LEVERAGING OPEN SOURCE E-LEARNING SYSTEMS WITH WEB 2.0 AND KNOWLEDGE STRUCTURES

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Articolul prezintă un wiki dezvoltat pentru realizarea unui conținut educațional structurat, accesibil printr-un browser web, folosit pentru definirea lucrărilor de laborator şi înțelegerea instrumentației de măsurare, necesare în universitățile cu profil tehnic. Acesta poate fi folosit ca ajutor complementar pentru mediile gratuite de eLearning, cum ar fi Moodle. Ideea pentru conceperea aplicației a fost să se permită profesorilor, crearea şi împărțirea unei baze de cunoştinte cu instrumente de laborator, precum şi, pentru folosirea şi refolosirea informației stocate în aceasta, pentru configurarea lecțiilor on-line asociate muncii studenților în laborator. Cunoştințele sunt structurate conform unei ontologii specifice domeniului instrumentației de măsurare, dar în acelaşi timp această ontologie se poate extinde cu alte concepte de către profesori.

The paper presents a wiki for creating structured educational content, accessible via a web browser, for defining practical tasks and understanding the measurement instrumentation – which are often necessary in technical universities. It can be used as a complementary aid for open source e-Learning environments, like Moodle. The idea is to allow teachers to create and share an instrument knowledge base and to use and reuse information for configuring on-line lessons related to the laboratory work. The knowledge is structured according to an ontology specific to the measurement instrumentation domain, but teachers are also able to extend it with other concepts.

Keywords: E-learning, knowledges structures, Web 2.0

1. Introduction

New generations of students in all domains have increasing computer skills and are familiarized with the new opportunities brought by social computing, enabling more interesting information retrieval by interaction, collaboration and sharing. Therefore, their expectations are towards continuous change and novelty, and teachers should be able to adapt the content of their lessons frequently, in respect with the feedback received from their students. The

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work presented in this paper has merged 3 important elements: e-Learning, Web 2.0 and ontologies.

Today, e-learning mainly consists of online courses, containing various learning objects. This led to the emergence of a dedicated learning technology, which organizes and delivers online courses — learning management systems (LMS). LMSs are currently developed by companies and Open Source (OS) organizations and are widely used in universities and colleges by thousands of students and teachers. They organize the learning content in a standard, predefined manner; thus, a course is divided into modules and lessons, in order to provide a well-defined structure. Most currently used LMSs offer support for creating online quizzes, tests and discussion forums [16]. Moreover, for increasing flexibility and rapidity in lesson creation, as well as for supporting communication between multiple actors, e-learning has assimilated new technologies offered by Web 2.0 [20] and ontologies [5].

The tool presented here was developed based on a previous study related to the integration of data collected from non-homogenous sources, particularly measurement apparatus and equipments [7]. There, we used a domain metamodel for a unitary representation and management of the information related to measured and processed data and of the measurement context (equipment calibration, settings characteristic for the experiment, sample properties etc.). After that, we realized that our metamodel grasps the ontology of the measurement instrumentation domain, which can also be used for increasing students' understanding during their practical work in the university laboratories. We decided to develop an educational application, aiming the following objectives:

- using the ontology for creating a knowledge base of instruments;
- considering teachers as primary actors for creating content, by defining measurement instruments and educational materials dedicated to the laboratory work;
- supporting navigability and Web accessibility;
- allowing teachers to add new concepts for characterizing devices, such as to be able to improve the ontology instruments to the community needs;
- reusing the knowledge about laboratory instruments when creating various lessons.

In Chapter 2, the paper analyzes how web 2.0 and ontologies are used in e-learning. Then, it shows how some of these technologies are used in our application, for developing complementary features for an OS learning system (Chapter 3). Chapter 4 explains the knowledge structure, which is the measurement instrument ontology used for creating lessons, and presents some related approaches. Chapter 5 describes the main functionalities offered for students and teachers, in order to reuse content. Chapter 6 explains how the teachers create new learning materials quickly for Laboratory Tasks.

