. The activities must favor the comprehension of the concepts, their classification and relation, reflection, the exercising of reasoning, and transfering of knowledge. The objective of professors and students always consists in the achievement of specific educational objectives, and the key to success is the students' motivation and will to carry out the cognitive operations, interacting appropriately with the instructional media available.

The instructional media is any type of material elaborated with the intention of facilitating the teaching and learning processes. Marqués poses that the effectiveness of these media will depend to a large extent on the way the professor directs its use in the didactic strategy framework that he is using.

A strategy is, in a strict sense, an organized, formalized, and goal-oriented procedure. Its application in daily practice requires the perfection of procedures and techniques whose detailed election and design are the professor's resposibility. Therefore, the strategy is a system of planning applicable to an articulated set of actions required to attain a goal. Thus, it is not feasible to talk about the use of strategies if there is not a goal where the actions are oriented to [16]. By means of the didactic strategy as a procedure, the professor intends to facilitate the learning process in students through activities that consider their interaction with particular content. The didactic strategy must provide motivation, information, and orientation to students in order to carry out their learning process [11].

The strategy must be based on a method; but unlike it, the strategy is flexible and can be shaped around the goals needed to achieve. In its application, the strategy can use a series of techniques to attain the objectives desired. Everything must be previously planned based on the educational objectives intended. At the end, what the students achieve as well as the didactic strategy used is evaluated.

Once the basic concepts around the didactic act are presented, it is necessary to deepen in the didactic activities which the students use to achieve the desired learning.

3.2 The Didactic Activities

The didactic strategy, as already mentioned, is basically constituted by a wide set of learning activities that the students develop as it was previously planned by the professor. As Conole [14] poses it, the learning activities occur in a given context in terms of the environment where it is developed, the adopted pedagogical approaches, the institutional procedures, and difficulties that may arise, and they are designed to fulfill a set of specified learning outcomes and evaluation criteria through a series of tasks using a set of tools and resources. Thus, each learning activity proposes specific learning objectives for the students, as well as some tasks that they must do. For the development of these tasks, the students have a series of resources. Some of these resources are physical (books, laboratory objects), digital (computers, software, Internet), human (professors, assistants), etc. Conole proposes a taxonomy that defines the components that integrate a learning activity [14]. One of the most useful aspects of the taxonomy is the detailed description of the nature of the task that the students will do as part of the learning activity to achieve the desired goals. This taxonomy is enriched by Marcelo [15], which includes the "evaluation" type of activity that is not present in the original version of the taxonomy. The types of activities according to these two authors are:

- *Assimilative activities*: they intend to promote the students' comprehension about specific concepts that the professor presents via spoken, written, or visual texts.
- *Information management activities*: involve the development of data search tasks, of contrasting and/or synthesizing, of collecting and analyzing quantitative or qualitative data and of analysis of a case, text, audio, or video. They are activities that demand from students not only to look for information related to a query or problem that must be solved, but also to analyze it and understand it. They are activities that generally follow others based on assimilation.
- *Application activites*: they demand from the students to solve exercises or problems applying principles or contents previously studied in class.
- *Communicative activities*: they are those where the students are asked to present information, discuss, debate, share, inform, etc.
- *Productive activities*: through them, students have to design, elaborate, and create a device, document, or new resource.
- *Experiential activities*: they are those that try to place the students in an environment close to the future profesional practice, whether in a real or a simulated context.
- *Evaluative activities*: they are the ones whose main and only objective is the evaluation of the student, regardless of the previous activities intentions to evaluate.

3.3 Classification of Didactic Activities in Subcategories

The types of activities proposed by Conole gather a great diversity of activities that could be classified in activity subtypes. In order to arrive at this subcategorization, the research done by Marcelo et al. [15] was taken into account. They analyzed the specific components that university professors use to guide the students' learning process. And they do this through the analysis of the learning activities and tasks that they organize. One of the conclusions from this study is that there are no differences in general among professors of different fields of knowledge in function of the learning activities that they plan. Considering this conclusión, the activities can be classified in activity subtypes not discriminating the field of knowledge where it is applied to, obtaining a subclassification of general use in the universitiy context.

