British Journal of Educational Technology Vol 36 No 3 2005 453–463

Managing content in e-learning environments

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Abstract

The use of e-learning environments to support teaching and learning has had great impact on the way content is developed and managed. In most cases, both teachers and students have had to re-adapt the way they prepare, access and engage with educational matter. The adjustment in human mechanisms for organising and interacting with educational content has become necessary due to the re-mediation of established practices through the introduction of software-based techniques to structure content, for example, using metadata. Whilst metadata standards provide effective guidelines for organising content in web-based e-learning environments, technology-based approaches to managing educational resources do not fully address social-cultural and pedagogical aspects of users in the context in which teaching and learning takes place. In this regard, the effectiveness of using metadata to structure the discovery and access to educational content should be considered in relation to the extent by which metadata descriptors are associated with established socio-cultural and pedagogical practices. Towards this end, we reflect on potential contributions of social-cultural and learning theories to the task of managing content in e-learning environments. The paper presents an activity-centred approach to abstracting contextually and pedagogically enriched metadata descriptions of educational content and interactions with learning objects.

Introduction

Traditionally, the task of managing educational content in learning institutions has been the responsibility of teachers and archivist or librarians (Greenberg, 2000). However, the current surge to implement information and communication technologies (ICT) within teaching and learning processes has created an inevitable need to store,

Published by Blackwell Publishing, 9600 Garsington Road, Oxford, OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA.

access and distribute educational resources via technology-based systems, particularly databases and web-based systems. This entails converting and restructuring educational resources into formats that are suitable for technology storage and delivery. Consequently, this transition has had great implications for both teachers and students as creators and users of educational content. As a result of this situation, there is the inevitable need for developers of educational technology to involve technical, information, and educational specialist when handling issues relating to managing and distributing educational content in e-learning environments. This development indicates recognition of the significance of pedagogical accountability in computer-based techniques introduced to manage educational content. In this regard, pedagogy-oriented international standards are being introduced to counterbalance technological focus in ICT-based techniques for managing educational content (IEEE-LTSC, 2002). These techniques include, for example the use of metadata to structure content into objects that can be described and tagged for the purpose of reusing, referencing, and controlling the flow and access to information (Hackos, 2002). However, whilst the use of metadata standards can enable users to search and discover information more efficiently, it is the usefulness or relevance of the discovered content to the purpose and context of use that matters most to the user. Therefore, inadequate or inappropriate accountability of relevant contextual and pedagogical perspectives during metadata abstraction can result in misinterpretation of the user's motives or objectives for searching and interacting with objects in the e-learning environment (Lim, 2002).

In order to examine issues raised in foregoing discussions in relation to the task of managing content in e-learning environments, we investigated the potential contribution of specific social–cultural and learning theories as a framework for conceptualising metadata categorisations and descriptions. The aim was to produce pedagogically meaningful and contextually relevant descriptions of content. In so doing, we focused on understanding contextual approaches to developing, using, and managing content by studying:

1. the nature of activities involved in managing educational content;
2. the methods and tools used to interact with learning objects; and
3. the purpose for which users interact with learning objects.

The study employs the paradigm of human activity as the unit of analysis so as to examine ways in which teaching and learning activities shape, and are shaped by, relationships, mediators, motives, and social–cultural influences from the environment in which content is created and used. Therefore, we considered the task of understanding and describing activities in context as an integral part of the metadata abstraction. This is due to the fact that acquired contextual insight is considered to be crucial to the appropriate categorisation and description of education content.

What is metadata?

The formal definition of metadata is data about data (Greenberg, 2000). Metadata is structured information that describes characteristics of a learning object, whereby the term learning object refers to an entity or learning resources that can be presented in both digital and nondigital form (IEEE-LTSC, 2002). Examples of learning objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organisations, or events referenced during technology-supported learning (IEEE-LTSC, 2002; (Suthers, Johnson & Tillinghast, 2002). This broadened definition of learning objects is important for our purposes because it recognises the significance of various forms of resources used in teaching and learning including human and nonhuman elements. One of the main reasons for structuring educational content is to group it into meaningful categories that can be referenced, searched, accessed, and updated by authorised users. Therefore, in order to categorise and describe learning objects meaningfully, content stakeholders (ie, users, creators, etc) need to establish common semantics for interpreting key characteristics of learning objects according to established practices of the context of use. In this regard, semantic metadata uses meaningful tags to label objects according to the nature of the content available inside the object itself as opposed to format tags that label information according to the structure or appearance of elements of the object (Hackos, 2002). The key point to note about semantic metadata is that effective use of semantic tags to enhance meaningfulness in content management is dependent on the awareness of issues and practices of the context from which objects are generated. In the meanwhile, contextual knowledge can relate to several aspects of content, including the description of activities and procedures involved in preparing materials and delivering teaching instructions. As a result, semantic knowledge about educational content is not always explicit, but may be evident in local cultural norms whose existence, execution procedure, and implications are not always formally documented. Towards this end, several standards have been introduced to provide guidelines and facilitate consistence in metadata abstraction. Some of the metadata standards are targeted towards the characterisation of educational content, for example the Learning Object Metadata (LOM) standard introduced by the Institute of Electrical and Electronics Engineers (IEEE) Learning Technology Standards Committee (LTSC) (http://ltsc.ieee.org/: IEEE-LTSC).

