Integrating Instructional Design and Hypermedia Design

Jacopo Armani	Luca Botturi	Ignazio Cantoni	Maria Di Benedetto	Franca Garzotto
ITC	NewMine Lab	HOC	HOC	HOC
University of Lugano	University of Lugano	Politecnico di Milano	Politecnico di Milano	Politecnico di Milano
Switzerland	Switzerland	Italy	Italy	Italy
armanij@lu.unisi.ch	botturil@lu.unisi.ch	cantoni@elet.polimi.it	dibenede@elet.polimi.it	garzotto@elet.polimi.it

Abstract: *The impact of new technologies in education has brought to the perception of an educational web site has a more or less standard features in several contexts. Yet, an analysis of the existing literature reveals that the practices of Instructional Design and Hypermedia Design have few if any contact points. We claim that an integration of the two processes – namely learning activities design and hypermedia design – would bring benefits in term of efficiency and effectiveness of the development process and quality of the final application. As a first step in this direction, we propose a general framework that integrates the existing approaches adopted in Instructional Design and Hypermedia Development for both design and for requirements analysis.*

Introduction

The new wave of eLearning has brought to a deeper and deeper integration of new technologies in education. Educational Web sites have become an almost standard feature of a large part of Higher Education courses: they are used for simple learning materials delivery (the syllabus, lecture slides, readings and assignments), as shared learning space (for group work, interaction with the instructor or the tutor, or discussion forum) or for more structured activity (cf. Harasim, Hiltz, Turoff, & Teles 1995).

Educational Web sites and applications could be classified as a specific type of hypermedia products, yet the development of the learning activity and of the educational hypermedia to support it are usually not integrated into a unique process. The two disciplines of Instructional Design (ID) and Hypermedia Design (HD) actually lack a shared model, although they both recognize the overlap of at least a part of their practice. This paper claims that integrating the two design process in a unifying framework would lead to enhanced results, better quality products, and reduction of development time and cost. The framework we propose, developed on the basis of existing literature, also includes the integration of the analysis phase of Instructional Design and requirements process carried on in the very early stage of hypermedia development.

The rest of the paper is organized as follows. Section two will provide some background in Instructional Design and Hypermedia Design, trying to emphasize commonalities and shared understandings. Section three four presents our framework. Section four draws the conclusions and outline the future steps of our work.

Background

Instructional Design (ID)

Reigeluth (1983) provides an insightful definition of ID: "Instructional design is concerned with understanding, improving and applying methods of instruction. (…) The result of instructional design as a professional activity is an *architect's blueprint* for what the instruction should be like (…). Instructional design as discipline is concerned with producing knowledge about optimal *blueprints.*" But what are the elements of a blueprints? ID has always been concerned with the integration of media, and more recently of new electronic media, in the educational activity (cf. Heinrich, Molenda & Russel 1993), and not just with a description of the activity as such. High-quality learning materials are an important quality factor for education, as testified also by the interest of standardization organization for the quality of the learning experience, for example in (IMS 2003).

The blueprint of instruction therefore includes the design of the learning materials that the instruction requires. Actually, all ID models contain a phase in which the learning materials are designed, developed, tested and eventually rehearsed. Examples are ADDIE (cf. IEEE 2003), the Dick & Carey model (1996), and the work by Morrison, Kemp & Ross (2003). Figure 1 sketches the Dick & Carey model. It is the most structured stepwise approach to ID, and the development of an hypermedia application or Web site would be represented as a sub-process of the *develop and select materials* phase. One could suppose that such a sub-process would benefit from the results of previous phases, yet in a common institutional setting, the instructor or the designer would go to the department Web programmer and explain what they need – unless some common language exists, or a predefined communication protocol, it is likely that the programmer does not get the whole picture of the course, but works on his/her (partial) understanding of the problem.