The process to reach the subcategorization of activities begins in the analysis of the 91 didactic activities consolidated in the study by Marcelo [15]. Having this list as an input, the activities were gathered in the types proposed Conole; and subsequently, subgroups were arranged according to the nature of the task. The consolidated activities and subactivities are presented in Table 1.

Once the types and subtypes of an activity were identified, we proceeded to specify the resources necessary to carry out each didactic activity, and how the resource could be instrumented using technology. To illustrate the process, Table 2 presents the specification of resources for assimilative activities. In the case of the assimilative-formation activity, the conventional resources used are videos, a board,

Table 1. Types and subtypes of didactic activities

Activity type	Subtype	Examples
Assimilative	Formation	Listen to the professors' lecture
	Reading	Read materials and documents
	Observation	Visit an institution or work zone with the purpose of observing
Information management	Analysis	Analyze a document from a script
	Search	Search for information in recommended sources
Application	Training	Solve mathematical problems without the professor's presence
Communicative	Tutoring	Solve students' doubts
	Assistance	Help the student to accomplish something
	Discussion and Exchange of information	Participate in question-answer dynamics
	Presentation	Defend a work
	Agreement	Get to common grounds
	Conference	Attend a conference, congress, workshop
Productive		Write an essay or composition
Experiential		Develop practice in a real context
Evaluative	Written	Answer an evaluation instrument of previous knowledge
	Spoken	Maintain an evaluation interview with the professor
	Feedback	Provide feedback of the result of an evaluation

audiovisual aids and documents. Within the resources, the professors or presenters have been included because at the moment of bringing them to the technology, it is necessary to provide a mechanism of communication that allows the interaction between professors and students.

For this same case, the specified conventional resources could be supported on technology using a video player that is extended to support board features (the player allows navigating the video by subject or slides previously defined by the professor), a presentation or document viewer, and a file repository viewer. Communication between professor and student could be done via chat, forum, or video call.

3.4 Interface Design for Didactic Activities

Resource classification according to the type and subtype of activity where they are used are the input for the construction of the interfaces to be designed. Based on this classification, interfaces with different configurations of resources were designed according to the activity to which it is associated. For example, a professor plans an

Table 2. Resources for the assimilative activities

Resources		Assimilatives		
Conventional	Supported on ICTs	Formation	Reading	Observation
Video	Video player (live or pre-recorded)	√		√
Board	Player with board characteristics	√		
Audiovisual aids (other ais)	Presentation and/or document viewer	√	√	
Documents	Repository viewer	√	√	
Specification of the activity	Task (Moodle)			√
Resulting documents or files from the student	Task (Moodle) with attached file			
Evaluation instrument	Questionnaire			
Professor, presenter	Chat	√		
Professor, presenter	Video call	√		
Professor, presenter	Forum	√		

assimilative formation activity for the students to understand the basic concepts of databases. This activity can be done through a video explaining the concept, a written text, or the interaction of both, i.e. a video that shows an explanation, and that it is also based on other resources as a presentation or other documents.

In this way, the professor has different ways of planning the activity according to the elements available or the learning styles of student groups. Based on this assumption, a set of interfaces were designed for each activity that meet specific needs in a given context. During the design of the different variabilities of interface for each didactic activity, design guidelines that promote usability were applied. These guidelines are related to the Gestalt laws of grouping [17], Nielsen's heuristics [18], Tidwell patterns of interaction [19] and the application of different usability tests in order to capture feedback supplied by the users (professors and students). The Fig. 3 shows two examples of interface prototypes of low fidelity for the assimilative-formation activity.

