Learning Objects for a Teaching and Learning Network in Structural Engineering

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Summary
The information and communication technologies allow the construction of suitable virtual teaching and learning environments. However, it is crucial the readiness of reusable interactive hypermedia contents. The efforts have been focused in the search of a metadata proposal for independent description of systems for the so called learning objects. The strategy is the adoption of an object oriented development methodology to support the creation, organization, storage and offer of these learning elements for the academic community based on software engineering techniques and tied to the standardization efforts. This work also intends to corroborate for the definition of a metadata model for use in a repository of educational objects with publication in a web portal seeking for dissemination to help teaching and learning activities of structural engineering and related areas.

Keywords : educational objects, learning objects, repository, applets, reusability, structural engineering

1 INTRODUCTION
A lot has been discussed about information and communication technologies (ICT) in the education, including distance courses. Nowadays, one of the good results of this are the construction and dissemination of virtual teaching and learning environment. Therefore, it is crucial the dissemination of reusable interactive hypermedia contents like the called learning objects.

The strategy lies in the construction of a object oriented methodology to support the creation, organization, storage and offer of contents using patterns. In the work here described, ideas to create a knowledge generation network emerge in the form of learning objects for the Education of Structural Engineers (http://www.cesec.ufpr.br/etools), seeking the support to the formation of human resources, associated to the search of ergonomic and pedagogical resources (Oliveira e Silva 2002) for the correct and coherent application of these educational elements.

Lots of effort has been focused in the search for a metadata proposal, standardized and independent of systems for the learning objects. Metadata is the generic term used to describe data that can be used to identify and to describe common characteristics among different documents.

The aim of the metadata proposals is to facilitate the search, the evaluation, the acquisition and, the use of learning objects for students or instructors or even for software processes. As a standard, it also facilitates to share and exchange learning objects, allowing the development of catalogs and inventories, considering the diversity of contexts in which the objects and its metadata can be reused (IEEE/LTSC 2004).

This work also intends, to contribute for the definition of a Brazilian's metadata model to catalog and storage of reusable objects supporting repositories to management and content learning systems (LCS - Learning Content System and LMS - Learning Management System). Thus, these reusable objects can reach: accessibility, which gives the access possibility in several locations; interoperability: the easiness in using the components in different and

independent platforms; and durability: continuous use of the language without recodification even with changes in the technology base (Tarouco et al 2003).

Another foreseen result is the generation of a learning object's collection for the Structural Engineering, with publication in a web portal for open dissemination and improvements by the use of educational technologies in teaching and learning activities as well as in related areas. The construction of this learning object's collection will allow the development of learning systems capable to provide the students the knowledge in any moment and anywhere.

However, the construction of this environment is not a trivial process of didactic material organization and neither, a mere transcription of books in new formats. It requires a lot of effort involving human resources and financial support.

One of the concerns of the project is in accomplishing an ergonomic analysis of the portal, looking for a possible integration between the usability and the learning process. This ergonomic development study looks for provide functionalities that supply the users' needs and give the intuition, facility and efficiency in its use. In educational portals, the interfaces should be creative and attractive (Kalinke 2003). The ergonomic analysis should be in consonance with the apprentice the system. That means, to learn about the system and to learn using the system, i.e., learning the concepts beginning from the manipulation of the learning objects in the web portal.

2 Standards And Learning Objects

The construction of an educational environment should take in consideration some technical aspects. One of them relies on the development and identification of the learning objects. The development of these objects should foresee the possibility of its reuse, organization and a metadata classification, stored in a learning objects system (LCS/LMS).

In addition, there are several efforts for contents or learning management metadata standardization, like LOM (IEEE/LTSC 2004) of the Learning Technology Standard Committee of Institute of Electrical and Electronic Engineers, IEEE/LTSC; SCORM (ADL 2004) of Advanced Distributed Learning; IMS-Metadata of the Instructional Management System Global Consortium (IMS 2004); and the Dublin Core Metadata specification (Dublin Core Metadata Initiative 2004). The Figure 1 shows the universe of relationships of two of the proposals besides the called EML language (The Open University of the Netherlands 2004).