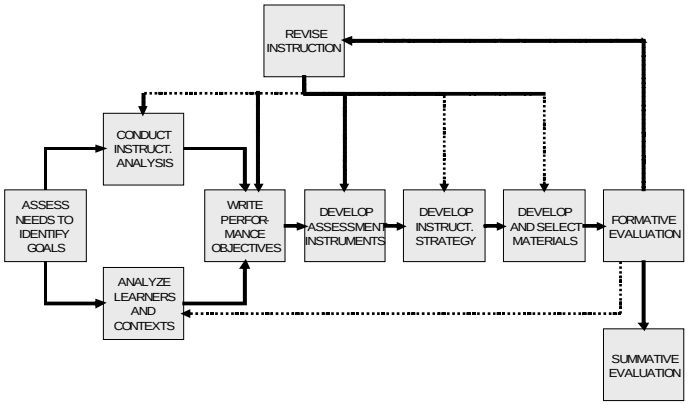

Figure 1 - The Dick & Carey model

Greer (1991 & 1992) describes the ID process as pivoted in the production of learning materials, and puts a special emphasis on the management of their creation, reproduction and delivery (Figure 2). Here again, after the blueprint is created, learning materials are produced as a specific process – here represented as starting with the *create draft materials* phase. The assumption behind this model is that ID *is* learning materials design, or at least that the activities are developed as a part of the learning materials. Greer's emphasis is justified by the consideration that the largest effort (as time and cost) in ID concerns learning materials, and that they are physical objects (as different from virtual descriptions of activities) for which a formal approval from the sponsors can be obtained.

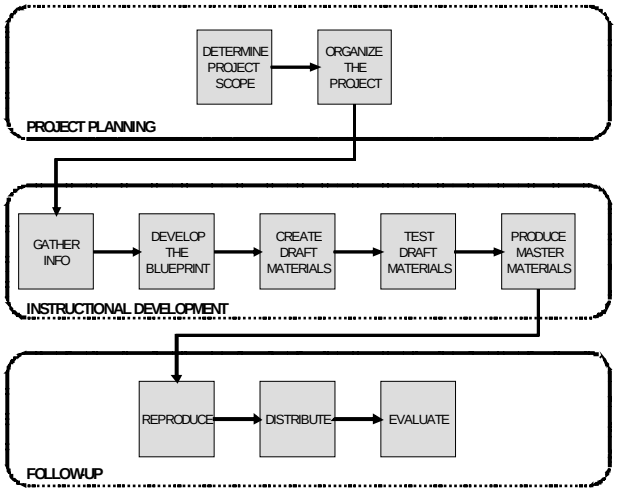

Figure 2 - Greer's model

The general point we want to make is that, while defining a specific phase for material development, traditional ID models do not explain what are its connections with other phases. This is particularly interesting in the case, more and more frequent (Bates 1999), in which hypermedia applications are given to some Web developers or external partners for development. In such a case, the instructor or instructional designer takes the role of commissioner and content provider, and the hypermedia development process develops more or less independently. Moreover, Web developers are likely to use a Web design model in order to design the application – a language an instructor usually does not understand.

Hypermedia Design (HD)

The research on hypermedia design models stem from past results from software engineering, database, management systems fields, merged with the peculiarities of a unique and multifaceted process: the development of multimedia contents and navigation based interaction. This combination has produced a "melting pot" of methods, models and languages which, thus far, have not evolved into an integrated solution. Modern hypermedia design languages can be divided in two groups: conceptual methods and system-oriented methods.

To the former group belong HDM (Hypermedia Design Method – Garzotto *et al.* 1993, 1995), W2000 (Baresi, *et al.* 2001), OO-HDM (Object Oriented-HDM – Schwabe & Rossi, 1998), RMM (Relationship Management Methodology – Isakowitz *et al.* 1995). These approaches aim at conceiving a website in terms of informative structures - structured

"objects" or "entities" and their relations, the access structures for reaching the information, and the navigation links to browse within and across the different structures. These languages are general-purpose, as they do not directly relate to the informative goals of the web site. They are also conceptual, since they abstract from implementation and technological aspects.
In the latter group we find models that are mainly intended to support the (semi) automatic dynamic generation of web sites from an underlying data base. As a consequence, these models provide primitives at a lower level of abstraction. Examples are Araneus (Atzeni *et al.* 1998), Strudel (Fernandez *et al.* 1998), Weave (Florescu *et al.* 1999), and WebML (Ceri *et al.* 2003).
The methods in both groups need to refer to concepts that are abstract conceptualisations of the features of a web application and that require a strong expertise in order to be effectively handled. Most of the proposed concepts are far away from the way of thinking adopted by ID (being, in most case, derived from software engineering and data bases) and are hardly understandable to non-experts. Therefore, the analysis, selection, and application of hypermedia design conceptual tools for a particular education project require competences that usually do not belong to the background of the instructor or instructional design. Consequently, the adoption of HD methods for the e-learning context, such as CADMOS-D (Retalis, *et al.* 2002) result often unusable for the instructor who wants to use them in course development.

