Visual Languages for Instructional Design: an Evaluation of the Perception of E^{2}ML

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Abstract. *In the last years, Instructional Design has seen the development of visual models for supporting and enhancing the design process. A part of them concern the definition of learning goals, while others address the definition of learning activities or learning materials. These tools supposedly reduce the cognitive load and enhance design communication. Few contributions try to assess the impact that such models have on the practice of Instructional Design. This paper first provides a general framework for the evaluation, indicating key issues and providing guidelines for the design of an evaluation program; then presents an implementation of the framework along with the data collected about E^{2}ML, a novel visual design language.*

Introduction: Instructional Design and the Use of Visuals

The design of instruction is a peculiar type of design, as its outcome is like the script of a play: it is an important element of the show, but not the only one – your enjoyment of a theatre representation also depends on the skills of the actors, on the performance of the orchestra, and on several other contextual elements such as the functioning of the heating system or the silence of the audience. Transposed to education, the quality of the instruction does not depend only on the lesson plan and on the learning materials, but also on the ability of the instructor, on the mood of the students, etc. As Morrison, Kemp & Ross (2003, p.2) put it, "Learning is haphazard; instruction is planned."

Design in such complex situations requires conceptual tools for organizing the work both mentally and physically, and that is what happens with the aid of visuals in Architecture, Mechanical Design, and recently in Software Engineering with UML (UML, 2001) or in Hypermedia Design with e.g. W2000 (Garzotto, Paolini, Bolchini & Valenti, 1999). Visuals indeed allow a synthetic representation of complex objects and reduce the cognitive load (Blackwell, 1997; Lewalter, 2003).

Instructional Design (ID) models have always been visually supported (cf. the use of visuals in Dick, & Carey, 1996; Morrison Kemp & Ross, 2003; Greer, 1992). The difference with other disciplines is that such models represent the design process as a sequence of steps or a set of elements, and not the object being designed, as it happens in architectural blueprints. To the purposes of this paper I will label these model *instructional design process models*.

In more recent years ID has seen the development of different visual models for representing the object of design. A part of them concerns the visualization of learning goals. To this class belong for example Merrill's Content-Performance Matrix (1983) and the revised Bloom's taxonomy (Anderson & Krathwohl, 2001). The goal of such models is to provide a mental classification framework for learning goals, useful for discussing them and creating a common understanding within the design team. Some novel works (Botturi, 2003; Belfer & Botturi, 2003; Belfer & Botturi, 2004) focused on the development of a blueprint language called E^{2}ML – Educational Environment Modeling Language for representing the educational activity as such, thus producing a documentation of the design process. CADMOS-D (Psaromiligkos & Retalis, 2002; Retalis, Papasalouros & Skordalakis, 2002) is another language specifically developed for the design of Web-based educational software applications. In order to distinguish them from design process models I will call them *instructional design languages* – models that support the representation of the object being designed (the learning goals, the instructional activities or the learning materials).

Despite the call of several authors for a continuous evaluation of design practices and tools (e.g. Osguthorpe & Zhou, 1989), few if any scientific contributions try to assess the impact of design languages in the actual design practice. No validated answer is available to questions as: Does this model enhance the quality of instruction? Does it make the design process more efficient? Does it allow the implementation of more challenging solutions? This is probably due to the intrinsic complexity of ID, and to the complex relationships among the elements analyzed below.

The goal of this paper is twofold: on the one hand to propose a general framework for the evaluation of visual instructional design languages, described in the next section; on the other, to present a first implementation of the framework for E²ML, reporting in the third section the evaluation method and presenting and discussing the data. Conclusions are presented in the last part of the paper.

A Framework for Evaluation

Evaluating a language is not an easy task. The use of a language is the result of complex interactions among the speakers and among the community of speakers and other communities, and its effectiveness is tightly connected to creativity. In some sense, a language is a flexible and continuously developing tool. Moreover, the specific domain of ID is manifold, as each organization and design team has its own practices (Schwier, Campbell & Kenny, 2003).