2. Web 2.0 and ontologies in eLearning

Web 2.0 is a concept that reunites sites and resources sharing common characteristics, without implying a clearly defined set of tools [14]; approaches such as Ajax, micro-formats, mash-ups or open APIs are considered its key technologies. Web 2.0 has supported the need to participate through social networking, and it is currently being adopted in educational tools also [1].

The key issue of an e-learning environment is to provide different ways of interaction, communication and collaboration among all the participants from the educational process. There are four basic components to analyze for evaluating an e-Education system [13]: *students,* which use the system to achieve learning goals, *teachers,* which use the system to monitor, guide and assist students in their learning process, e-*Content,* which provides the important pieces of information (including multimedia and interactive elements) and the possibility of self-evaluation, and *technology,* which allows access over Internet or Intranet, through Web browsers.

The term Web 2.0 arose and revolutionized the Internet, facilitating interactive information sharing, interoperability and collaboration on the World Wide Web [1].

Consequently, new ideas have been developed in the education area, identified under the name of “eLearning 2.0” [1], which involved the change of key aspects in the old curricula and fostered the following new approaches:

- Since the Internet network is used as a platform, the concept of “studying at any place, any time” evolves;
- Collective intelligence and rich user experiences affect the concept of authority in educational systems;
- Tags and RSS (Rich Site Summary) readers allow us to revisit traditional taxonomies, knowledge organization and information retrieval;
- The user has the option to choose between several devices for his or her work.

E-learning 2.0 combines complementary tools and services [16] - such as blogs, wikis, and other social software – in order to facilitate the creation of ad-hoc learning communities.

In order to create more exciting learning opportunities for students, teachers have started to experiment using blogs and forums [15], although these were not initially intended for e-learning activities.

Learning content is created and distributed in a very different manner. Rather than being composed, organized and packaged, e-learning content looks like a blog. Students can aggregate it using their own RSS Reader or other similar applications.[14]

Wikis are used in education to support collaborative work and to facilitate cooperation within the academic environment. Teachers can update the materials at any moment and distribute them to students. “A wiki is essentially a website constructed in such a way as to allow users to change content on the site” [19]. A wiki is used to refer to the created document, the site where it is located and the software that produce it.

However, behind the accessibility of a huge quantity of information and the possibility to react for all the actors, the education process needs bearings for finding the right way, and criteria for well structuring the existent knowledge. That is why the modern e-Education is often oriented towards standardizing the vocabulary and using the new ontology engineering [2], either informally, simply as a way to express primary concepts and the relations between them, or formally, applying standard languages like:

- DAML+OIL (a successor language to DAML- DARPA Agent Markup Language, and OIL- Ontology Inference Layer, that combines features of both),
- OWL (Web Ontology Language) [3] or
- RDF (Resource Description Framework).

Besides the conceptualization of the studied domain, ontologies are currently used in order to improve the very process of learning, helping to dynamically inter-relate individual work with the social context, as in the cultural-historical activity theory [4]. Thus, the knowledge is created collaboratively, using one or several ontologies for performing a task, organizing shared artifacts, generating inquiries, developing meta-cognitive skills. At another level, ontologies were also proposed for comparing curricula in various European universities, for supporting the transfer of credits [6]. The flexibility allowed by nowadays tools led to the definition of folksonomies also, light semantics shared and created by communities, which may be used in similar ways as the formal ontologies [5].

3. EquiLAB – a wiki leveraging open source LMSs

EquiLAB is an application dedicated to laboratory work with non-homogeneous instruments, as one usually has in academic environments. It is realized as a Web application - to be accessed from multiple locations of the university, by many teachers, researchers and students - and it was implemented using HTML, PHP and JavaScript. An important criterion for selecting the implementation technologies was to take advantage of the open source solutions. The environment for creating, handling and storing the database is MySQL. EquiLAB can generate web pages describing laboratory tasks, which can be accessed by students through a web browser. As Web 2.0 is a trend in the World Wide Web, we have used some of its specific technologies, like wikis and the use of descriptors or tags. This new kind of sites is based on a lightweight or simplified programming model, as opposed to websites where the whole software development is produced from scratch. We also used Ajax to create some parts of our e-learning applications.

