Instructional Process and Digital Resources

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Every step of the instructional process can get much advantage from the several educational resources (contents and tools) available on the Web. The main problem is to find the most appropriate resources for our goals, and the information to use/re-use them in our teaching/learning activities. Several standard metadata schemes exist and are used, such us Dublin Core and IEEE Learning Object Metadata (LOM), that can enhance web instructional resources discovery, even if they were mainly designed for the web-cataloguing of bibliographic items. In this paper we propose a classification scheme of instructional digital resources, specifically adapted for the instructional process we will illustrate, taking into account that web resources can be teaching/learning materials (learning objects), but also "tools", i.e. computer software, that need additional technical information to be used.

1. The instructional process

The teaching/learning activity can be considered as a process [Dick and Carey, 2008], called the instructional process, which starts with the definition of what the learners should know and finishes with the evaluation of what the learners actually know. Basically the teacher has to decide what to teach, and how to teach, i.e. the teacher has to choose contents/skills and methods of her/his teaching activity.

The instructional process consists of several different steps. According to the specific teacher's style and teaching model, different schemes can be defined and used. In general we can identify the following basic steps of the instructional process:

1. Analysis:	Identifying *instructional goals*, i.e. targets to be reached by the learners. Defining specific *instructional objectives*, i.e. what the learners will know or be able to do, learners' skills and knowledge after completing the instruction, and criterion references to measure learners' achievements. Identifying the *entry level of the learners* (understanding, ability, and attitude) and the context in which the acquired knowledge is used. in which what the learners
2. Preparation:	Selecting *instructional methods*. Planning *instructional strategies.*
3. Implementation:	Creating, assembling, and reviewing *instructional materials*: creating lessons, teaching/learning activities and evaluation activities. Administering *instructional materials*.
4. Evaluation:	Checking what learners actually have learned, referring to the desired instructional objectives.
5. Revision:	Reviewing instructional analysis, objectives, methods, strategies, and materials, to improve the learning performance if the results are not satisfactory.

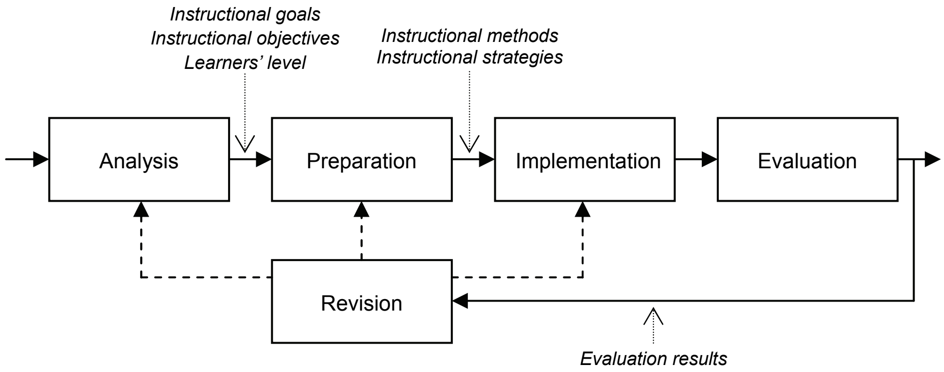

Fig. 1 – Block diagram of the instructional process

At each step of the instructional process some action is taken, based on the information produced by previous steps. The analysis step produces instructional goals and objectives, together with information about learners' level that are used by the preparation step to choose instructional methods and strategies. The implementation and evaluation steps are based on the decisions taken in the preparation step and represent the actual teaching/learning/evaluation activities. As in every feedback system, if the evaluation results are not satisfactory, the revision step introduces some corrections to analysis, preparation, and implementation steps, in order to improve the overall performance of the instructional process.

In a traditional view of the teaching activity, the teacher is the main actor in the instructional process, even when – in an e-learning environment – she/he is not physically present in the classroom, and has just the role of instructional designer/evaluator. However, more recent theories are moving the focus on the learners, so the successful results of the instructional process depends not only on the teacher, but also on the learners themselves, the learning materials, and the learning environment. Also the interactions teacher-learners and learners-learners are to be considered, together with how the didactical materials are proposed to the learners.

In each step of the instructional process the teacher makes use of different tools, supposed to be the most appropriate for that step. Also different materials are produced and/or used in each step of the process (see Fig. 1). Tools can be traditional or digital (for example, blackboards and chalk are traditional tools, smart-boards and electronic table are digital tools). In the same way, materials can be available in the form of traditional textbooks or as (multimedia) digital contents, usually called learning objects or, even better, digital learning materials [Bell and Shank, 2007 and Wiley, 2002], including any digitally available materials, and not only web-based ones.

