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Improving the Reusability and Interoperability of E-Learning Material

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***Abstract*—**A key requirement for e-learning materials is reusability and interoperability, that is the possibility to use at least part of the contents in different courses, and to deliver them trough different platforms. These features make possible to limit the cost of new packages, but require the development of material according to proper specifications. SCORM (Sharable Content Object Reference Model) is a set of guidelines suitable for this purpose. A specific adaptation project has been started to make possible to reuse existing materials. The paper describes the main characteristics of SCORM specification, and the procedure used to modify the existing material.

***Keywords*—**SCORM, e-learning, standard, educational effectiveness, assessment, methodology, open access.

I. Introduction

IN the last years, at the Politecnico di Torino several initiatives brought to the development of a rather consistent amount of educational material for e-learning. Being developed by different authors in different contexts, these materials follow different formats and styles, which make difficult to reuse them to assemble new courses. In the same period the standardization of e-learning material emerged and became accepted as the basic requirement for cost reduction through sharing and reuse.

These experiences put in evidence the need for a more coordinated effort in the development, and the combination of the above issues: availability of educational material (with no specific provision for reuse), and emerging of "design rules" to embed easy reuse into the material structure and organization became the starting point for the project described in this paper.

The project aim is to make existing material compliant to SCORM specification, thus achieving indexing, retrieval, and easy reassembly capability. Special care is devoted to the assembly of courses customized for the needs of specific groups of students, e.g. to fill specific lack or misunderstanding in preparation. The work started from courses in Physics, since there is a consistent amount of material already available, and because good understanding of these contents is a key requirement for engineering students.

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II. SCORM

SCORM (Shareable Content Object Reference Model) [1], designed by the ADL (Advanced Distributed Learning) [2], is a reference model used to help instructional designers and technicians to design and develop effective and efficient e-learning courses and e-learning platforms. SCORM is related to the way educational content should be organized and packaged in order to be delivered efficiently and effectively; the specifications do not address any aspects related to the educational quality or methodologies.

A Learning Management System (LMS) lets the learner use a virtual environment where she/he can find either the educational content or the distance learning services such as chat, forum, virtual blackboards, virtual classrooms, etc...

SCORM helps instructional designers to set up a direct connection between the LMS and the educational content: a SCORM compliant LMS allows to correctly import and deliver SCORM compliant courses.

SCORM could be used to reduce overall costs associated to the design and development of multimedia education contents by highlighting aspects such as:

- accessibility: the educational content should be easy to be searched and delivered
- adaptability: the educational content should be learner centered
- durability: the educational content could be re-used
- reusability: the educational content should be modular and easy to update
- interoperability: the educational content should be able to be delivered without errors

The cost reduction is not the only objective of SCORM. By using it correctly it is possible to set up a flexible and distributed system that allows efficiently aggregating, disaggregating and organizing educational content.

A SCORM course is composed by digital educational content with descriptive and functional information.

The descriptive information addresses three topics:

- technical info about the location of files related to the educational content
- structural info about the educational content, used to describe the list of units that compose a course and the way of using it
- detail info used to describe all the characteristics of

the educational content

The functional information is related to the delivery of content and the relations between the platform and the educational content. The information that the content can send to the LMS are for instance the percentage of course delivered to the learner or the score of the learner as response to specific questionnaire.

A. *Structure of a SCORM Course*

A SCORM course includes two parts:

- a manifest file (imsmanifest.xml)
- all the other sections (files, resources, etc…)

The manifest file is divided into three sections:

- Resources
- Organizations
- Metadata.