In the construction of learning objects, knowledge generation exists. This helps to develop and offer learning objects for Engineering Education.

Learning Objects' definition according to IEEE/LTSC, refers to "any entity, digital or not, that can be used and reused during the learning process using technology". Such objects can have hypermedia content, instructional content, learning objects, and support software (IEEE/LTSC 2004; Tarouco et al 2003).

Learning objects are elements of a new teaching and learning methodology based on the use of computers and the Internet. They are object oriented based with the characteristic of reusability.

In addition, the facility for description, creation, manipulation, and content visualization in the Internet, leads to the use of the XML language (eXtensible Markup Language) which was developed to describe documents' content, and projected to be used in the Internet according to the definition of the World Wide Consortium – W3C (W3C 2004). It is a favorable tool for the storage and description of data for the metadata that will be used in the portal and it offers larger flexibility than HTML to define tags. It is a free and expandable language, allowing authors of web documents to create its own tags. This facilitates a exchange of information between the author and the user of the web sites.

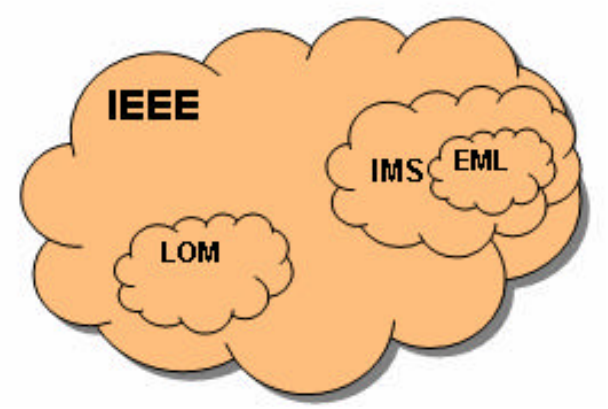

Figure 1 - Some standards and relationships in the learning objects world

XML language supplies a description of the document in a tree form, becoming appropriate for storage of data in the Web. The first representation of these data in the proposed repository's portal is in a taxonomy fashion (Figure 2). For example, it is possible to classify structures considering their n-dimensionality as follows:

- structures:
  - framed structures (one-dimension):
    - trusses;
    - frames;
    - grids;
    - arches;
    - cables;
  - bidimensional structures (two-dimensions):
    - plates;
    - shells;
  - tridimensional structures (three-dimensions):
    - solids;
    - dams;
    - blocks.

For the development of XML documents a procedure is being used in the project's repository that will generate the data structure generating the XML documents in real time. Through these documents it will be possible the integration among the portal of the referred project and others from different universities, facilitating the improvement, through the technology, of the teaching activities and engineering learning and related areas.

In this project, the contents should be structured and organized in a metadata model that is adherent to one of the standardization proposals. On example is the LOM (Learning Objects Metadata) (LTSC/IEEE 2004), a standard that follows the generic purposes of metadata. The developed learning objects, organized and following these stored standards can be recovered when and how it is necessary. Another characteristic is the capacity to reserve blocks that can have references for another objects and be combined sequentially to build larger learning units.