The IEEE and LTSC

The IEEE is a non-profit making association of technical and professional organisations and individual members drawn from several countries worldwide. The LTSC is commissioned by the IEEE computer society standards activity board to develop accredited technical standards, recommended practices, and guidelines for learning technology (http://ltsc.ieee.org/: IEEE-LTSC). Therefore, the LTSC formally and informally coordinates other organisations when producing specifications and reviewing recommendations for introducing new standards. Meanwhile, the actual process of developing standards is carried out by working groups through a combination of face-to-face meetings, conferences, etc. One such group is the Instructional Management Systems (IMS) represented by a global learning consortium of educational institutions, commercial entities, government agencies, and systems developers in the area of distance education (http://www.imsglobal.org/: IMS). The IMS is focused on promoting openness in the development and specifications of metadata standards in order to facilitate

Table 1: Nine categories of learning object metadata (LOM)

LOM category	*Description*
1. General	Presents general information about the learning object such as title, language, and keywords
2. Life cycle	Outlines the history of the development of the learning object including changes that have occurred in features during its evolution, eg, version and current status
3. Meta-metadata	Information about the metadata instance itself rather than the learning object that the metadata instance describes
4. Technical	Information about technical requirements and technical characteristics of the learning object
5. Educational	Outlines educational and pedagogic characteristics of the learning object
6. Rights	Information about intellectual property rights and conditions for using the learning object
7. Relation	Outlines features that define the relationships between the learning object and other related learning objects
8. Annotation	Provides comments about experiences of using the learning object. Includes details about who created the comments and when the comments were created
9. Classification	Describes the learning object in relation to a particular classification system

Note. From IEEE-LTSC, 2002

efficient distribution and interactions with learning objects. Whilst the IEEE's LTCS introduced the LOM standard, IMS contributed to the development of this standard by introducing the use of eXtensible Markup Language to facilitate semantic structuring of content.

The LOM standard

The LOM standard was introduced by the IEEE LTSC to provide pedagogical accountability when abstracting metadata for educational resources. The key focus of the LOM standard is to specify the syntax and semantics of metadata for grouping and describing educational resources into learning objects. Learning Object Metadata presents a hierarchical metadata structure consisting nine top-level categories including the Educational category (IEEE-LTSC, 2002). The nine top-level categories of LOM present a basic structure for organising and classifying content as shown in Table 1.

Despite the pedagogical focus of metadata standards like LOM, metadata standards are not normally conceptualised and developed with a specific context and learning theory in mind. Therefore, the significance of using metadata standards including LOM to manage educational resources need to be considered in relation to established practices in the context in which objects are used and created. Given this consideration, there is a need to investigate potential contributions of specific theories of learning and practices when abstracting metadata requirements for educational content.

Research context and pedagogical framework

The context for this study is the Lab@Future project (http://www.labfuture.net), an e-learning research and development project funded by the European Union (EU) as part of the Information Society Technologies (IST) programme.

Overview of the Lab@Future project

The Lab@Future project is focused on leveraging educational use of ICT by exploiting advancements in virtual reality, 3D, and mobile technologies to produce innovative tools for supporting teaching and learning activities in participating high schools in the EU. This premise is based on the rationale that implementing these technologies into mixed reality technologies and computer-generated objects interfaced with mechatronic systems, augmented virtual reality and mobile technologies in a 3D multi-user environments, will achieve this objective. In this sense, the term "mechatronics" refers to the synergistic integration of mechanics, electronics and computer technology (or IT) to produce enhanced products, processes or systems (Alciatore & Histand, 2003). However, it was recognised that developing effective ICT tools for educational use requires good understanding of pedagogical and contextual practices. In order to achieve this remit, user activity-centred design methods and techniques grounded in the framework of *activity theory* (Leont'ev, 1978) were used to conceptualise teaching and learning practices in the targeted environment of deployment. The conceptualisation of pedagogical perspectives was considered from the point of view of the *theory of expansive learning* (Engeström, 1987). These theoretical perspectives are described as follows.