Proposal for an Integrated Framework

The integrated model we propose considers three main levels of activities, as in Figure 3: the *Educational Context Level*, the *Requirements Level* and the *Design Level.*

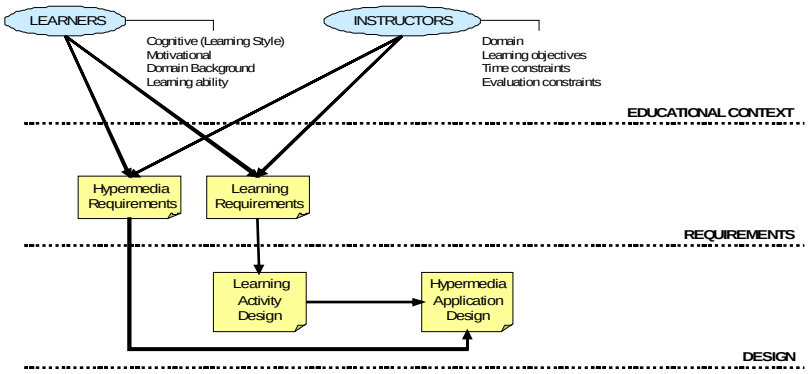

Figure 3 – Integrated Framework

The Educational Context Level

The Educational Context level includes all the elements that are traditionally part of the analysis phase in ID models (Dick & Carey 1996), grouping them in two sets: learners and instructors analysis.
The learners analysis includes four elements:

1. An analysis of the *learning styles* (preferred modes of perceiving and processing information), that can be modelled according to e.g. Kolb's (1999) or Felder's (1988) models. For example, we might have a class of students in mechanical engineering whose general preferences are for a sequential (as different from random) presentation of content in written form (and not visual).
2. An analysis of *motivational aspects*, i.e. the perceived importance of the instruction and the perceived possibility of success (Eccles & Wigfield 2002a; 2002b). A more specific analysis can be done following the ARCS model (Keller 1983; Keller 1984; Keller & Suzuki 1988).
3. The *domain background*, i.e. the previous knowledge that the learners have of the specific content to be taught.
4. *Learning abilities*, i.e. how learners are able to learn by themselves or with specific learning materials, respectively how much guidance they need.

The instructors analysis includes four elements that describe the teaching offer from a general point of view.

1. The Domain is an indication of the specific content of the instruction. This might range from a simple indication of the discipline (e.g. literature) to a more detailed "editorial plan" and a specification of the information sources (books, web sites, course notes…)
2. The Learning objectives is a statement of the goals of the instruction, i.e., a description of what the learners should know or be able to do after they completed the activities. Goals can be defined according to several guidelines, such as those defined by Gronlund (1995), and classified by types using Bloom's (Bloom at Al. 1956; Bloom et Al. 1964) or Gagné's (1982) taxonomy, or mapped onto classification grids, such as Merrill's Content-Performance matrix (1983) or Anderson & Krathwohl's revised Bloom's taxonomy (2001).
3. Time/space constraints (if the case), i.e., the total amount of hours of instruction, number of sessions, duration in weeks or months, availability of space, possibility of attendance to lectures in a determined geographical location, etc.
4. Evaluation constraints: while the design of the evaluation is part of the design itself, often instructional activities in institutional setting have constraints, such as the presence of a mandatory final written exam, or of a mid-term evaluations, etc.

The Educational Context level does not present striking novelties. *The novelty introduced by this model is to exploit such information both for hypermedia and instructional design*, during the activities carried on in the following levels.

The Requirements Level

The information collected on the Educational Context level provides an input for the definition of specific requirements for the design of learning activities and of the hypermedia application.
At this stage learning requirements should be intended as features that the learning activities should have in order to allow learners a better or faster achievement of the learning goals. Learning requirements can be assigned to specific design dimensions (adapted from Cantoni, Di Blas 2002 and Botturi 2003):

1. Use of time: if the learning activity is held in synchronous or asynchronous mode, if it has a predefined start date and end date, etc.
2. Use of space: if the learning activity contains face-to-face sessions and/or distance activities, etc.
3. Grouping: if the learners work individually, in pairs, etc., in groups or as a whole class.
4. Guidance: what kind of frontal teaching, scaffolding and feedback is provided to the learners.