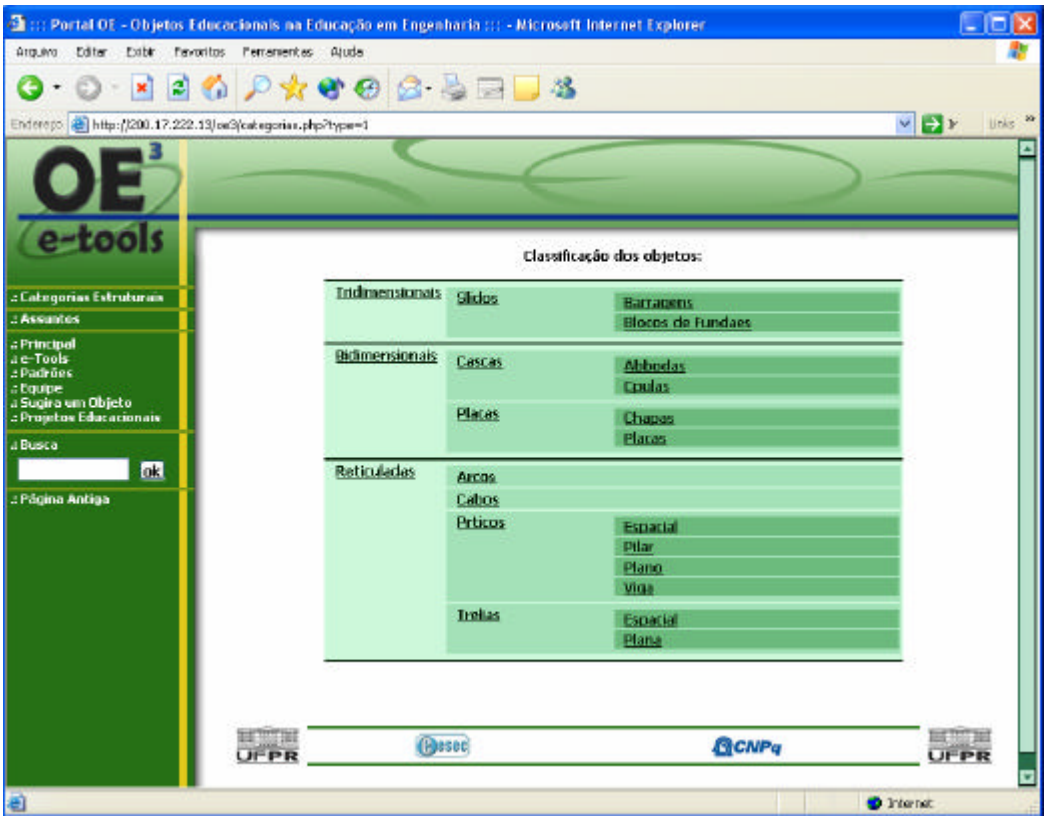

Figure 2 – N-Dimensional/Geometric Classification for the Structural Engineering Objetcs

2.1 Sample of metadata for a learning object

A XML description of a learning object using the LOM metadata specification is shown below.

```
<?xml version="1.0" encoding="UTF-8" ?>
<!--  edited with XRAy XML Editor  -->
<!--  <!DOCTYPE lom SYSTEM "imsmd_v1p2p2.dtd"> -->
- <lom xmlns="http://www.imsglobal.org/xsd/imsmd_v1p2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation
="http://www.imsglobal.org/xsd/imsmd_v1p2 imsmd_v1p2p2.xsd">
   - <general>
   - <title>
      <langstring xml:lang="pt">object's title  </langstring>
     </title>
     <language>pt</language>
   - <description>
      <langstring xml:lang="pt"> Textual description of the LO's content</langstring>
     </description>
   - <keyword>
      <langstring xml:lang="pt"> key word </langstring>
     </keyword>
 - <technical>
     <format>exemplo: applet/java; video/mpeg</format>
     <size> em bytes</size>
```

<location type="URI">learning object's URL </location>
</technical>
- <educational>
- <interactivitytype>
- <value>
<langstring xml:lang="x-none">Can be Active, Expositive or Mixed</langstring>
</value>
</interactivitytype>
- <learningresourcetype>
- <value>
<langstring xml:lang="x-none">May be Simul Exerc Lecture other </langstring>
</value>
</learningresourcetype>
- <intendedenduserrole>
- <value>
<langstring xml:lang="x-none">Teacher Learner Author or Manager</langstring>
</value>
</intendedenduserrole>
- <context>
- <value>
<langstring xml:lang="x-none">School, Higher Education, Training or outro</langstring>
</value>
</context>
- <typicalagerange>
<langstring xml:lang="x-none"> Age interval or the students minimum age </langstring>
</typicalagerange>
- <description>
<langstring xml:lang="pt"> How used object Commentary </langstring>
</description>
</educational>
- <rights>
- <cost>
- <value>
<langstring xml:lang="x-none">The use of the object requires or not payment</langstring>
</value>
</cost>
- <copyrightandotherrestrictions>
- <value>
<langstring xml:lang="x-none">Restriction Copyright or others if to apply or not to apply if object</langstring>
</value>
</rights>
</lom>