Key Issues in Evaluation

The evaluation of an instructional design language has to cope with a number of issues, some related to design in general, others specific of the educational setting. The following paragraphs introduce four key issues, specifying for each of them an indication to be taken into account.

Context Sensitivity
The actual use and effectiveness of a design language strictly depend on the designer, the type of instruction to be designed, and the overall institutional and educational context. The complex connection between these elements makes it difficult to define an evaluation protocol. For example, E²ML is suitable for system-level design; nevertheless, while some courses would benefit from it (for example a mixed-mode course), other courses even in the same institution may not (for example a face-to-face lecture series). At the same time, some designers may feel so familiar with it to use it also for quick design of small courses, where it would otherwise not be useful. It is therefore important to clearly specify the organizational and operational context of design, the types of instruction being designed, the competencies and background of the designers, and the goals and constraints in using the language.

Eclectic Benefits
In order to evaluate the impact of a tool, one should figure out what benefits it brings to its users. The point is that a language may bring a number of different benefits, but only some of them could be achieved in a single instance situation. For example, some may use a visual language as it makes easy to revise courses, although it requires some additional time for the first design; some others may use it as a standard visualization for all courses, so that any designer can quickly get the rationale of any course; etc. It is therefore necessary to declare what are the specific benefits expected from the use of the language – both from the point of view of the evaluators and from that of the designers.

Course Quality Assessment
A relevant element in the evaluation of a design language is the quality of the product. Yet the uniqueness of each educational environment, as a whole composed by a subject matter, a method of instruction, a class, the teaching staff and the learning materials, makes quality assessment of a single course problematic, as the large number of pages about evaluation in the literature testifies. Formative and summative evaluations in fact are measures of the intrinsic quality of a course and of its adequacy to the goals for which it has been developed, and could not be used as comparative values without a strong bias. Is a course a good course because all learners achieve the objectives, although none of them was able to do any other course in the same term because of work overload? Is a course a good course because the 3D animations developed for it won a prize, although the course overspent budget? The elements to be considered are many – strictly pedagogical, administrative, institutional, etc. – and are often tightly intertwined. The comparison of two courses increases the difficulty, as no parameters can be set for both of them in order to identify variables: for example, no two courses on the same topic may have the same class with the same entry level; and no two courses can be designed by the same designer with the same level of expertise. It is therefore necessary to split the different dimensions, and analyze them separately: learning quality, media development, management and budget, etc.

The Importance of Time
Time is of paramount importance for the integration of a language in a community's practice. The progressive rearrangement and smoothening of the language through use is an important and deciding process, as it should be considered that a community's language should be developed and negotiated by the community itself. It could be taken as hypothesis that the introduction of a language would follow the pattern of innovation diffusion (Rogers & Shoemaker, 1971). It is indeed likely that it would lower

productivity for a little while, raising it afterward. An evaluation program should therefore observe the evolution of the design practice and of the quality of the instruction over a long period and over more courses.

Elements for Evaluation

The issues presented above are only a part of those that must be considered in the evaluation of an instructional design language, and others could be listed: no two design teams work the same way; the choice of technologies has an impact on design; the different personal and cultural degrees of openness and will to collaborate of designers and instructors matters, etc. So what elements of a language could be evaluated? The following paragraphs try to put forth some hints.

Specific Sub-activities
The quality of a tool is its adequacy to a problem solving activity for its users (Hoyer & Brooke, 2001). Given the complexity of instructional design, specific and limited sub-activities could be observed, and this may provide elements for evaluation. An example would be a new designer in charge of redesigning two courses developed by someone else: she has only the course materials for the former, and a complete documentation e.g. in E^2ML for the latter. Her evaluation of her own work, and of the aid of the documentation, along with a measure of effectiveness (e.g. time spent), would offer a measure of the impact of E²ML on a particular situation.

Communication Events
Specific communication events could be observed as part of the sub-activities of the design process, as relevant test for a language. For example, the meetings of a design team could be videotaped in order to see the role that diagrams play when discussing objectives or activities.