The application has been designed for three actors: Teacher, Student and Administrator (see Fig. 1). Each of these roles has specific features:

- Teacher – has the most important role in this application, because it can introduce and characterize new equipments, it can manage the content of each lesson and it can associate the correspondent equipments for laboratory tasks.
- Student - can view courses and their associated lessons.
- Administrator - can create accounts for teachers and students, can manage the rights associated with these accounts and delete users.

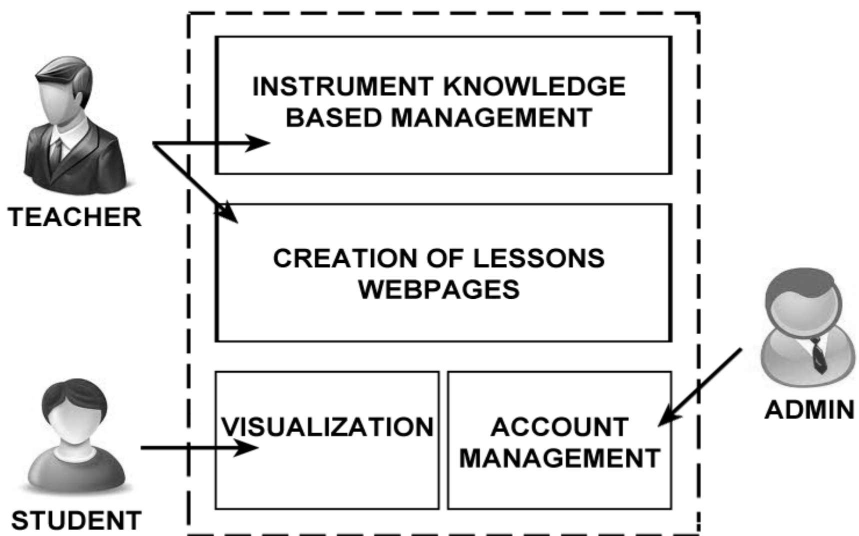


Fig. 1. EquiLAB Users

EquiLAB web site supports personal contribution and content generated by users [21], characteristic to Web 2.0. Moreover, one can configure the equipment characterization criteria, the lessons and the courses. Apart from the classical user management, EquiLAB has 3 main groups of functionalities: managing content related to measurement instruments, creating web pages with lessons and visualizing the structured learning content.

EquiLAB supports authorized users (teachers, researchers, PhD students) to manage information about measurement instruments and descriptions of laboratory tasks, like students' practical work or research activities. They can introduce knowledge about their own equipment, organized uniformly, according to the ontology of the measurement instrument domain (see Chapter 4) and then use the information for rapidly creating lessons associated with them.

The integration with the available LMS can be done by defining links that point to the URLs of the lessons defined with EquiLAB. The lesson URL link can be incorporated in the e-learning platform of the university.

Some well-known OS learning management systems are Moodle [17], Docebo [23] and Sakai [24]. Other platforms used in universities are closed-source, like Elab [25] - an eLearning application builder, enabling rapid development, integration, updating and deployment of eLearning courseware and content – or ELeap - a secure platform delivering intuitive e-learning and business training in an enhanced multimedia environment, using Web 2.0 technologies like Ajax and Rich Internet Applications (RIA) [26].

In our case, we link web pages generated with EquiLAB to the Moodle platform, chosen in order to improve the quality of the teaching process at Automatic Control and Computers Faculty from University "Politehnica" of Bucharest. This is an open source, freeware LMS, translated in 75 languages and allowing the adaptation of the user interface [12]. The intention was to blend the traditional way of teaching with Web technology, supporting a more flexible interaction with students and answering to their current needs. Thus, students log on to the Moodle e-learning platform, go to their course and, among other resources uploaded for the correspondent week, find a link to the lesson created with EquiLAB, for which the teacher can assign a supplementary password.