Even if the instructional process does not occur in a full e-learning environment, for each step we can find and profitably use some digital resources that support traditional contents and methods. Increasing numbers of tools become available on the web every day. Three main categories of instructional tools [Horton and Horton, 2003] can be identified for:

1. Creating, modifying, re-using contents.
2. Offering contents.
3. Accessing contents.

Each category of tools corresponds to a specific role in the instructional process:

1. The producer of contents (designer, author, writer, illustrator, photographer, animator, videographer).
2. The system engineer.
3. The learner (student, reader, user, consumer).

Also some special tools are available for the analysis, preparation and evaluation steps, to help instructional analysis and instructional goals and objectives specification.

2. Repositories and "referatories"

Numerous tools and learning materials are stored on the web and very often they are available at no charge. It would be very convenient to find, access, and reuse them when needed, instead of starting from scratch every time. The reason why it is not so popular to reuse such resources is that it is very difficult to know where they are and how to get and use them in an effective way. Also for those who would like to create their own learning objects it would be very useful to be able to look at existing materials and software tools, if they were easier to retrieve.

The search and retrieval of digital learning materials have been made easier by the creation of databases of learning objects, called "repositories", and databases of links to learning objects, called "referatories", i.e. repositories of references.

Efforts have been made by international organizations to create standard metadata definitions for classifying the so-called learning objects, such us Dublin Core (DC), IEEE Learning Object Metadata [IEEE-LOM] and the Shareable Content Object Reference Model [SCORM]. Many repositories base their metadata sets on those standards, but the instructional process perspective is usually missing. The search functions just work on a kind of keywords basis and sometimes the search is very frustrating and discouraging.

3. Metadata for a "smart" search

The more the web is rich in information, the more we need special search tools that should be able to surf the web in a "smart" way to achieve more sophisticated and higher level tasks.

When we start designing a lesson, after writing our instructional goals, we would like to have at our disposal a search "agent" that could find the best set of tools and materials that match our desired goals. Together with goals, objectives, and specifications of our instructional activity, additional information has to be provided about *type of interaction* (teacher/learner, learner/computer, learner/learner, etc.), *type of tools* needed (multimedia, textbook, etc.), *usage methods* (distance learning, in presence learning, etc.), and so on [Petrone et al, 2010].

To make this task possible we need a Semantic-web-like approach [Berners-Lee et al, 2001], and first of all we have to define an appropriate set of instructional metadata, i.e. descriptive data about the digital resources from the instructional point of view, and to use and/or create specific vocabularies to standardize the description of the instructional digital resources already present on the web. Based upon those metadata and vocabularies we can define the structure of the repository/referatory, that will contain instructional resources' characteristics and locations.

The appropriate set of metadata we have in mind is the one that fits the instructional process as previously described. In this sense not all the metadata defined in DC, or IEEE LOM, or in other standards are useful or needed, and some others are missing. Some efforts have been already made to define more suitable sets of metadata for instructional contexts [Alvino et al, 2009]. Our experience and feeling is that too much metadata and too technical vocabularies are not useful and discourage the user of search engines. How many times do we use the “advanced search” function of Google? Also, too much and complex metadata makes the job of expanding the database much more time consuming and complicated.

4. A taxonomy for instructional digital resources

Everything on the web is a digital resource. The typical digital resource is *a piece of information* (content), but it can be also a *procedure* (tool). A piece of information is useful *to know* something. A procedure is useful *to do* something. These two kinds of objects are very different in nature and usage, but both are very useful in the instructional process.

An (instructional) digital resource can be classified from several points of view. To make the search activity less frustrating and more successful, we need to describe digital tools and contents from several different *points of view*, and we need to define and assign metadata that correspond to different classification schemes. Our metadata set has to be flexible and extensible in order to consider any future point of view that could be useful. Concerning instructional digital resources, many different learning theories and models are available that can help creating those classification schemes. Some choices are made at this level that could not eventually be the best one from the user point of view. So the proposed metadata should be able to adapt to future needs and requirements.

Some metadata are needed to identify the digital resource (as also defined in DC and IEEE LOM):

title	::=	<tool/content title>
creator	::=	<author or creator>
publisher	::=	<publisher>
date	::=	<date of creation>
location	::=	<resource location>
language	::=	<resource language as defined in RFC1766 (“en”, “en-GB”, “fr-CA”, “it”)>
rights	::=	<copyright statement>
cost	::=	{*freeware*, *open source*, *commercial*, *other*}