3.5 Implementation of the Didactic Strategy Model

Once the interfaces for each type and subtype of activity were designed, the didactic strategy model was implemented. As it was mentioned, the didactic strategy is conceived as a process that is composed of learning activities and control actions carried out by the professor. According to this definition, the didactic strategy model must have the necessary elements that allow the modeling of a process. The literature reports a wide variety of languages for modeling processes, flow diagrams [20], (BPMN, SPEM, UML) as well as education (PoEML [9], E^2ML [10], CoUML [8]) among many others. Any process language could be used as a starting point for the implementation of the didactic strategy model. However, the notation language of the flowchart was chosen in order to maintain the simplicity of the model. Also, providing a greater acceptance

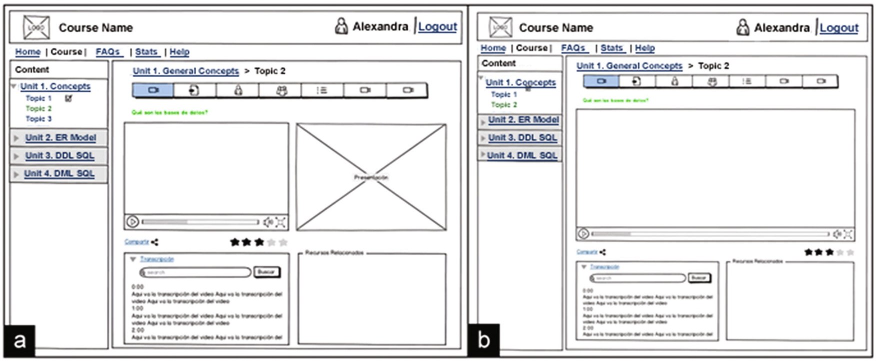

Fig. 3. Interface prototypes for the assimilative-formation activity; (a) includes the components of video player and file repository; (b) includes the components video player, presentation, and file repository

Table 3. Selected symbols of the flow diagram language for the didactic strategy model

	Symbol	Meaning
Control actions		*Start/End*: It is used to indicate the beginning and end of a didactic strategy
		Decision: Represents the comparisons of two or more values. It has two outputs of information, true or false
		Flow: Shows the logical tracking of the diagram and the execution direction of the operations
Activity	[type] name	*Activity:* shows an action to be performed related to type of didactic activity. The type of didactic activity is shown in brackets "[]"

among the professors who know and use the flowcharts in different domains. Table 3 presents the language symbols of the selected flowcharts to implement the didactic strategy model.

For this version of the didactic strategy model, the flowchart language symbols have the same syntax but differ somewhat in their semantics, in the sense that activities are of the types and subtypes of didactic activities.

Each type of activity has interfaces associated that deploy the technological components to carry it out. Thus, a model is conceived, which taken to computation, is executed in a specified sequence, showing the student the activities to be developed in order to reach his learning objectives.

3.6 Concept Test

To validate the viability of the model on the LMS platforms, a concept test in the Moodle platform was made. To do this, a model editor was built in the Moodle