4. Measurement instrument ontology

Starting from the metamodel introduced in [8], we are currently elaborating an ontology regarding the measurements performed with various laboratory apparatus and equipment, in order to structure the knowledge using similar criteria, and to allow students to be quickly introduced to new instruments. Our purpose is to keep this ontology as simple as possible and then to let teachers introduce other concepts in a similar way, creating a folksonomy, which can help us for upgrading the ontology, on the basis of the users' community contributions.

As UML is being promoted for representing ontologies also, we use a class diagram to present the taxonomy with the underlying concepts of our lessons, plus the relationships between them (see Fig. 2). The concepts that are visible to the graphical interface of the teachers are colored with gray. The most important for characterizing the measurement instruments are:

- *Sample* – the measured object, which is often described through its mass, density and material;
- *Setup* – the class of information related to the equipment settings, necessary for performing a correct measurement;
- *Experiment* – information related to the measurement experiment, generally including the operator name, the date and the time;
- *Data* – including the physical measures whose amounts are determined throughout the experiment;
- *Curve* – representing a list of values corresponding to the evolution of a physical measure in respect with time or with another measure.

From this representation, one understands that a measurement can be performed on a certain sample, using previously done settings related to the instrument setup (Setup) or / and to the experiment (if the instrument is a sophisticated equipment). The results are represented separately, as simple data or as experimental curves.

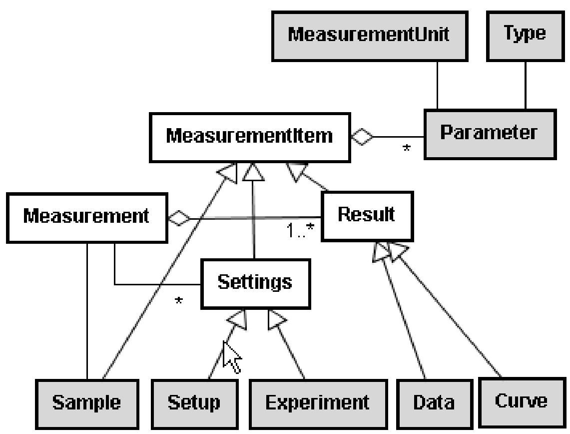


Fig. 2.The schema level of measurement instruments ontology

The main purpose of this conceptualization was to increase the students' understanding related to the facilities of the studied instruments, such as to be able to learn quickly how to use a new apparatus or equipment, as well as to have a framework for comparisons. After creating a new lesson, this one is used in traditional laboratories with real devices, unlike VLAB presented in [9], which is dedicated to the specification of virtual laboratories. Similarly to our approach, [10] defines the upper and lower ontology of a specific domain - the sustainable development - for structuring knowledge in their teaching tool.

The scope of our ontology covers the result data and the context in which they were measured – from the point of view of the person who uses and interacts with the equipment. Our concepts have some correspondences in LECIS

(Laboratory Equipment Control Interface Specification) UML profile [27], which can be used as a standard for automating laboratory work in heterogeneous laboratories. However, the profile describes control interfaces, state models and device properties and gives IDL (Interface Description language) definitions for CORBA-based environments.

For defining new lessons we implemented the structure we are currently using in our laboratories, plus the facility to select the studied equipments, whose description has been defined once and is being reused. A more general structure may be adopted by also taking into account an ontology - for characterizing heterogeneous learning objects, as proposed in [11].

5. Instrument Knowledge Base Management with EquiLAB

EquiLAB supports collaborative characterization of measurement instruments according to the ontology presented in Chapter 4. The Home page for the Teacher is the Equipments page (Fig.3).