Institutional Changes
The impact of a language could be observed also on the social dimension, as it provides for example the possibility to create a shared repository of courses, or to define pedagogical patterns, etc. Moreover, it could include the training of novice designers, the sharing of expertise and best practices, the reuse of design, and the communication inside and outside the team as elements of knowledge management. The guidance of the integration would as well be at stake: who is sponsoring the introduction of the new language? What are the major drivers? What the perceived benefits and fears?

Expressive Power
One of the most important intrinsic features that make a language useful is its expressive power, i.e. the extension of the domain of objects that it can describe. Can it equally well represent instruction delivered with different media, or in different settings? Can it grasp the essence of different pedagogical approaches?

An Evaluation of E^2ML

This section reports a preliminary evaluation of E^2ML – Educational Environment Modeling Language. The evaluation, conducted between May and September 2003, was designed in order to assess the first impression that experienced designers got from the language in terms of usefulness for their practice.

About E^2ML

E^2ML is a visual language for the design of educational environments. The main issue E^2ML is concerned with corresponds to what Greer (1992) and Reigeluth (1983) called the development of a blueprint: a representation of the instruction that all stakeholders, designers, developers and instructors can see, understand in a similar way and, hopefully, agree upon. The development of an E^2ML blueprint means modeling the instruction into a set of documents that provide a support for the people involved in the design process. The documentation is organized into three document sets:
1. Goal Definition, i.e., a declaration of the educational objectives. This is composed by two documents: the goal statement and the goal mapping (which exploits a goal visualization model).
2. Action Diagrams, i.e., the description of the single learning and support activities designed for the instruction.
3. Overview Diagrams, i.e., two overviews of the whole design, showing the dependencies between activities and the activity flow (a sort of visual calendar).

As any real design process and any real instructional situation has its own unique features, the language can (and should) be adapted, simplified or detailed, to the needs of the specific context or design team. The

documents are produced at different moments in the design process, and do not have a tight correspondence with specific phases. An example of E^2ML diagrams is provided in Figure 1, while a complete introduction to the language is available in (Botturi, 2003) and (Belfer & Botturi, 2004).
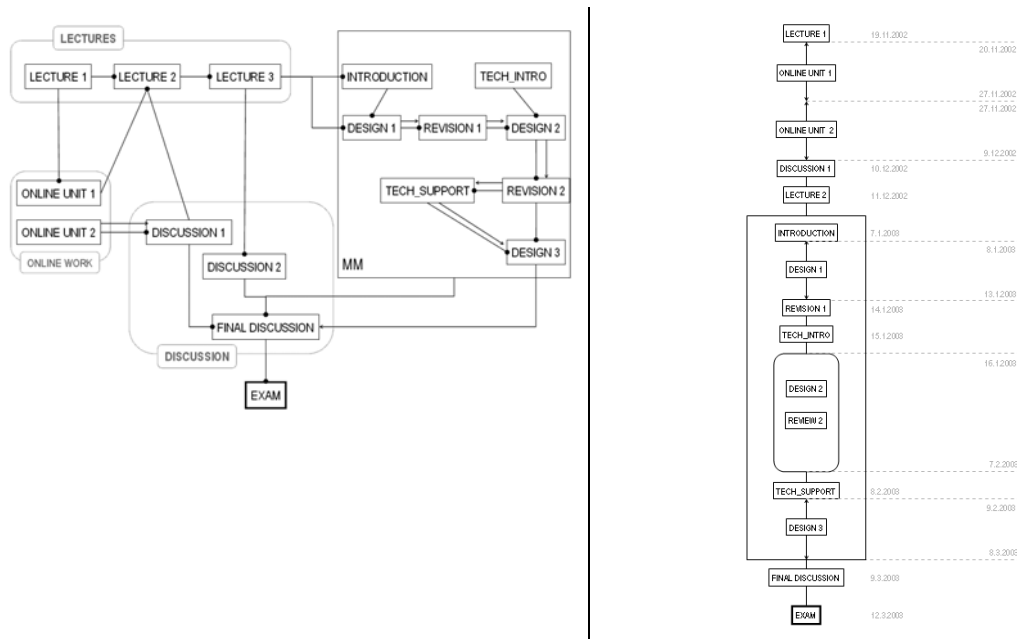