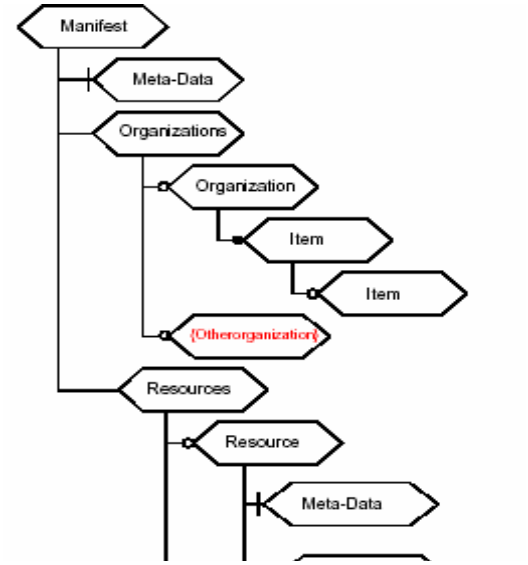

Fig.1 Manifest file sections

The manifest file is a text file with strict syntax that can be manipulated by any text editor. The other sections of the content include all the delivered content pages, with all the functional information needed to communicate with the LMS.

The functional information is transmitted by using Javascript code. The educational pages must be in HTML format.

B. *Design of a SCORM Course*

The creation of an effective SCORM course requires technical and educational skills. The mandatory tools are an editor of educational content (which depends on the type of object to create), and an XML editor to create the manifest file. The manifest file should include all the info about the resources, organizations and metadata sections, as defined by ADL.

Several SW tools can be used to simplify the creation of the content and of the manifest; is it possible to use different software for each step or integrated environment which allows the development of SCORM-compliant content.

In the last few years the availability of efficient Open Source tools and environments strongly reduced the cost of setting up a development environment.

C. *Which version of SCORM and how to use it?*

The SCORM 1.2 specification [3] is the most stable and tested version. The SCORM 1.3 specification (also called SCORM 2004) [4] includes new complex sections such as sequencing and navigation which have not been completely tested.

The SCORM is composed by different documents:

- Overview: it describes the SCORM specification from a generic point of view. It is the document to be read before starting any SCORM process
- CAM (Content Aggregation Module): it explains how to organize content. It defines learning objects (or sharable content objects), assets and the structure of metadata and manifest file
- Run Time Environment: it defines the runtime specification and gives the communications between the LMS and the educational content. This section is essential for designers of SCORM compliant e-learning platforms
- Sequencing and navigation: this section is missing in the SCORM 1.2 specification and it describes how the LMS interact with pages of the educational content.

III. FIL[1]: Fisica in Linea project

FIL [5] is a web based general physics course designed both to give support for the study in face to face lectures and for the use in distant learning courses of the Engineering Faculties of the Politecnico di Torino. The general structure of FIL is similar to the one usually implemented in a number of analogous products which nowadays many universities offer to their students. Mainly we have a collection of HTML pages with the structure of a hypertext, in which various links and hot words permit the navigation across all the available materials.

Fig. 2 shows both the general index of FIL and the one for a specific topic.

[1] Acronym of "Fisica in Linea" = Physics on Line in Italian

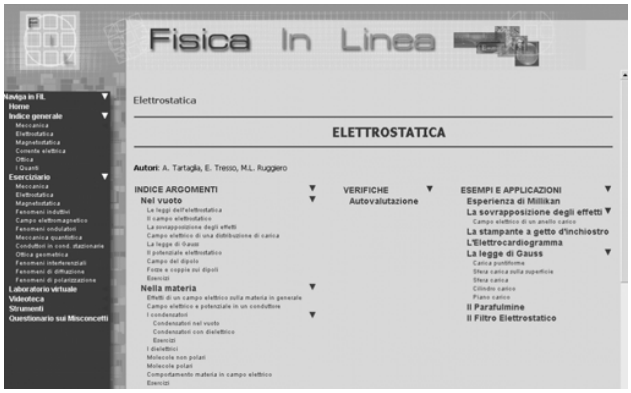

Fig. 2 On the left side it is possible to see the partially opened general index of FIL. The central and main portion of the figure contains the specific index for Electrostatics including sub-items, the link to the self-evaluation tool and the examples

The texts are concise and essential in order not to reproduce the equivalent of a standard book: on one side books remain a fundamental tool for the study; on the other, nobody really wants to read a book on the screen. The explanatory text is interspersed with graphics and in particular animated graphics. A typical page is shown on Fig. 3. The animations, most often FLASH-objects, are in general activated by the students; together with plain animations there are a number of simulators (usually Java-objects) allowing for a stronger interaction of the user with the simulation, and, conceptually, with the physics of the phenomenon which is being simulated. The platform integrates the main explanatory path with an applications inventory, a link to a self-evaluation tool, and a section devoted to exercises in various form. As for the exercises they correspond to a whole book and have different forms of interaction with the user.