(Notice that the lists of dimensions reported here and below for hypermedia requirements are general and flexible, and might be extended or specialized according to the specific nature of an educational project.)

Hypermedia requirements can be organized along another set of dimensions, as suggested by the AWARE model (Bolchini, Paolini , Randazzo 2003). Dimensions can help organize design activity. In fact, designers can then adopt any design method (UML, WebML, HDM, or informal approaches) to shape design solutions in term of detailed specifications solving the requirements. The AWARE requirements dimensions include:

1. *Content*: refers to that set of ideas and messages that the site communicates to its users. Ideas and messages are mainly specified in term of types of information chunks provided, and should match (as the Structure of Content, the Access Paths, and the Navigation dimensions) the instructional strategy of the educational activity..
2. *Structure of Content*: providing coarse-grain insights about how the content pieces identified might be structured. By "structure" is meant the organization of the content. Providing initial requirements about the structure of content means expressing the need of highlighting particular types of information or pieces of content or messages within the pool of educational material.
3. *Access Paths*: This dimension captures the strategy behind the hypermedia access structures and refers to the navigational paths available to the user in order to start navigation, to locate and reach the content needed for accomplishing his or her goal within an educational activity. Access path requirements may specify that the learner should be allowed to access the needed information in a totally unconstrained mode, or be guided in the exploration of the offered content following the guided tours best corresponding to his or her expectations.
4. *Navigation*: suggesting connections between different information pieces allowing the user to navigate from one piece of content to another.
5. *Presentation*: providing guidelines and visual communication strategies for presenting content, navigational capabilities and operations to the user.
6. *User Operation*: properties on those operations that are visible to users to complete some tasks, e.g. , doing an exercise or submitting an assignment.

The AWARE requirements taxonomy is obviously open and always revisable. Future e-learning web applications (e.g. mobile applications, web-based collaborative 3D environments) may call for ad-hoc types of requirements and may suggest new dimensions to be considered.

Conducting the analysis of the two types of requirements at the same time and in a coordinated way has the advantage of:

1. Creating a unitary shared understanding among the different components of the team
2. Better organizing the efforts in the early stage of application development
3. Enhancing the effectiveness and efficiency of both design processes.
4. Improving the mutual consistency of learning and hypermedia requirements, and, consequently, of the design activities (discussed in the next section)

The Design Level

The Design level leverages the requirements previously defined and makes design decisions both for the learning activity and for the hypermedia application. Figure 3 shows that learning requirements are the basis for a sound development of the learning activities, which might be conducted with a language as EML (Belfer & Botturi 2004; Belfer & Botturi 2003; Botturi 2003). On the other hand, the definition of the learning activities along with hypermedia requirements is the basis for a sound design of the hypermedia application, which may now rely on a specific model such as W2000 (Baresi, *et al.* 2001).
From this point on, the two design processes can run in parallel, with some checkpoints, as their specific content has been defined and structured together.

Conclusions and Future Work

This paper started from the remark that the development of technology-based learning solution may benefit from the combination of methods used in the current practice of instructional design and hypermedia development both for the requirements analysis phase and the design phase. We propose a general framework which identifies the roles of the different approaches adopted in these two disciplines and suggest how to integrate them.

We point out that an integration of the instructional design and hypermedia design methods with a common requirements analysis would increase effectiveness and efficiency in the overall development process, resulting in an enhanced overall quality of the learning experience:

1. *Effectiveness*: educational learning materials are designed for the specific support of some learning activity. Considering the requirements identified in the ID process, such as the learning goals, the learning styles of the students or the learning setting, improves the design as it provides a detailed description of some key requirements for hypermedia design: the users of the application (the learners), the users' goals (i.e., the learning goals), and the context of use (i.e., the learning setting). On the other hand, the ID process would experience an improvement if it could be made aware of the decisions behind specific hypermedia product solutions.
2. *Efficiency*: a large part of the requirements analysis in the HD process overlaps with learning requirements. If the two of them are correctly developed but not integrated, it is likely that the analysis will be done twice, with a consequent increase of costs.

Yet the integration of the two processes and of the different approaches is not an easy task. First of all, no unified model currently exists – the proposal introduced in this paper is a tentative solution to fill this gap. Secondly, and this is a larger issue, the instructor's and instructional designer's profile does not include the advanced web design competencies required for producing high-quality hypermedia applications. For this reason, the model presented below should be intended also as an interaction framework among different professional profiles.