Figure 1 – Examples of E^2ML overview diagrams

Setting

According to the framework presented above, this evaluation was focused on a specific moment of the introduction of the language in the design practice – the very first introduction – and concerned a specific indicator, i.e. the perception of usefulness as expected benefit. The institutional context was determined by selecting the target population: feedback was collected from designers employed as course designers or course developers in Universities in Canada and the United States. Given the selection of a restricted time span, the evolution of the language and of the institutional practice were not observed. Finally, the evaluation was not based on the quality of courses. The data collection took two main forms:
1. Two focus groups were held at DE&T, University of British Columbia, Vancouver, involving 10 designers with different backgrounds (computer science, media production, instructional design, education, and religious studies) and different ways of doing design.
2. 12 designers from different institutions were interviewed and then required to fill in a feedback form after they had assisted to a group or individual presentation of E²ML.

Focus Groups

The overall impression that all designers expressed during the focus groups is that E²ML looks potentially powerful, flexible and adaptable to different strategies and situations. Its main innovative feature is its visual orientation, which provides a synthetic view of the instruction: they confirmed that they develop a mental image of the course that they never express, if not implicitly in the course materials, and that can be visualized with E²ML, providing "an interesting focus for the discussion" in the design team.

According the their perception, E²ML is mostly useful for keeping the overall consistency of a course, and in particular:
1. To discuss the consistency of goals and instructional activities (as general approach, activity structure and assessment) with the instructors or course authors: "they usually discuss the goals and then forget them in the actual planning". "A consistent strategy is something difficult to explain, and visualization is an important support".
2. To blueprint a course, as it "works well in organizing people's thinking", and "may speed up collaboration", also allowing a greater detail than usual textual blueprints.

3. To "make the evaluation more evident", identifying activities in which the achievement of specific goals is assessed.

While designers feel E²ML could be learnt in a reasonable amount of time, its complexity may make it difficult for instructors and course authors – "it has, from what I can see, a steep learning curve". From this point of view, visual learners might be favored, although designers do not think this is a prerequisite for using E²ML. Besides the design activity, E²ML is felt as a possible support for communicating the structure of activities to the students. From a practical point of view, all designers agree that E²ML should come with templates or a specific software application.

Finally, two more formal considerations emerged, concerning its expressive power:

1. The flexibility of E²ML with regard to learning objects on the one hand, and the necessity of a specific product-oriented model for the development of specific resources.
2. Time and durations are not evident in E²ML.

Feedback Interviews

Interviews were a semi-structured discussion of the model based on some cases, and confirmed the results of the focus groups, providing important elements for their correct interpretation. Interviewees were then asked to formalize their answers filling in a short feedback form. The feedback form was organized in two main parts:

1. Scenarios: designers were presented short descriptions of situations, and then asked if E²ML would have been a support for the specific instance.
2. Statements: designers were presented some general statements about E²ML, and they were asked to check the ones they felt true. Half of the statements indicated positive features, half negative ones.

Scenarios

The scenarios presented different typical situations in ID, and each of them was conceived as representative of a specific design activity (e.g. team organization) or quality (e.g. consistency). Table 1 reports the scenarios descriptions, along with a synthetic statement of the feature at stake.