A relevant section of the whole platform is represented by the virtual laboratory: 5 complete simulators of practical experiments, developed by a group at the Valladolid University in Spain, with whom we are collaborating. A typical snapshot of a laboratory may be seen in Fig. 4.

FIL also has a section from where videos and presentations may be freely downloaded. The tools section ("Strumenti") includes a complete lecture notes book ("Materiali per lo studio"), useful links, glossary, tables of physical constants, etc. Most, but not all, of the materials available on FIL have been produced by our group at the Politecnico. Other objects come from freely accessible sites of other universities and/or from direct collaborations with other groups. In this field it is pointless to pretend to be self-sufficient; the best comes from an open source policy which we completely agree upon. FIL is freely accessible at http://www.lamp.polito.it/fil.

Now, in order to enhance the efficacy of FIL and to monitor the progress made by the users, we have started the project being presented in the present paper which implies the reorganization and standardization of the existing learning objects. A better delivery of the contents will be made through a dedicated platform such as Moodle (it could also be Claroline). The evaluation and self-evaluation activities become a necessary component of the learning activity and track will be kept of each individual step of the user. As for the contents, they continue to be enriched in order to have a growing stock of basic physics contents, which may be used in different ways. By now specific animations and simulations of FIL can be and are used by teachers in the class room in what may be called computer aided teaching.

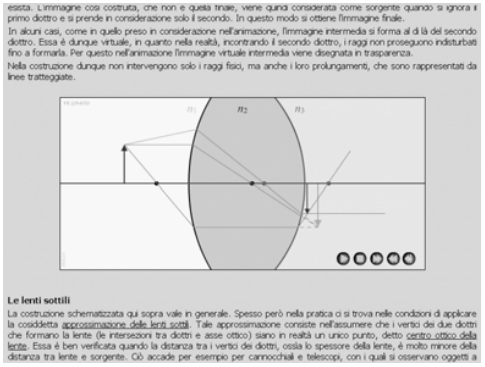

Fig. 3 The page of FIL concerning the thick lens, with the flash animation for the geometrical construction of the principal rays. The animation can be used by teachers in the classroom lessons

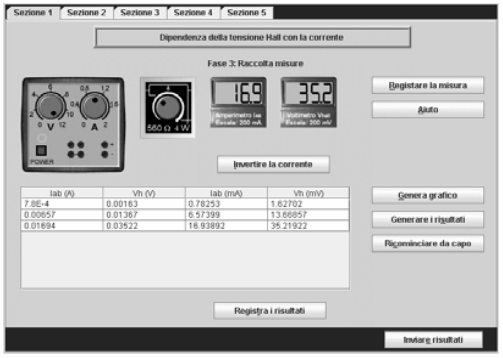

Fig. 4 One page of FIL belonging to the virtual laboratory on the Hall effect

IV. FIL – Migration to SCORM

The main idea of the FIL-SCORM migration project is to improve the educational effectiveness of on-line teaching and learning resources by allowing authors to assemble new courses customized for the needs of specific groups of learners using existing material. Moreover the project includes a global revision of the existing educational material created for the FIL project. Authors should be allowed to assemble different educational paths in order to let each learner to improve specific knowledge and remove the most common misunderstandings about physics. The SCORM model will be used in order to reduce the costs and to get standard compliant educational material that could be reused in the future.

The FIL migration to SCORM project has been divided into

different phases.

- analysis of the existing educational material.
- adding content specific Metadata
- design of the structure of a Learning Object
- design of a SCORM template
- creation of Learning Objects from existing material
- creation of SCORM Learning Objects
- LMS repository
- Assessment and evaluation

A. Analysis of Existing Educational Material

The first phase of the project is related to the analysis of the existing educational material. As described in previous sections, FIL content has been developed by using WEB technologies. It is essentially made up by HTML pages, with FLASH animations; interactive quizzes developed in Javascript and applet Java simulators.