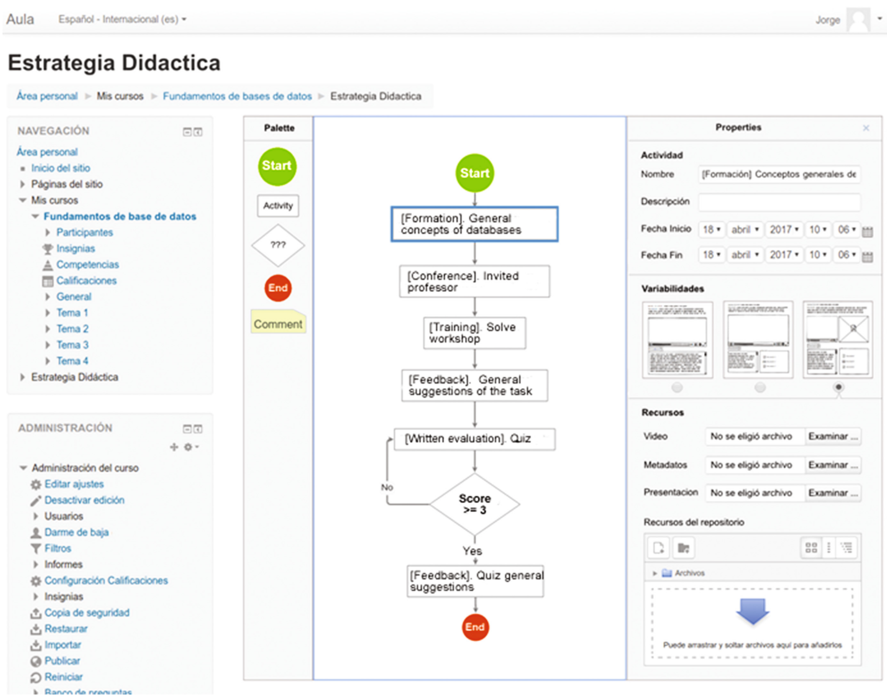

Fig. 4. Model editor of a didactic strategy in the Moodle platform

environment that allows to draw the model, select presentation interfaces for each type of activity, and execute the model following the sequence.

For the implementation of the model in the Moodle environment, a plugin that extends the internal navigation of Moodle was created, so that in any registered course in the platform has a workspace. In it, you can create, modify, visualize, and interact with the didactic strategy. In addition, this plugin allows you to extend the Moodle database to be able to consume or write the corresponding data to the didactic strategy without requiring other data sources external to the platform. For the creation of the modeling environment, the GoJS javascript library was used, which facilitates the creation of interactive editors. The models are stored in the Moodle database and then dynamically rendered to the course students within the space set for this purpose.

The process for the construction of didactic strategy models starts within the course environment. In Fig. 4, the interface of the model editor is observed, which has three sections: the palette, where the symbols of the language are; the working area, where the symbols are dragged and the model is constructed; and property zone, where the data of each activity is configured and the resources are related according to the selected interface.

To illustrate how the editor works, the sequence of activities is presented in Table 4. There, a didactic strategy model is constructed for the thematic unit “general

Table 4. Sequence of activities for the unit "General concepts of databases"

Activity: **[Formation]**. General concepts of databases
Activity: **[Conference]**. The importance of databases – Invited professor
Activity: **[Training]**. Solve workshop
Activity: **[Feedback]**. General suggestions of the task
Activity: **[Written evaluation]**. Answer quiz
Decision: If the evaluation is lower than 3, repeat. Otherwise resume
Activity: **[Feedback]**. **Q**uiz general suggestions

concepts of databases". The professor, once in the model editor, constructs the model by dragging the different symbols to the work area according to the types of activities that he wants to perform. At this point, the professor is focused on performing his work; that is, planning according to the learning objectives and possible learning styles he has detected in his students. Once the model has been built, the professor configures each didactic activity. For this, he must select the activity and go to the properties area where depending on the type of interface selected, he will be prompted for specific resources.

For the example illustrated in Fig. 4 and in Table 4, the configuration of the first activity "*[Formation] General concepts of databases*" requires the professor to enter the general data of the activity (description, start and end dates), to select an interface type according to the resources available; and finally, to associate the resources. In the case that the teacher selects the interface that has a video player, a presentation viewer, and a file repository, the teacher will have to upload a video and its metadata, a presentation and the files that it wishes to unfold in the repository as selected files related to the activity. The interface associated to the activity that unfolds in the student's view is the one observed in Fig. 5.

If it were to set up a page similar to the one selected in the example using Moodle elements, the teacher must add each element and set it individually. This, considering the teacher knows the technology and knows how to integrate the different elements. The example above illustrates one of the advantages of the approach to be addressed in this research. The other advantages observed in the concept test are listed below:

- The model allows the teacher to focus on his planning work, so the technological aspects remain in the background
- The interfaces associated with the didactic activities are designed taking into account the specific contexts and needs of students and professors
- The configuration of the interfaces is simple
- The technological components that are arranged in the interfaces have a similar design to those that the Moodle platform deploys, so there is no breaking of the mental model that users of the platform have
- The professor can create easily different didactic strategy models according to the needs and learning styles of groups of students