SCENARIO	KEY
You are in the development team for a course in Economics along with a faculty, a subject expert from the corporate world and a Web programmer. It looks like you talk different languages and it is not easy to understand each other. Would E²ML enhance internal team communication?	Team communication enhancement
You are tight on schedule with a course, and you run to the Web programmer for having things online in the next few days. Unfortunately, the Web developer is on holiday – you find a newly hired guy to replace him. Would E²ML support Web material development, and support the new guy in understanding what you want to do?	Material development
The authors of a course have decided to use a mixed face-to-face and online strategy, which is also new for you under some respect. Would E²ML support checking if the course would work as one consistent whole before trying it with real student?	Consistency
A course requires the intervention of tutors in a number of different activities. It looks like they will be working very hard. Would E²ML help detecting work overload time spans?	Overload time spans
A course did not work – a lot of students drop out. Would E²ML serve as a diagnostic tool in order to identify what to redesign?	Diagnostic tool
Last year you developed a successful course, and the President want it replicated this year. The problem is that the materials should be updated, and the original author has retired. Would the E²ML documentation help working with the new author for reusing/readapting the instruction?	Adaptation (different instructor)
In the same situation as above, what if the same course, with the same author, is offered to a different target (e.g. students from a different Faculty)?	Adaptation (different target)
You meet a colleague from Europe, and you discuss with him the way you do courses. You say you try to be constructivist, and the same says he. But going on you actually disagree on a number of practical decisions in course development. Would E²ML be useful for more effectively comparing designs and courses?	Compare courses
Would the E²ML documentation be useful for checking the implementation status of a course?	Checking implementation status
A new young course developer is hired at your department. You are asked to mentor him and teach him some tricks. Would E²ML representation of courses be useful to let her see the way you do your job and the types of decisions you take?	Teaching novice designers

Table 1 - scenarios

The scenarios results are summarized in Figure 2: each feature is represented as a bar, as indicated in the chart key. Values go from 0 (the feature is not supported by E²ML) to 2 (the feature is well supported by E²ML). Intermediate values should be intended as degrees of possibility: 1 means something like "It is possible to use E²ML in order to do that, but it would require some rearrangement".
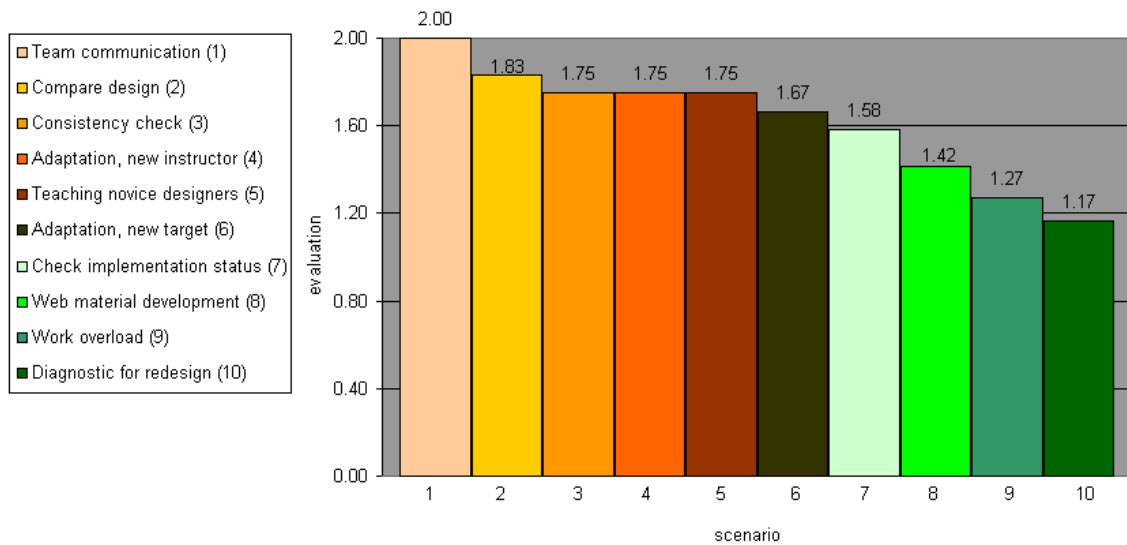

Figure 2 - Scenarios evaluation chart

All interviewed designers basically felt that all the proposed features were supported by the language. In particular, all of them expressed confidence that it can enhance team communication (bar 1) and support the comparison of different designs (bar 2). Also very high confidence was expressed for the use of E²ML as a language for keeping the overall consistency of the instruction (bar 3), adapting a course when the instructor changes (bar 4) and for teaching novice designers (bar 5).