3 Some Brazilian Experiences

In the Federal University of Paraná (UFPR), the Civil Engineering Research Centre (CESEC – http://www.cesec.ufpr.br/etools) is developing computer based engineering educational applications since 1986. With the Internet/WWW phocus and the learning objects approach, it is relevant the *eTools* colaborative project dealing with the development of Java applets and Flash (Macromedia Flash 2004) applications. The main subjects are the Structural Engineering and the Computacional Mechanics.

In the context of the *eTools* initiative, the *OE3* (*Objetos Educacionais para Engenharia de Estruturas* which is the acronym in Portuguese for Learning Objects for Structural Engineering) repository has available learning objects specifically developed for disciplines like Strength of Materials, Structural Mechanics, Reinforced Concrete Structures, Steel Structures, and Wood Structures.

In the eTools cooperation activities, some other Brazilian universities are working as could be seen at one of the others project web site: http://www.tecgraf.puc-rio.br/etools. The different produced software resources permit the graphic interacttive manipulation and visualization of complex situations under structural analysis and simulation.

To help Physics teaching and learning activities, the University of São Paulo has the LabVirt initiative with a portal for educational objects that are described following the IEEE LOM standard (http://labvirt.futuro.usp.br).

Finally, one relevant effort is the CESTA project (http://www.cinted.ufrgs.br/CESTA) that looks for the systematic and organized learning objects cataloging using the LOM standard and the LDAP directory services (Tarouco et al 2003).

4 Open Platform for Development of the Learning Objects Repository

The educational objects can be generated and used in various formats: applets Java; animation sequences (like Macromedia Flash programs); video or audio; presentations (like Microsoft's Power Point presentations) that can be combined with plain texts, and hipertexts. Together hipertexts and multimedia elements create the so called hypermedia which can be a very interesting tool for education. Any of these (learning objects and hypermedia elements) can be combined and used to lead the user to reflect about a specific content or situation and construct his own knowledge.

In the OE3 project here described, the learning objects are preferentially developed in Java language (Sun Microsystems 2004), because it is a simple language and the programs can be executed in all the platforms of operating systems, due to its concept of virtual machine. Its library is part of a system that defines portable interfaces. Java is a language projected to support applications in networks, as well as it is object oriented based, what makes it possible to supply reusable software.

The chosen operational system for the repository server is Linux. As an open platform it presents good economy saving resources.

The basic language for the development of the portal is for PHP – recursive acronym for Hipertext Pre Processor (The Apache Foundation 2004) - because it is a fast and dynamic language for the Internet application and, efficient in generating HTML pages dynamically. PHP is a server-side scripting language and possesses access to several systems of databases starting from the language SQL (Structured Query Language) (W3Schools 2004). One of the very well know open and free database system is MySQL (MySQL AB 2004) that is capable to process and generate a great amount of information, enough for the content of the current portal. It is also free and open code, being a multithread database: the program creates a link for each

customer that establishes a connection with the server. It doesn't interfere in the user platform. Another advantage is exactly in his security mechanisms and reliability.

5 The *OE3* Learning Objects Repository

The *OE3* repository is part of a Structural Engineering Education web portal under construction.

5.1 Repository main functions

The OE3 repository implemented main functionalities are:

- two diferent ways of cataloging the learning objects:
  - one related to a n-dimensionality classification (Figure 2);
  - the other, a list tied to the regular themes of the undergraduate Civil Engineering course:
    - Structural Systems:
      - Reinforced and Prestressed Concrete;
      - Steel Structures;
      - Wood Structures;
    - Introduction to Solid Mechanics;
    - Strength of Materials;
    - Theory of Structures: Static and Hyperstatic.
    - and, Building Structures;
- (b) suggestion form for new learning objects;
- (c) two different search mechanisms: a fast search for any keywords that can be directly typed; a compound advanced search with up to three combinations of title, description, URL, author, keyword, year, format and technology.