We identified the main tasks to be developed before starting the SCORM migration process:

- analysis of the structure of the existing content
- evaluation of the time needed to study each concept
- identification of the metadata for each concept (authors, copyright, taxonomies and ontologies, technical info, etc…)
- identification of links to external files or resources (images or animations) for each HMTL page
- identification of missing content

Each content topic has been revised and updated by removing any link to external resources, in order to have self consistent educational content.

B. Metadata

To create SCORM compliant educational content, metadata should be added to the Learning Objects, to let the content be searched and reused efficiently. SCORM specifications use the LOM Metadata scheme [6]. A "metadata" instance is a set of informations that fully and adequately describes relevant characteristics of the learning unit, in order to facilitate search, evaluation, exchange, acquisition, and reuse. The IEEE LOM (Learning Object Metadata) specification is used by SCORM.

Metadata should contain information at least about the name of the course, the course description, the course provider, the course extent, the authors, the date, the curriculum level, the learning style it supports, what part of learning environment it is and when it was last updated. Additional data-elements, such as the "Learning style" can be added as attributes of a specific category.

More than eighty metadata attributes are defined by the LOM scheme and the filling process can be very long. A tool to enable the completion of metadata has been developed within the 3DE project [7] and it will be used for the insertion of metadata about the FIL content. Recurrent metadata are automatically filled (e.g. author's information, etc…) in order to reduce the time required to fill in the metadata information.

C. Structure of a Learning Object

It is essential to determine the structure of the Learning Object, in order to define a Learning Object template to be used for the content aggregation.

Lots of Learning Object definitions can be found all over the Internet; one of the most used is the following: "a learning object is a self-contained piece of learning material with an associated learning objective, which could be of any size and in a range of media". Learning objects are capable of re-use by being combined together with other objects for different learning purposes.

The most important features of a Learning Object, thus, are:

- restricted "logical" size
- independence / self-consistency
- reusability
- accessibility
- interoperability between different LMS.

These elementary Learning Units are then aggregated to compose higher-level Units of Instructions, such as Lessons, Chapters, Courses, etc....

Starting from the concept of Learning Object described above, we designed for this project a particular content structure, divided into twelve elementary sections, each of which can be mandatory or optional:

- **title**: the title of the LO – (*mandatory)*
- **course presentation**: a brief introduction to the content of the LO – (*mandatory)*
- **learning goals**: what the learner should know at the end of the LO – (*mandatory)*
- **entry test**: the learner must be provided with tools to measure her/his competences, in order to identify "faults" and to correct them as soon as possible – (*optional)*
- **previous courses**: previous courses that the learner must have studied before – (*mandatory)*
- **prerequisites**: prerequisites needed by the learner to start the LO – (*mandatory)*
- **theory recall**: direct links to theory concepts – (*optional)*
- **bibliography**: links to related resources (books, papers, Web sites, etc..) – (*optional)*
- **core**: the real content – (*mandatory)*
- **examples**: examples related to the content of the core – (*mandatory)*
- **recommended exercises**: exercises that should be done carefully by the learner – (*optional)*
- **final self-assessment test** – (*mandatory)*

The navigation through the content can be free (no restrictions) or directly related to the results of exercises and final test (restrictions can be applied if the minimum score needed to start the next LO is not fulfilled).

D. Creation of a SCORM Template

After the definition of the structure of the Learning Object we have developed a SCORM Learning Object template which includes all the sections (mandatory and optional) described in the previous paragraph. A set of SCORM calls to be used for the communication between the SCORM Learning Object and the LMS has been added. The manifest file has been written by using RELOAD [8], one of the most popular Open Source tools used to create SCORM content. The template will simplify the creation of future SCORM Learning Objects.

E. Creation of LOs starting from Existing Material

The creation of Learning Objects implies a cooperative effort between content authors and instructional designers.

The first step for the design of effective and efficient Learning Objects starting from existing content is to compute the correct size of a Learning Object. This information is strongly based upon different parameters such as:

- how much information is needed to achieve the learning result;
- the level of reuse that the author whishes to obtain.