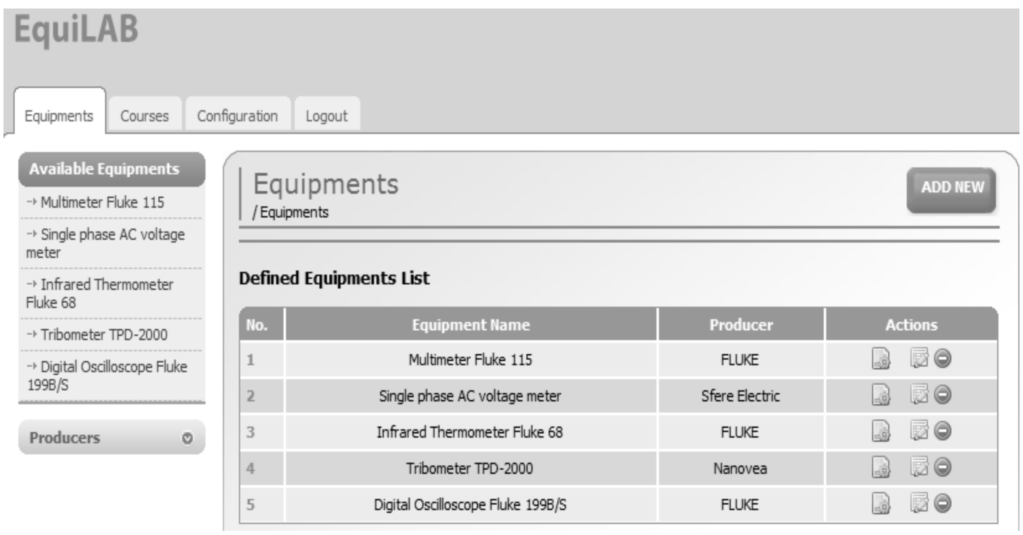


Fig. 3. The equipment page

This group of functionalities is accessible to the Teacher and contains:

- introducing new equipment, characterized by: name, producer, description, link to its website, equipment picture and data model picture;
- managing the parameters that characterize the equipment, using the button  from the Actions zone, grouped according to the concepts identified in the ontology (see Fig. 2): Setup, Data, Curve, Sample and Experiment;

- editing and deleting information about an existing equipment (using the buttons situated in the Actions zone);
- introducing new equipment producer.

The equipment parameters are described by their name, measurement unit (selected from a list of International System units) and type (real, string, boolean, enumeration). To show the potential of applying this classification for any complex equipment, Fig. 4 presents the list of parameters characterizing the experiments that can be performed with TDP-2000 tribometer. As described in [28], this device is used for friction and anti-wear characteristics measurement for solid materials (metal or not-metal material) and for various lubricants (fluid and solid lubricants and greases).

Parameters List for Equipment: Tribometer TPD-2000

Setup | Data | Curve | Sample | **Experiment**

List of: Equipment Experiment Parameters

No.	Parameter Name	Measurement Unit	Type	Actions
1	Experiment type	NO	Enumeration{disk_on_disk, block_on_disk, side_roll}	
2	Disk1Id	NO	String	
3	lubricant	NO	String	
4	beltRatio	NO	Real	
5	normalForce	newton	Real	
6	outputFile	NO	String	
7	startRecordImmediately	NO	Boolean	
8	startRecordWhenForceValue	NO	Real	
9	RecordingMode	NO	Enumeration{FastMode, SlowMode}	

Fig. 4. Experiment Parameters for Tribometer

We chose to impose a small number of classification concepts, in order to keep the editor simply to use. However, there is a large variety of equipments with diverse characteristics and our future work for enriching the instrument knowledge base is going to make the ontology evolve. For supporting end-users contributions for this, EquiLAB allows teachers to define new parameter groups, which appear as new Tabs, where one can edit the correspondent parameters. As depicted in Fig. 5, this is the way tribometer working modes (Disk_on_Disk, Block_on_disk, Side_roll) can be modeled.