5.2 The minimum object description characteristics

Any user can suggest learning objects. To accomplish this it is necessary to fill an available web form that follows the LOM minimum list of characteristics as described:

- General Information:
  - Title (object´s name)
  - Web address / URL
  - Description (purpose, how it works)
  - Keywords
  - Structure (atomic, collection, chained, hierarchic, linear)
  - Aggregation level (fragment, lesson, course, course set)
- Life Cycle:
  - Version
  - Status (draft, final, revised, not available)
  - Contribution (1 to 4) (author, dissemination/publication, unknown, promotion, termination, validation, editor, graphic designer)
  - Institution or person;
  - Date;
- Technical Information:
  - Format (applet, application, video, text, animation, other)
  - Size (Bytes)
  - Location
  - Necessary technical requirements:

        - Type: required technology to object use, like operational system, browser, etc.
        - Technology name, like MS-Windows, MS-Internet Explorer, etc.
        - Version
    - Time Interval (example: ´PT1H30M´= one hour and thirty minutes or ´2M15S´= two minutes and 15 seconds)
- Educational Information:
    - Interactivity type (active, expositive, mixed)
    - Educational resource type (exercise, simulation, questionnaire, diagram, figure, graphic, index, slide)
    - Interactivity level (very intense, intense, medium, low, very low)
    - Potential user - ´square´ (teacher, author, student, administrator/manager)
    - Context (high school, undergraduate, training, other)
    - Typical user age (example: ´7-9´, ´18- ´, ´only adults´)
    - Dificulty level (very easy, easy, medium, dificult, very dificult)
    - Description
- Author Rights:
    - Costs (yes, no)
    - Copyright (yes, no)
    - Comments
- Relationship with other objects:
    - Type of relationship (part of, has part, is a version of, has a version, is a format of, has a format of, makes reference, is referenced by, is based on, is base for, requires, is required for)
    - Object source:
        - Input
        - Description.

The results of a search in the repository show only part of the internal description as follows: title (link active), author, technology, date, web location (URL), and description.

5.3 Some *OE3* Samples

5.3.1 Steel Structures Applets

Regarding to the steel structures modeling, another set of applets is available in a web course (as seen at http://www.cesec.ufpr.br/metalicas/) and also in the repository (Figures 4 and 5).

The first one deals with compressed steel structure elements, calculating the maximum design load to avoid buckling (Figure 4). The user can determine the cross section properties by choosing specific shapes in a list or by giving geometric dimensions.

After the cross section is chosen, the support restrictions of the steel element need to be pointed. The instability lenght factor is then calculated or even a chosen value can be typed. With the actual column lenght and the axial load, the resistance is calculated for three diferent steels. All the calculations are based on Brazilian regulations (ABNT - NBR 8800).

The applet shown in Figure 5, deals with the rupture limit and the calculation of the effective net area in bolted elements. The user can define different failure paths using the mouse or the keyboard. He also needs to indicate the position and the diameter value of the holes. If the critial path is not pointed, the applet shows the right critical path. The applet has snap and grid capabilities.