For the instructional characterization of digital resources, we propose the following set of metadata and their possible values:

resource type	::=	{*tool, content*}
granularity	::=	{*curriculum*, *course*, *lesson*, *page*, *media*}
instructional step	::=	{*analysis*, *preparation*, *implementation*, *evaluation*, *revision*}
user role	::=	{*producer* (course authoring, web site authoring, testing and assessment, media editor, content converter), *learner* (content browsing and playing), *engineer* (content hosting and management)}

topic	::=	<specific topic title>
grade level	::=	{*preschool*, *kindergarten*, *primary school*, *secondary school*, *college*, *adult* (learning and training), *disabled persons*}
interaction type	::=	{*teacher/learner(s)*, *learner/computer*, *learner(s)/learner(s)*}
target audience	::=	{*whole class*, *small group*, *couple*, *individual*}
instructional method	::=	{*direct* instruction, *interactive* instruction, *indirect* instruction, *independent* study, *experimental* learning}
cognitive dimension	:=	{*knowledge* (remembering), *comprehension* (understanding), *application* (applying), *analysis* (analyzing), *evaluation* (evaluating), *synthesis* (creation)}
knowledge dimension	::=	{*factual*, *conceptual*, *procedural*, *metacognitive*}
content/tool area	::=	{*art*, *astronomy*, *biology*, *mathematics*, *science*, *technology*, *history*, *social science*, *foreign languages*, *other*}
content/tool type	::=	{*assessment*, *narration/description* (lecture, presentation, exhibit, story telling), *reference*, *construction*, *demonstration* (tutorial), *discussion* (forum, small work group), *simulation* (role playing, instructional games, field trips), *illustration*, *imagery*, *modeling*, *brainstorming*, *problem solving*, *case studies*, *drill and practice* (apprenticeship), *generative development*, *research project*, *web quest*, *expert system*, *evaluation*, *map*, *portfolio*, *platforms*, *documentation*, *communication*, *sharing tool*, *other*}

A more detailed set of metadata could be defined at this level, but, again, too much information is difficult to maintain and keep up to date, and soon this becomes very discouraging.

When we start searching the web for instructional contents and tools, we usually have in mind a *topic*, belonging to a specific *content area*, a *target audience* with its average *skill level*, and, for a school audience, a *grade level*. Also we know the *methods* that will be adopted during the teaching/learning activity. We may eventually refer to specific learning theories. For example, some tools and contents can be useful *to foster learners' ability to remember*, while some others *can activate or improve critical thinking*, respectively *knowledge* and *evaluation* in terms of Bloom's Taxonomy [Bloom and Krathwohl, 1956]. It is not possible to make an exhaustive taxonomy of digital resources from every learning theory point of view. Concerning the *cognitive* *process dimension*, we explicitly refer to Bloom's Taxonomy, as revised by Anderson and others [Anderson et al, 2001], also including the so-called *knowledge dimension*, i.e. the *type* of knowledge the learner should acquire (*factual*, *conceptual*, *procedural*, and *metacognitive*). We consider Bloom's Taxonomy and its revision a good classification scheme for instructional digital resources, since we consider instructional goals and objectives as the starting points of the retrieval activity of such resources on the web. Also we add a *granularity* annotation to each resource, taking into consideration that a study *curriculum* is an aggregate of courses, and a *course* is an aggregate of lessons. Each *lesson* can be composed of many parts and each part can consist of text, pictures, and so on. In the web language each part of a lesson can be seen as a *page*, and its components are *media* (individual pictures, blocks of text, animation sequences, video passages, etc.).

5. Technical characterization of instructional resources

Digital resources are software tools and digitally formatted contents, i.e. they are *technological objects*, and so they have to be characterized from a technical point of view. The following set of metadata is proposed for the technical characterization of instructional digital resources:

digital format	::=	<data type of the resource, see mime formats>
hardware requirements	::=	<hardware requirements: *processor type* and *speed*, *memory, display size* and *colors, hard disk size, CD or DVD units, audio output, audio input, video input*>
software requirements	::=	<software requirements: *operating system*, *browser*, *media players* (plugins), *Java VM*, etc.>
connection requirements	::=	<connection requirements: *connection type*, *connection speed*>
required knowledge	::=	{*low*, *medium*, *high*}
usage complexity	::=	{*low*, *medium*, *high*}
technological complexity	::=	{*low*, *medium*, *high*}
management complexity	::=	{*low*, *medium*, *high*}

It's important to specify hardware and software requirements, as well as the technical skills needed to use web resources profitably in our instructional process. In a previous paper [Petrone et al, 2010] we already introduced some of these characteristics that should be taken into account, such as *required knowledge, usage complexity, technological complexity, management complexity*. The values associated with those parameters have been defined in a qualitative way as *low*, *medium*, *high*. More parameters and metadata are added to better specify how to use the digital resource. In the case of an e-learning environment, that is the natural context in which web digital resources are used, it's also very important to specify *connection requirements*.

6. Conclusions and developments

The set of metadata we presented in this paper is the basis for a future implementation of a repository/referatory of instructional digital resources. We introduced special metadata to better characterize web resources from the instructional point of view, and also from the technical point of view, considering intrinsic digital nature of those resources. Our main aim is to propose a set of metadata that will enhance the possibility of re-using the huge instructional materials available on the web by means of a dedicated "recommender" system that will help browsing and searching the web in a "smarter" way. The main structure of the database will be implemented with a classical top-down approach, while users will be given tools to update database contents and also to modify and improve digital resources classification schemes, using a bottom-up approach [Ferrara et al, 2010].

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