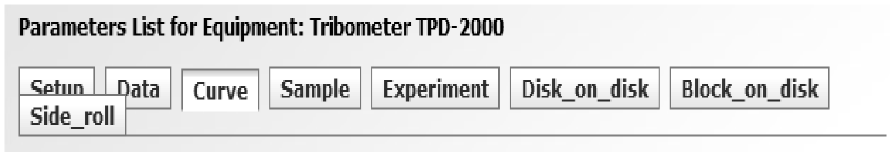


Fig. 5. The modified list of parameter

Thus, these parameters can also be tagged, according to concepts introduced by the Teacher, who actively participates for organizing the site categories and creating a folksonomy, unlike the classical e-learning applications, where tags are considered low-level descriptors.

Moreover, the Teacher can also use the Configuration Tag to create and manage measurement units and parameter types.

6. Creation of Lesson Web Pages for Laboratory Tasks

From the Teacher point of view, the application is a wiki, allowing teachers to manage information about a course or a lesson at any moment. In the Course Tag, one can create and configure the course, can attach lessons to the course and can assign the descriptions of the studied equipments to the lesson.

To create a new lesson, the professor must respect a standard structure, containing: name, topic, description, technical background, list of tasks and list of necessary measurement instruments (expandable with detailed information). For doing this, the Teacher has to choose from the previously defined list the equipments, as depicted in Fig. 6. Thus, the learning objects related to the measurement instruments can be reused and, moreover, they can be shared among different teachers.

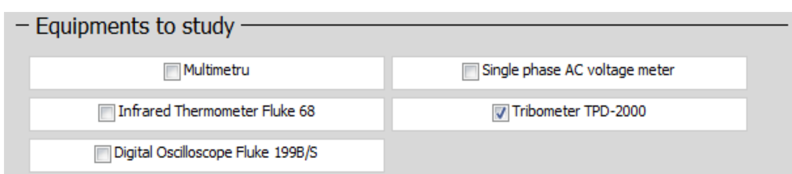
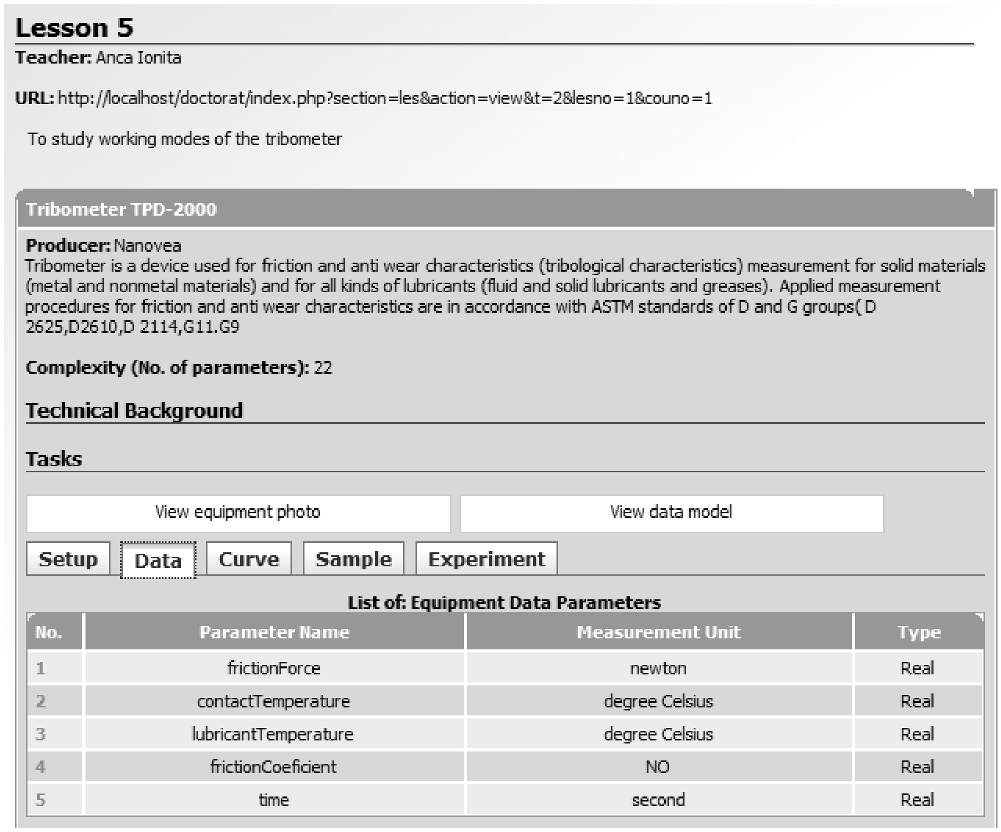