Activity theory and theory of expansive learning

Activity theory presents a collection of basic ideas for conceptualising both individual and collective practices as developmental processes of the context in which human activities normally take place (Kuutti, 1996). The idea of studying human activities as developmental processes is crucial for identifying changes and contradictions that exist in an activity. Therefore, contradictions serve as the means by which new knowledge about the activity being examined emerges (Engeström, 1987). According to Leont'ev (1978), the concept of activity entails a complete system of human practices, that is, purpose-driven activities, explicit and inexplicit methods for carrying out activities, physical and conceptual tools used as mediators when executing activities. Engeström (1987) conceptualised a representational model to portray the various key elements of an activity system as shown in Figure 1.

The *activity triangle model* represents an outline of the various components of an *activity system* into a unified whole. Participants in an activity are portrayed as *subjects* interacting with *objects* to achieve desired *outcomes*. Meanwhile, human interactions are mediated with each other and with objects of the environment through the use of *tools*, *rules*, and *division of labour*. Mediators represent the nature of relationships that exist *within* and *between* participants of an activity in a given *community* of practices. This approach to modelling various aspects of human activity can draw the researcher's attention to important factors to consider when analysing teaching and learning activ-

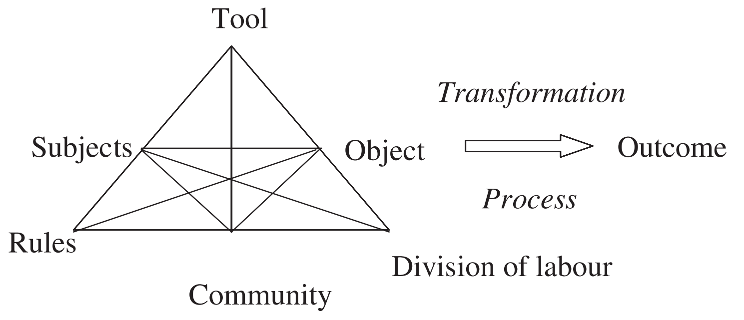

Figure 1: The activity triangle model (Engeström, 1987)

ities for content management purposes. However, activity theory does not include a theory of learning per se, instead, activity theory-oriented pedagogical concepts are incorporated in Engeström's (1987) theory of expansive learning.

Theory of expansive learning

The pedagogical stance of the activity-theoretical concept of expansive learning differs from traditional types of learning in that:

- Contents and outcomes of learning emerge as new forms of practical activity and artefacts constructed by both students and teachers in the process of tackling real-life projects and during problem solving.
- Learning is driven by genuine developmental needs in human practices and institutions, manifested by means of disturbances, breakdowns, problems, and episodes of questioning the existing practice.
- Learning proceeds through complex cycles of learning actions in which new objects and motives are created and implemented, opening up wider possibilities for participants involved in that activity.

This perspective on teaching and learning highlights the potential impact of new tools as vehicles for transforming activity and also of those engaged in activity. This pedagogical stance can be extended to the conceptualisation of methods and techniques used to manage content in e-learning environments.

Managing Lab@Future educational content

From our viewpoint, the concept of managing content incorporates the editorial processes of gathering, creating new, or selecting suitable educational materials from existing resources for web delivery. Efficient execution of such processes requires the establishment of a method or criteria for gathering and selecting educational materials. Furthermore, the editorial process may involve the task of converting educational resources and materials into formats that are appropriate for web delivery. Therefore, our stance with regard to this editorial process is that the methods used to create, gather, select, and categorise educational resources should reflect established practices of targeted context of use. In most cases, technology-based educational content is either supplied by authors, for example, teachers, or automatically generated using technology-based techniques. In situations whereby human beings are actively involved in generating and selecting content, theory-based methods can enhance and enrich these procedures by accounting for social–cultural and pedagogical practices of the targeted context of use. Within the Lab@Future project educational content was gathered during the requirements specification stage of the system development process from teachers, students and other stakeholders in participating schools within the EU. In order to capture both pedagogical and social–cultural issues surrounding the creation and use of content, a decision was made to use a theory-driven approach when gathering user and content related information. This grounded approach to gathering user and content related information about educational resources was implemented through use of the eight-step model (ESM Table 2) so as to operationalise the activity triangle model (Figure 1).

The eight-step model is a requirements abstraction tool, which is incorporated within the Activity-Oriented Design Method—a requirements capture methodology grounded in activity theory (Mwanza, 2002). In order to gather data, ESM-based open-ended questions were circulated to Lab@Future project partners in each EU country responsible for coordinating participating schools in focused subject areas, namely:

- Fluid Dynamics in vocational training schools in Germany;
- Geometry in Austrian high schools;
- History in high schools in Greece; and
- Environmental Awareness in high schools in Slovenia.