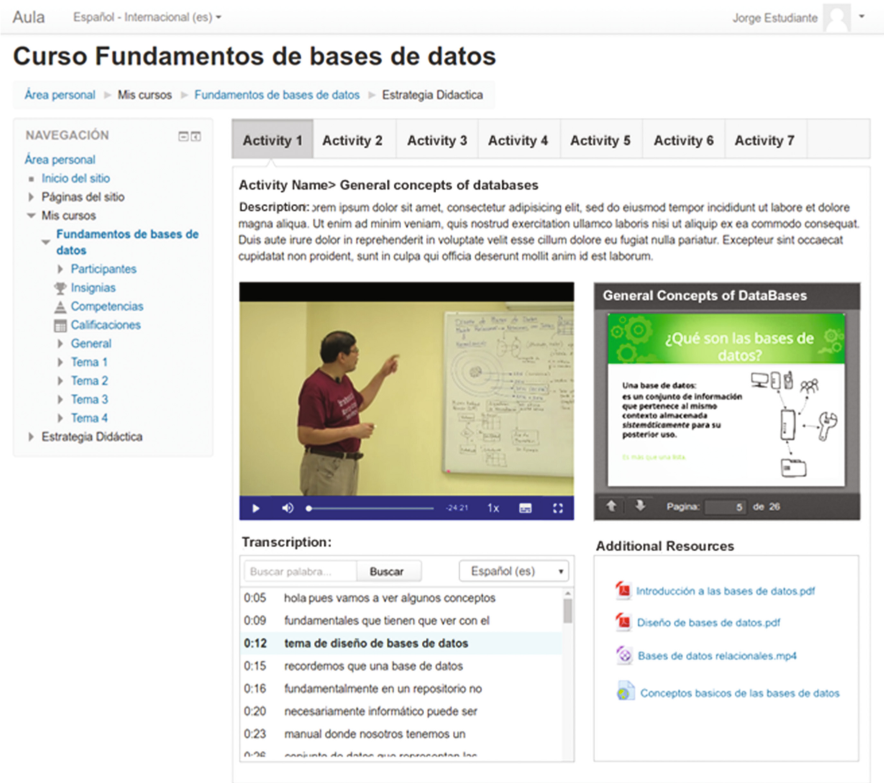

Fig. 5. Student view of the selected interface for the formation activity "General concepts of databases"

4 Conclusions and Future Works

This article presents a method for the inclusion of the didactic strategy model and its implementation in a computational environment through a concept test on the Moodle platform. The didactic strategy model is conceived from the analysis of conceptual models of the didactic act and a study on the didactic activities that the professors use in university teaching. Once the model is conceived, it is implemented in the Moodle platform, creating a model editor, which allows the creation of didactic strategies according to the needs and profiles of the students. The activities that make up the model have associated interfaces that use different configurations of the technological elements used by Moodle. The advantages offered by this method of inclusion of the didactic strategy model are varied and are emphasized in allowing the teacher to focus on the planning of didactic activities, leaving technological aspects on the background. All this can be achieved through the categorization of activities for which interfaces are designed; these consider students' and professors' specific contexts and necessities. The interface configuration is simple, and it is congruent with the mental model that

Moodle users have. Thereof, the teacher can easily create different models of didactic strategies according to his necessities and students' learning styles.

Advances in research have allowed us to identify future works in order to provide greater functionality and usability to the didactic strategy model, namely: (i) integrating new symbols that allow a greater versatility to the process flow and visually enriching the existing ones in such a way that they are expressive and easy to recognize, (ii) performing a quality assessment of the model in order to detect improvements at the usability level, (iii) creating an interface editor and generator that can be tied to the types of activities in order to expand the presentation possibilities according to the purposes of the activity and the available resources; and (iv) adopting a standard mechanism for the storage of models in such a way that didactic strategy models already created can be shared and reused. From the methodological standpoint, future works can be oriented to evaluate if the model editor in Moodle in fact improves the teacher's job regarding his traditional way of activity planning. In the same way, a comparative evaluation on other EMLs can be executed to determine if the categorization of activities improves the expressiveness and communication in the model.

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