This framework will be refined and tested through the development of case studies, currently carried on at Politecnico di Milano and University of Lugano. We are also attempting to map the different types of requirements on a set of design properties, to relate educational activity design dimensions on hypermedia design dimensions. This work will lead to the definition of a set of design patterns (Alexander 1997, Gamma 1996, Garzotto et al. 1999) for e-learning hypermedia, coupling pedagogical "problems" with high-level hypermedia design solutions, for enhancing the reuse and sharing of experience from both instructional design and hypermedia design.

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References

C. Alexander, S. Ishikawa, M. Silverstein, M. Jacobson, I. Fiksdahl-King, & S. Angel. *A Pattern Language.* Oxford University Press, New York, (1997).

Anderson, L.W. & Krathwohl, D.R. (2001). *A Taxonomy for Learning, Teaching and Assessing. A Revision of Bloom's Taxonomy of Educational Objectives.* New York: Addison Wesley Longman.

Atzeni, P., Mecca, G., Merialdo, P., Masci, A. & Sidoni, G. (1998). The Araneus Web-Base Managment System. SIGMOD 98.

Baresi, L., Garzotto, F., and Paolini, P. (2001). Extending UML for modeling web applications. 34th Annual Hawaii International Conference on System Sciences (HICSS'34), Maui, HI, USA.

Bates, T.W. (1999). *Managing Technological Change.* San Francisco, CA: Jossey-Bass.

Belfer, K. & Botturi, L. (2004).Online Learning Design with Pedagogical Patterns. SALT Orlando Conference 2004, Orlando, Florida, USA (in print)

Belfer, K. & Botturi, L. (2003). Pedagogical Patterns for Online Learning. ELEARN 2003, Phoenix, Arizona, USA.

Bloom B.S. (with Engelhart, M.D., Furst, E.J., Hill, W.H. & Krathwohl, D.R.) (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain.* New York: David McKay.

Bloom B.S., Krathwohl, D.R.. & Masia, B.B. (1964). *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook II: Affective Domain.* New York: David McKay.

Bolchini, D., Randazzo, G., Paolini, P., Adding Hypermedia Requirements to Goal-Driven Analysis, in Proc. 11th IEEE International Conference on Requirements Engineering RE'03, Monterey, California, USA, 2003.

Botturi, L. (2003). Designing Technologically New Educational Environments. Ph.D. Thesis, University of Lugano.

Botturi, L. (2003). E2ML - A Modeling Language for Technology-dependent Educational Environments. EDMEDIA 2003, Honolulu, HI, USA

Cantoni, L. & Di Blas, N. (2002). *Teoria e Pratiche della Comunicazione.* Milano: Apogeo.

Ceri, S., Fraternali, P., Bongio, A., Brambilla, M., Comai, S. & Matera, M. (2003). *Designing Data-Intensive Web Applications.* San Francisco, CA: Morgan Kaufmann.

Claxton C.S., and P.H. Murrell. Learning Styles: Implications for Improving Educational Practice. *ASHE-ERIC Higher Education Report No.* 4, ASHE, College Station, 1987

Dick, W. & Carey, L. (1996). *The Systematic Design of Instruction* (4th edition). New York: Harper Collins College Publishers (6th edition published in 2001).

Eccles, J.S., & Wigfield, A. (2002a). Motivational beliefs, values, and goals. *Annual Review of Psychology*, 53, 109-132.

Eccles, J.S., & Wigfield, A. (Eds.) (2002b). *Development of Achievement Motivation.* San Diego: Academic Press.

Felder, R.M. (1988). Learning And Teaching Styles In Engineering Education. *Engineering Education*, 78(7), 674–681

Fernandez, M.F., Florescu, D., Kang, J., Levy, A.Y. & Suciu, D (1998). Overview of Strudel – A Web-Site Management System. *Networking and Information Systems*, 1(1), 1998.

Florescu, D., Levy A.Y., Suciu, D., Yagoub, K. (1999). Optimization of Run-time Management of Data Intensive Web Sites, VLDB 1999.

Gagné, R.M., Briggs, R & Wager, W. (1992). *Principles of Instructional Design* (4th edition). TX: HBJ College Publishers.