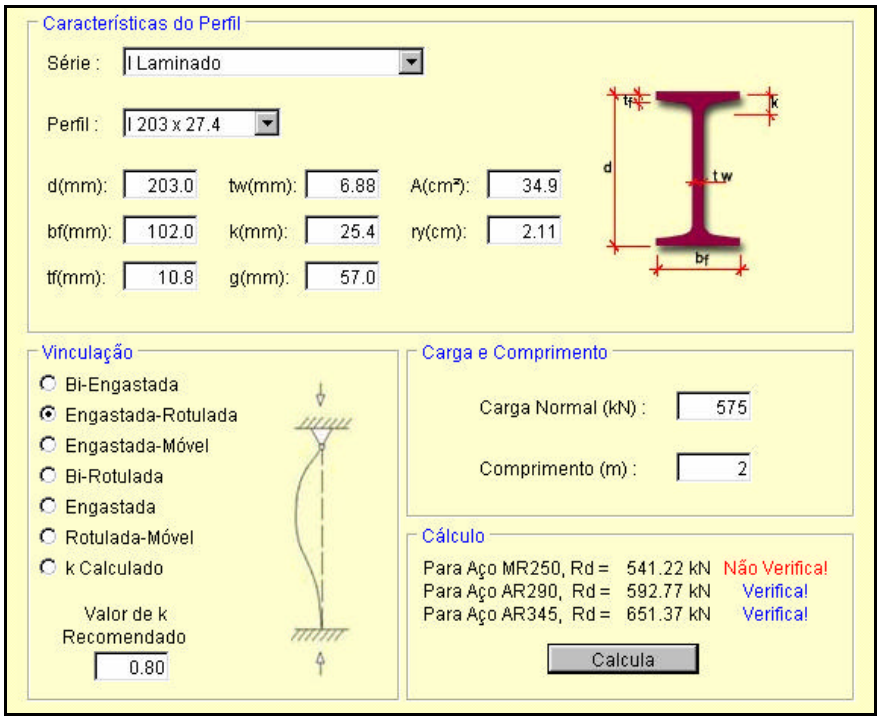

Figure 4 - Applet for compressed steel elements - buckling

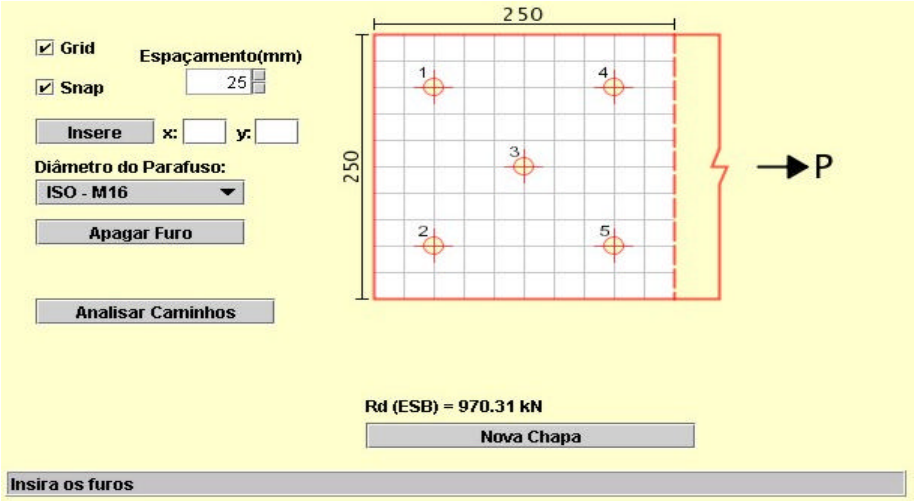

Figure 5 - Applet for tractioned bolted plates

5.3.2 Wood Structures Applet

For wood based structural systems a buckling applet is shown in Figure 6. It handles geometric section, length, load, excentricities, support restric tions, and diferent wood types.