The next step is to determine the level of interactions of the educational multimedia content with the learner as well as the learner data to be tracked (for example the learner id, the total completion time, the lesson status, lesson bookmarks, session time, etc...). The analysis of the existing educational material is extremely important in order to:

- set the criteria to be used to segment existing learning content into effective and efficient Learning Objects. This task will allow to disaggregate and re-aggregate educational content in order to create a Learning Object focused around one or more learning goals
- identify educational content to be created from scratch
- identify educational content to be revised (text errors, animations that do not work correctly, missing images, removal of any external links or links to other learning materials in order to get self-contained Learning Object)
- identify educational content to be completely rewritten by the content author.

By taking into account these recommendations we started a complex phase for the global revision of the existing educational content in order to create self consistent SCORM Learning Objects.

F. Creation of the SCORM Learning Objects

The creation of a SCORM Learning Object is a complex step. In the previous sections we described the structure of a Learning Object, we formally set up a Learning Object template to be used for the creation of the SCORM Object and we identified a set of recommendations to be followed during the migration of content to SCORM Learning Objects. The educational content has been divided into Learning Objects by taking into account different parameters such as the total completion time of the Learning Object and the educational objectives. The physical creation of the Learning Object starting from existing content is a technical issue.

SCORM objects will be created by filling the defined template with the existing content. For this purpose we will use Macromedia Dreamweaver HTML editor.

The template also includes a set of SCORM calls, but it is necessary to add new SCORM calls in order to track user data and fully manage the communication between the LMS and the Learning Object.

G. LMS Repository

By following the previous step we will rapidly get a set of Learning Objects with the proper structure. These Learning Objects will then be uploaded on a Learning Management System based upon Moodle [9]. The LMS allows learners to use interactive services such as chat or forum in order to have a completely new collaborative learning experience. The repository allows to setup different educational paths by combining learning objects in different ways. Authors will be able to search for specific existing Learning Objects and to assemble customized educational paths with different target objectives.

H. Assessment and Evaluation

The main objective of the described project is to improve the educational effectiveness of the content. In order to verify the real effectiveness of the proposed methodology we plan to set up some specific assessment and evaluation sessions.

The evaluation methodology is concerned with finding out how well users can use something, what they think about it, and what the major problems are, with the aim of improving design and re-design phases.

The process of the evaluation is essential for assuring quality of use:

- how effectively and efficiently intended users can achieve particular goals using a product or prototype
- how satisfied they are with it
- how well it meets specific requirements (e.g learnability, appeal, engagement, error avoidance, etc.)

There are different methods for evaluating a product, an environment or a process. It is important to select a set of methods that are practical and valuable for use in product assessment:

- **inspection methods,** based on having evaluators only examine a software product without involving end users.
- **user testing**, based on observation of the use of systems or prototypes by a sample of users (in lab or field), to assess quality of use and identify problems

- **user satisfaction methods**, which employ interviews or questionnaires to gain insights into what users think of a product, identify areas of difficulty and assess satisfaction.

The evaluation of user satisfaction aims to discover what people think and feel about using a product and to assess the perceived quality of use. It is based on asking people to share their experiences and opinions, usually in a structured way by responding to specific spoken or written questions.

It may involve drawing out insights by facilitating commentary or discussion on the experience of using something. There are well established techniques for eliciting user views, identifying issues, and measuring user satisfaction. We will define some specific questionnaires to be filled by the users before and after the use of the educational content. The results will be collected and statistically analysed in order to get some useful information that could be used to improve the process used to create the content and the services.

V. Conclusion

The creation of a common repository where different authors can find a variety of SCORM compliant Learning Objects, and use them to compose different learner centered educational paths will greatly reduce the cost of new developments. Mixing material from different authors adds variety of teaching styles, thus providing to learners more chances to find something better fit to their individual learning habits. These combined effects will offer a great opportunity to improve the educational effectiveness of the open learning experience.

The assessment and evaluation phase will provide information about the effectiveness and usefulness of the methodology and will make possible further refinements. The methodology developed in this project can thus be moved also to other educational areas of COREP and of Politecnico di Torino.

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