Fig. 6. The options: equipments to study

Once the lesson is defined in this way, it can be read either from EquiLAB or from any open source LMS, like Moodle. One generates a lesson web page, whose URL link can be incorporated in the e-learning platform of the university, as shown in the example of lesson for tribometer, from Fig. 7.



Lesson 5

Teacher: Anca Ionita

URL: http://localhost/doctorat/index.php?section=les&action=view&t=2&lesno=1&couno=1

To study working modes of the tribometer

Tribometer TPD-2000

Producer: Nanovea
Tribometer is a device used for friction and anti wear characteristics (tribological characteristics) measurement for solid materials (metal and nonmetal materials) and for all kinds of lubricants (fluid and solid lubricants and greases). Applied measurement procedures for friction and anti wear characteristics are in accordance with ASTM standards of D and G groups(D 2625,D2610,D 2114,G11.G9

Complexity (No. of parameters): 22

Technical Background

Tasks

View equipment photo | View data model

Setup | Data | Curve | Sample | Experiment

List of: Equipment Data Parameters

No.	Parameter Name	Measurement Unit	Type
1	frictionForce	newton	Real
2	contactTemperature	degree Celsius	Real
3	lubricantTemperature	degree Celsius	Real
4	frictionCoeficient	NO	Real
5	time	second	Real

Fig. 7. The lesson for the tribometer equipment

Professors and the students enrolled at their courses can see the new learning content, with lessons supporting weekly laboratory work. Students have the possibility to view the instruments described according to similar criteria and presented in a unitary fashion (see Fig. 7). They can also visualize a data model of the equipment, helping them to understand it better. Fig. 8 presents a part of the tribometer data model - related to its working modes.

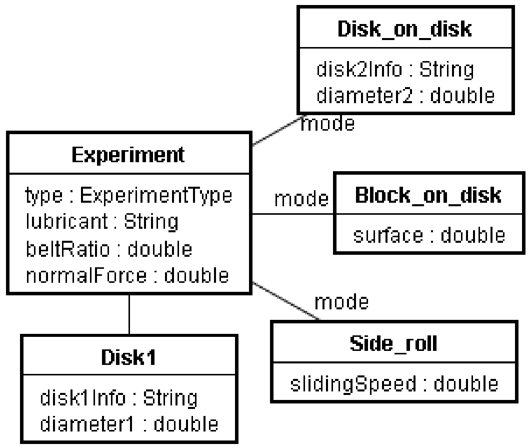


Fig. 8. Partial data model for the tribometer

In this chapter were presented the functionalities offered by the application, for teachers, in order to reuse the content, such as information about the equipments and how to create new learning materials, such as courses and lessons.

7. Conclusions

Web 2.0 can be used for creating complementary tools, which generate innovative forms of learning objects. In this paper we applied some of the associated technologies, like wikis and Ajax, for developing EquiLAB, a Web application allowing teachers to collaboratively create a knowledge base with descriptions of measurement instruments, to share information and to use it for rapidly configuring new web pages with lessons, for supporting laboratory work.

In order to respect similar criteria and improve students' understanding, all apparatus and equipment characterizations conform to a common classification, based on the ontology of the measurement instruments domain.

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