Lab@Future partners used ESM-based open-ended questions as “aide memoire” when asking for educational materials and information about teaching and learning practices in targeted schools. Educational content and information about practices were gathered by Lab@Future partners during interviews and other field studies involving teachers, students, and technical assistants in participating schools.

Table 2: The eight-step model

Step	*Identify the:*	*Question to ask:*
1	Activity of interest	What sort of activity am I interested in?
2	Objective	Why is the activity taking place?
3	Subjects	Who is involved in carrying out this activity?
4	Tools	By what means are the subjects performing this activity?
5	Rules and regulations	Are there any cultural norms, rules, or regulations governing the performance of activity?
6	Division of labour	Who is responsible for what, when carrying out activity, and how are the roles organised?
7	Community	What is the environment in which this activity is carried out?
8	Outcome	What is the desired outcome from carrying out this activity?

Note. From Mwanza, 2002

Description of Lab@Future educational content

The nature of content and other resources collected for the Lab@Future project consists of various types of educational materials and contextual information about methods and practices surrounding teaching and learning activities in participating schools. Educational content was presented in various data formats including audio, video, paper-based text, and digital form. Subject-specific content gathered include the following:

- History subject area—historical images of ancient artefacts and historical sites presented in paper-based and digital form;
- Fluid Dynamics subject area—digital photographs of technological equipment used when teaching, for example cables connecting various types of cylinders on a factory assembly line;
- Geometry subject area—various images of geometric objects and illustrative formulae for manipulating objects;
- Environmental Awareness subject area—paper-based and digital images and information about organisms living underwater. This included an illustration about the impacts of pollution, and, methods used to test for pollutants in water.

In all cases, digital and paper-based content about school curriculum, syllabus and various types of reports was obtained. Figure 2 presents a sample visualisation of educational resources and practices in the History subject using the activity triangle representation.

The approach to gathering educational content using the ESM tool (Table 2) enabled us to abstract activity-centred teaching and learning scenarios that are relevant to the targeted environment of Lab@Future application. Teaching and learning scenarios (Carroll, 2000) were abstracted as story-like descriptions or narratives of user practices and educational resources. Scenarios were later elicited into user roles so as to envision inexplicit methods used to create and interact with learning objects. Information gathered formed the basis for conceptualising meaningful entities and attributes during metadata abstraction.

Metadata requirements for Lab@Future

The Lab@Future project was strategically focused on exploiting specific pedagogical theories in all design activities. For this reason, specific theories of learning and human practices were to be exploited in all systems design activities including metadata abstraction. As a result of this strategic stance, we found that LOM-based vocabularies were in most cases inadequate and inappropriate for our pedagogic focus and theoretical orientation. However, a key advantage of using the LOM standard is evident in the provision for extending LOM top-level categories (IEEE-LTSC, 2002). For our purposes, this implies that extensions can be created and added to LOM top-level categories so as to introduce theory-driven subcategories and elements drawn from specific theories of learning and social–cultural perspectives. We therefore, focused our efforts on extending the LOM Educational category in order to abstract theory-