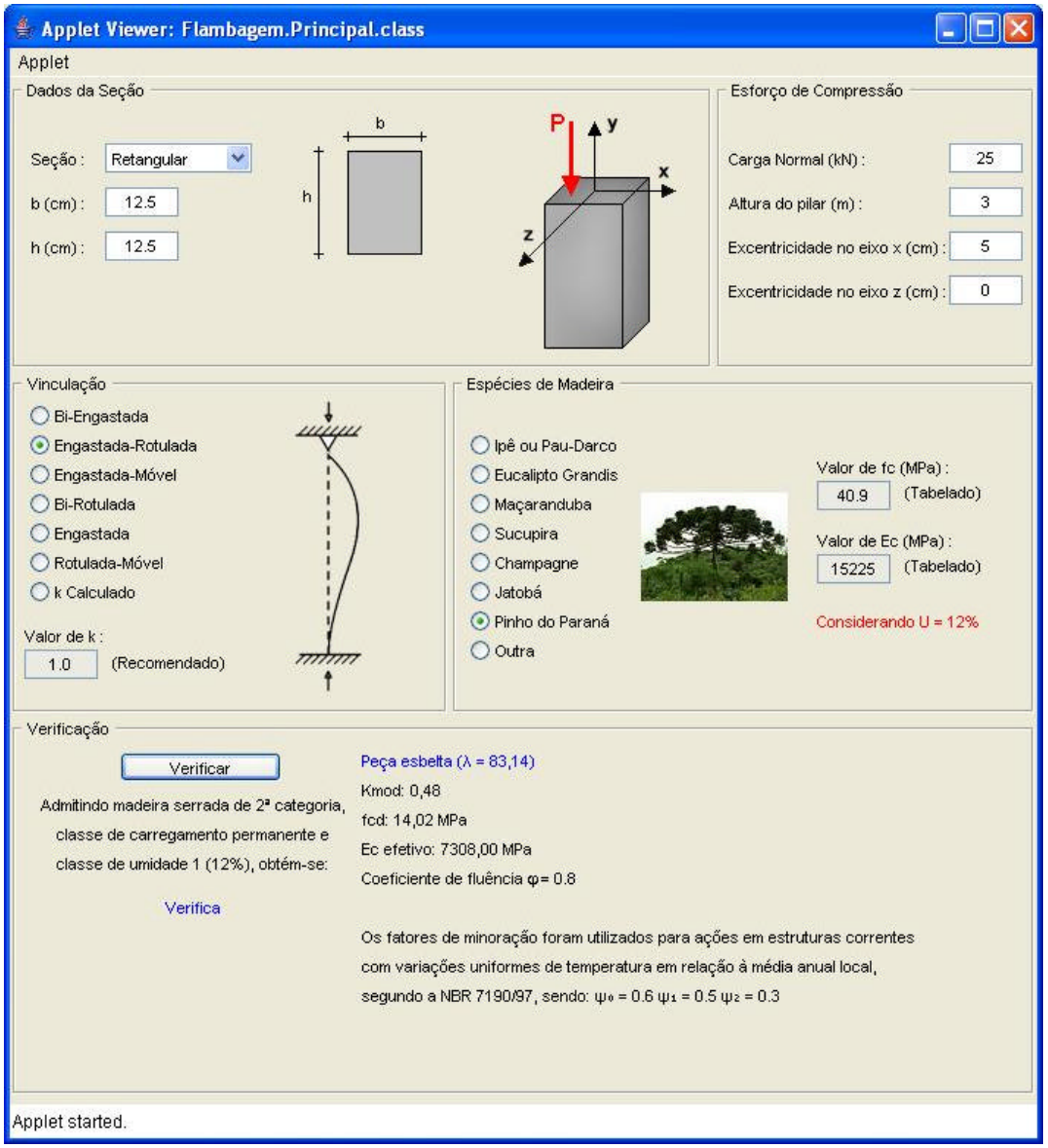

Figure 6 – Buckling of wood elements applet

5.3.3 The e-Truss web application

E-Truss application represents a web-based application to create, modify and analise framed structures (Figure 7). In this version, only plane trusses are treated.

A computer program to solve plane trusses can be divided in three different phases: pre-processing, analysis, and post-processing. The first phase treats the structure identification in terms of nodes identification and location, elements identification and element incidences, node restrictions, geometric and physical properties, and loadings. The analysis solves the formed linear equation system, giving the nodal displacements and the axial solicitation in the elements. The post-processing presents the nodal displacements, the deformed structure, and the efforts in the individual elements.

The e-Truss has a thick web client architecture. The web browser using the HTTP protocol, requires to the server a web page containing a Java applet. This applet permits to the user the pre- and post-processing of plane trusses. The analysis is then performed by a C++ program running in a Linux Slackware 2.0.6 server, when requested by the Java applet, that uses a Common Gateway Interface (CGI) mechanism.