E. Gamma, R. Helm, R. Johnson and J. Vlissides. *Design Patterns. Elements of Reusable Object-Oriented Software*. Addison-Wesley, 1996

Garzotto, F., Paolini, P. & Schwabe, D. (1993). HDM – A Model-based Approach to Hypertext Application Design. *ACM Transactions of Information Systems*, 11(1), 1-26.

Garzotto F, L. Mainetti, P. Paolini. "Hypermedia Design, Analysis, and Evaluation Issues". In *Communications of the ACM, 38* (8), Aug. 1995

Garzotto F, P .Paolini, D. Bolchini, S. Valenti. Modeling-by-patterns of web applications. In Advances in Conceptual Modeling,, P. Chen. D. Embley, J, Kouloumdjian, S. Little (eds.), *Lecture Notes in Computer Science 1727*, Springer 1999.

Greer, M. (1991). Organizing and Managing the Instructional Design Process. In Briggs, L.J., Gustafson, K.L. & Tillman, M.H. (eds.) *Instructional Design: Principles and Applications* (2nd edition). Englewood Cliffs, NJ: Educational Technology.

Greer, M. (1992). *ID Project Management: Tools and Techniques for Instructional Designers and Developers.* Englewood Cliffs, NJ: Educational Technology.

Gronlund, N.E. (1995). *How to Write and Use Instructional Objectives* (5th edition). NJ: Prentice Hall [revised edition of the 1985 text].

Harasim, L. Hiltz, S.R., Turoff, M. & Teles, L. (1995). Learning Networks. Cambridge, MA: MIT Press

Heinrich, R., Molenda, M. & Russell, J. (1993). *Instructional Media and new Technologies of Instruction* (4th edition). New York: Macmillan.

IEEE (2001). *Reference Guide for Instructional Design and Development.* From http://www.ieee.org/organizations/eab/tutorials/refguide/mms01.htm (last visit August 2003).

IMS (2003). *IMS Meta-Data LOM Specification* [information model, XML binding and best practice and implementation guide]. From www.imsproject.org (last visit August 2003).

Isakowitz, T., Sthor, W. & Balasubramanian, P. (1995). RMM: a Methodology for Structured Hypermedia Design. *Communications of the ACM,* 38(8), 34-44.

Keller, J.M. (1983). Motivational Design of Instruction. In Reigeluth, C.M. (ed.), *Instructional-design Theories and Models: An Overview of Their Current Status.* NJ: Lawrence Erlbaum Associates.

Keller, J.M. (1984). The Use of the ARCS Model of Motivational Design in Teacher Training. In Shak, K.E. (ed.), *Aspects of Educational Technology, vol. XVII: Staff Development and Carreer Upgrading* London: Kogan Page.

Keller, J.M. & Suzuki, K. (1988). Use of the ARCS Motivational Model in Courseware Design In Jonassen, D.H. (ed.) *Instructional Designs for Microcomputer Courseware.* Hillsdale, NJ: Lawrence Erlbaum, 401-434.

Kolb D.A. (1999). *Learning Style Inventory.* Boston, MA: Hay/McBer Training Resources Group.

Kwok M., and Jones C.. (1985) Catering for different learning styles, *Association for learning Technology (ALT-J) 3,* 1, pp.5-11

Merrill, M.D. (1983). Component Display Theory. In C.M. Reigeluth, (ed.), *Instructional-design Theories and Models: An Overview of Their Current Status.* NJ: Lawrence Erlbaum Associates Publishers, 279-333.

Morrison, G.R., Ross, S.M. & Kemp, J.E. (2003). *Designing Effective Instruction* (4th edtion). NJ: Wiley & Sons.

Reigeluth, C.M. (1983): *Instructional-design Theories and Models: An Overview of Their Current Status.* NJ: Lawrence Erlbaum Associates Publishers.

Retalis, S., Papasalouros, A. & Skordalakis M. (2002). Towards a Generic Conceptual Design Meta-Model for Web-Based Educational Applications. In *2nd International Workshop on Web Oriented Software Technology,* Màlaga, Spain.

Riding R.J. and Cheema I.. Cognitive style. An overview and integration, Educational Psychology – International *Journal of experiential educational psychology VII,* No 3-4, pp.193-125 (1991)

Schwabe, D. & Rossi, G. (1998). An Object Oriented Approach to Web-Based Application Design. *Theory and Practice of Object Systems* 4(4).