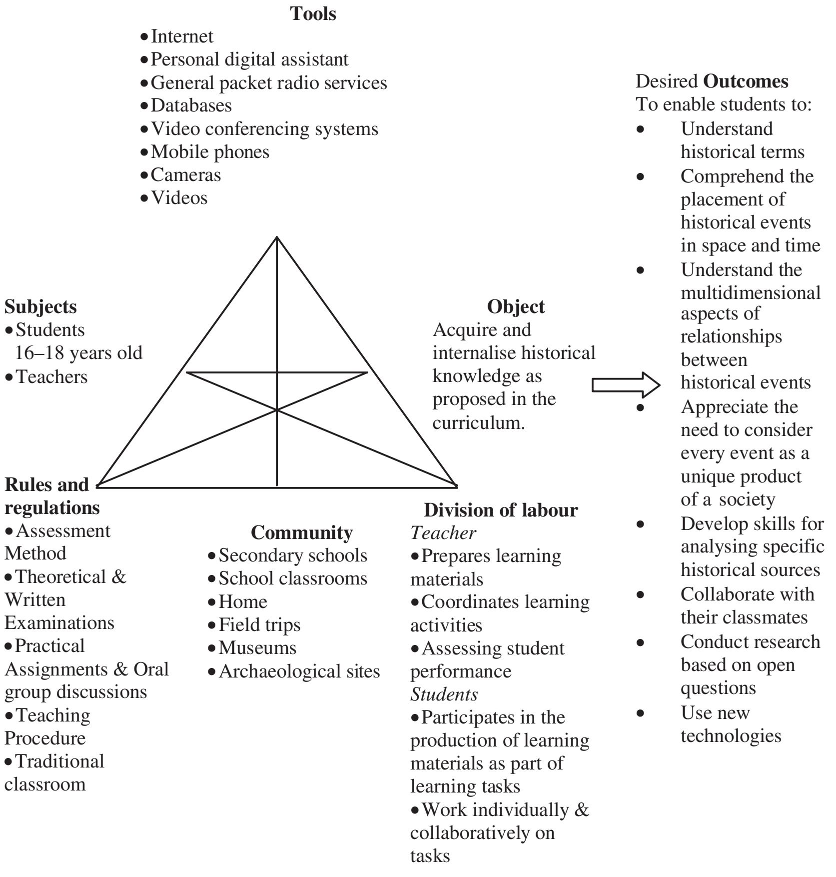

Figure 2: Visualisation of objects in the Lab@Future history subject

based subcategories and descriptions that were relevant to the Lab@Future project as indicated in Table 3.

In the method shown in Table 3, labels of the activity triangle model (Figure 1) were used to form subcategories for extending the LOM Educational category. In terms of implementation, we recommended that the new subcategories used to extend the LOM Educational top-level category be classified as open vocabularies up until team consensus on the interoperability of the new terms has been established.

In developing our method for extending the LOM Educational category, we were partly inspired by Suthers *et al's* (2002) approach that involved describing the nature of learning objects, thereafter identifying LOM categories in which those descriptions fitted. The main idea was to only introduce new elements in situations where generated descriptions of resources do not fit into any of the existing LOM categories. However, the most imperative aspect of our approach to abstracting metadata descriptions emerges from

Table 3: Lab@Future extension of the learning object metadata Educational category

LOM category	*Description*	*Examples from the History subject area*
1. General		
2. Life cycle		
3. Meta-metadata		
4. Technical		
5. Educational		
5.1 Subjects	Information about people who create, use, and maintain objects	Teachers—Specialisation Students—Estimated level of subject complexity
5.2 Tools	Details about current and past conceptual and physical tools used	Cameras School curriculum Videos
5.3 Objectives (Purpose)	Details about subjects' shared motives for engaging in activities	Acquire and internalise historical knowledge as proposed in curriculum
5.4 Rules and regulations	Give information about cultural norms and established practices	Student performance assessed in examinations and class assignments
5.5 Community	Details about the environment or context in which objects are created and used	School classrooms Museums Archaeological sites
5.6 Division of labour	Give information about the allocation of roles and responsibilities when carrying out activities	Teacher—prepares teaching materials Students—produces learning materials during class exercises
5.7 Desired outcomes	Information about desired outcomes from learning activities	Comprehend placement of historical events according to curriculum
6. Rights		
7. Relation		
8. Annotation		
9. Classification		

the fact that our method groups and describes educational resources from a grounded perspective. In so doing, we sought to understand and interpret relational aspects of educational resources in context so as to establish the dynamic and holistic configuration of activities surrounding the creation and use of learning objects. Therefore, Lab@Future metadata descriptions incorporate social–cultural and historical analyses of interactions between people, organisations, technologies, and information, all of which form the learning objects that constitute educational content exploited in the Lab@Future.

Conclusion

It is increasingly becoming evident that techniques used to manage educational content in web-based systems cannot be confined to official specifications of metadata standards. Confining metadata abstraction to defined boundaries of official standards can hinder progress in the enhancement of the usefulness of objects discovered following a search. Therefore, metadata abstraction methods based on specific theories have a role to play in facilitating the conceptualisation of contextually and pedagogically grounded insights about learning resources. In the Lab@Future project, we exploited these perspectives by introducing an activity-centred approach to abstracting theory-based extensions to the LOM Educational category. Our method introduces theory-based vocabularies used to categorise and describe educational resources within the Lab@Future project. Vocabularies introduced in this method are intended to assist in the incorporation of established pedagogical practices so as to enhance meaningfulness in interactions and usefulness in the nature of objects accessed. Finally, our method does not include schematic recommendations for implementing new vocabularies; instead, we put emphasis on the fact that activity theory-based vocabularies may be used to semantically describe various features of the data that form learning objects.

Acknowledgements

This study was carried out under the Lab@Future project, which is funded by the EU under the IST programme. We are grateful to all partners on the Lab@Future project for insightful debate around metadata.

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