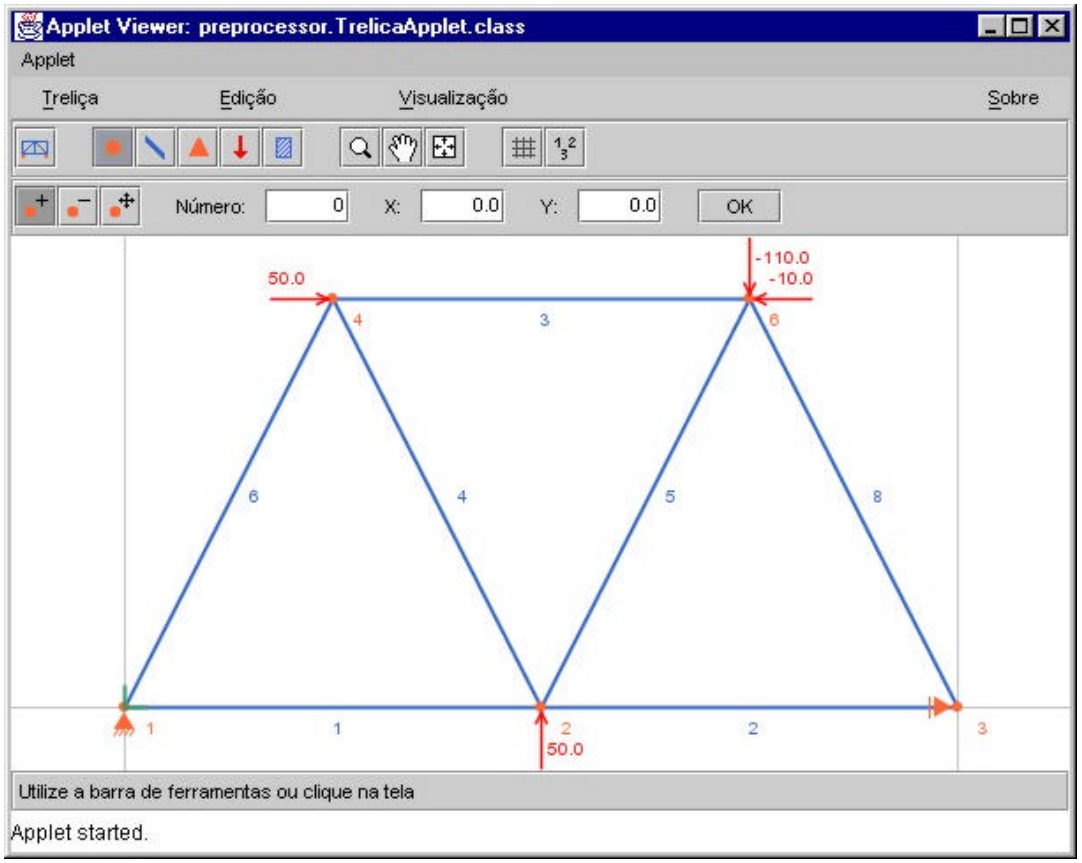

Figure 7 - The e-Truss Graphic Interface

6 Conclusion

The initiative to develop an object oriented methodology to learning objects seeking its organization and storage doesn't represent an isolated initiative as it can be verified in other experiences referenced in the text. This work also concerns with the context of a wider study about the development of learning objects and its storage and recovery with appropriate pedagogical uses.

The presented standards are not an isolated or final solution to describe metadata. However the most important is the warranty of accessibility and interoperability of the learning objects, with independence of platform and durability.

The described project (*OE3*) is part of an integrated cooperative network (*eTools*). Thus, it can be considered as extreme relevant in terms of the cooperation through the Net in research projects, taking advantage of the communication readiness and increasing the use of Internet/WWW for research and educational purposes.

Under the optics of the software development, the use of free and open software tools developed in academic institutions should also be highlighted. The character of open application, of public domain, free of costs to the final user (teachers and students, engineering professionals), as

reusable objects for application in teaching, learning and professional activities, shows that the effort is worthy.

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The project´s URL is http://www.cesec.ufpr.br/etools/oe3.

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