The use of E²ML for the adaptation of existing designs with different students (bar 6) has a slightly lower score. Designers feel that E²ML may be useful for working with the instructor, while changing student target often means redesigning the course form scratch. Comments about these scenarios pointed out that the rationale of a course is given by the epistemological beliefs of the instructor – Richards & Rodgers' (1982) *approach* layer – and that often effective learning depends more on that than on the design of specific activities or on the quality of support materials – the *design* layer –, where E²ML seems to be more applicable.

The use of E²ML for checking the implementation status (bar 7) also got a middle confidence score, while lower confidence was expressed regarding the use of E²ML for the development of instructional materials (bar 8): designers feel that it is too high-level for implementation, and that what they usually pass to Web programmers is a more specific description, or some content to be put into HTML pages.

Noticeably, the lowest confidence is for two important elements: the identification of workload (bar 9) and the use of E²ML as a diagnostic tool, i.e. for identifying negative unexpected learning outcomes (bar 10). Although both of them got a final score above 1, the result shows a large space for improvement.

Statements
The statements indicated positive and negative features concerning the overall expected impact of the language. One last statement concerned the development of a software application for the creation of E²ML diagrams. They are the following:

- Positive statements:
    o E^2ML can enhance the quality of instruction.
    o E^2ML can support the implementation of more challenging design solutions for education.
    o E^2ML can smoothen the design process.
- Negative features:
    o E^2ML is too complicated.
    o E^2ML has too many elements.
    o The effort E^2ML required in writing the documentation is not rewarded anyway.
- E^2ML would be nice if it could be used with a software application.

Unlike for scenarios, designers had here a binary choice: the statement applies or not. The results are reported in Figure 3, where the values (between 0 and 1) represent the percentage of people that checked each item.
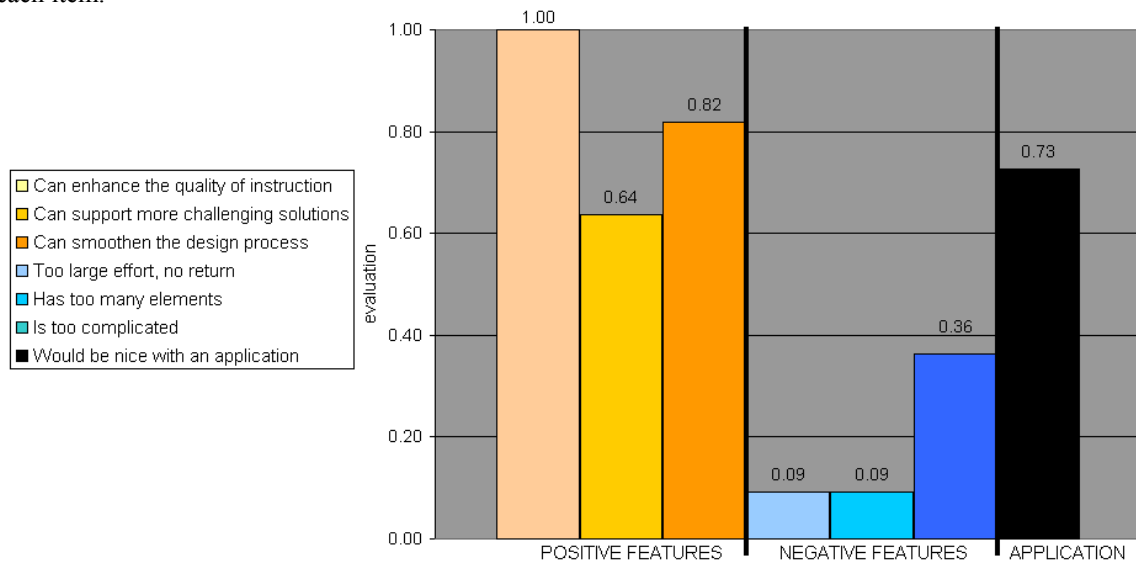

Figure 3 - Statement results chart

At a first sight it is clear that positive features are felt more correspondent to the reality than negative ones. Remarkably, all designers think that E²ML can enhance the quality of the instruction, and a great part of them that it can smoothen the design process. Moreover, only few think that it is too complicated, and a very small part finally thinks that it has too many elements and that the effort eventually spent in learning and using E²ML might be too large with respect to the return. Finally, the development of an E²ML application would be welcomed by the greatest part of the interviewed designers.

Discussion

Far from being a complete evaluation with a definitive claim – also given the small sample –, the data presented above were collected with the goal of providing an initial measure of the first impression of E²ML on experienced designers. According to the goals of this paper, the method and the result should be read under three different perspectives:
1. As an implementation of the evaluation framework. Under this respect, the framework provides guidelines for defining the elements for the evaluation: the limitation of the time span observed, the focus on specific elements as expected benefits, the non-emphasis on course quality, the selection of a specific institutional context.
2. As an evaluation of a specific visual instructional design language, namely E²ML, which seems to meet some needs of instructional designers and provide interesting possibilities.
3. As an indication for the development of visual instructional design languages, which are perceived as potentially powerful tools, provided that they are flexible, adaptable and easy to use.

A natural follow-up for the evaluation of E²ML would be the assessment of its actual use and impact in the long term in a community of designers, considering also the institutional changes it fosters.

Conclusions

After a short state of the art summary, the first part of this paper proposes a general framework for the evaluation of visual languages in ID, providing a set of guidelines and critical issues that should be taken into account. The second part of the paper provides an example of application of the framework to the evaluation of E²ML, a novel visual blueprint language. The data collected offer interesting insights about the use of visual languages in ID: designers expressed an overall positive impression about E²ML, which they considered an interesting new tool showing potential usefulness for their practice.

As a general contribution to ID research, this paper provides some initial evidence that designers see visual models as interesting new possibilities, and provides indication about their features and the evaluation of their impact on the practice.

References

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.

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

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

Blackwell, A.F. (1997). Correction: A picture is worth 84.1 words. In C. Kann (Ed.), *Proceedings of the First ESP Student Workshop*, 15-22.

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

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

Garzotto, F., Paolini, P., Bolchini, D., & Valenti, S. (1999). Modeling-by-Patterns of Web Applications. In *International Workshop on the World Wide Web and Conceptual Modeling* (WWW CM '99), Paris, France.

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

Hoyer, R.W. & Brooke B.Y. (2001). What is quality? In: *Quality Progress*, 34(7), 53-62.

Lewalter, D. (2003). Cognitive strategies for learning from static and dynamic visuals. In *Learning and Instmction,* 13, 177-189

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

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.

Osguthorpe, R.T., & Zhou, L. (1989). Instructional science: What is it and where did it come from? In: *Educational Technology, 29*(6), 7-17.

Psaromiligkos, Y. & Retalis, S. (2002). Configuration Management for Web-Based Instructional Systems. In *2nd International Workshop on Web Oriented Software Technology*, Màlaga, Spain.

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.

Richards, J. & Rodgers, T. (1982). Method: Approach, design, and procedure. *Journal for Teachers of English to Speakers of Other Languages Quarterly,* 16(2), 153-168.

Rogers E. & Shoemaker, E. (1971). *Communication of Innovations, A cross-cultural approach* (2nd edition). New York: The Free Press.

Schwier, R.A., Campbell, K. & Kenny, R.F. (2003). Instructional Designers as Change Agents: Perceptions of Communities of Practice. Paper presented at the *Annual Conference of the Association of Media and Technology in Education in Canada – AMTEC 2003*, Montreal, Canada.

UML (2001). *UML 1.5 Specification*. From www.uml.org (last visit August 2003).