NETWORKED KNOWLEDGE ARCHITECTURES
Tools *versus* Standards of Learning Design

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Abstract: There is little doubt that the key term of Networked Learning is "connections": connections between people, information and their context dependent knowledge productive activities. The need of being able to *create new information by structuring information* and the emergence of *new tools for dynamic knowledge organization* challenged the earlier educational notations and technological standards already in the beginning of the Semantic Web. Today we face another challenge: the confrontation of tools and standards in the forefront of competing e-didactic conceptions of knowledge, and learning design. Different approaches to Learning Design (the Larnaca Declaration or Diana Laurillard's "Teaching as a Design Science") concentrate on pedagogical patterns while the new Training and Learning Architecture (TLA) of Advanced Distributed Learning, e.g., is centered upon the flow of student activities. After reviewing the needs of Experience Design and xAPI Activity Tracking from the point of view of dynamic knowledge organization, the paper points out that networked learning calls for tools capable of creating Dynamic Knowledge Architectures. Giving examples of dynamic concept formation, it argues that Linked Open Data visualization of meta level concept formation is capable to represent activities as well as semantic content. The analysis of interoperability issues of semantic knowledge structures and learning activities supports the conclusion that problem centered activity design demands effective App integration.

Key words: Learning Design, Knowledge Organization, Networked Learning, Dynamic Knowledge Architecture, Experience API, TLA of ADL, Multimodal Meta-language

1 Introduction

Design thinking is present in pedagogy ever since people in designated roles are planning teaching and learning activities and prepare resources for knowledge transfer. It has gained special attention in the 21st century beyond the traditional preoccupation of educators, and produced such standards, or *de facto* standard formal specifications in e-learning as IEEE LOM, the ADL SCORM versions, or the IMS LD models derived from the work of the Valkenburg Group. [1] In a wide range of educational contexts it lead to the re-conceptualization of 'Teaching as a Design Science' (TDS) [2], to the introduction of Intelligent Tutoring Systems (ITS) in education [3], or to the development of new models and environments for connectivist teaching-and-learning [Cf. 26 with 28, 30, 31]. Networked learning poses a new challenge for design thinking because it not only has to take the perspective of the self-organizing learner but also has to connect different contexts of her learning activities, which include those of others as well. New tools and standards like the Total Learning Architecture (TLA) of ADL [5] are emerging for bridging the gap between directed learning, let it be formal or informal, and, the by now natural, *networked* learning situation of the self-directed learner.

The so-called "new generation of SCORM" specifications are on the way not only because former approaches to designing learning environments, to preparing learning resources, or planning and organizing learning activities answered problems of e-learning from a different social position, and because that position has radically changed, *blending* different types of learning. The advance of mobile learning, the Internet of Things and the development of the

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Semantic Web call for the new standards, erasing the "e" from e-learning, since the electronic media and the Internet are becoming a natural part of *all types* of learning. The technological progress is not waiting for pedagogic conceptions to follow suit, rather turns directly towards the needs of the networked learners/teachers producing a diversity of networking tools. The new technological standards serve the interoperability of online learning (and teaching) processes that are much more *dynamic* than those are that were common before networking. These standards provide new opportunities for different ways of design thinking.

In what follows the paper after reviewing certain *changes in education oriented design thinking* (2), discusses what the '*dynamics*' of these processes mean and imply for *meta-level notations* of *learning design* (3), analyses the needs of developing *networked knowledge architectures* and evaluates the *potential of* the *emerging technological standards*/specifications (4). Referring to a former analysis [17], it points to current tensions between *Learning Analytics oriented Activity Tracking* and the available *tools* for creating *networked knowledge maps*, which are able to provide multimodal learning experiences. It suggests solving the tension by *executable* Linked Open Data *visualizations* of the process *of meta level concept formation*, which *integrate semantic content with problem solving learning activities* and concludes that dynamic knowledge architectures should integrate user compiled *Apps for multimodal knowledge representation* and *organization*.

2 Shifts in the perspective of design thinking

'Design thinking' has its own pre-history and historical periods hallmarked by the 1962 London Conference on Design Methods [7], or the first Design Thinking Research Symposium in 1991 [8], that represent *systematic conceptions* of design which were preceded by such approaches as Zwicky's Morphological Analysis (1948) and the classic methodologies of art, science and engineering. Although the methodological discussions led to S. A. Gregory's well known distinction between '*scientific method*' and '*design method*', what was widely accepted already in the 60s, the struggle between schools considering design as art *versus* science was still an issue at the time of the academic recognition of the field [9]. Gregory's distinction (which defined 'Design Science' as the scientific study of design, but did not consider design itself as a science) also influenced methodologies and conceptions of the development of information systems via Simon's transplantation of Gregory's terminology to AI and the study of the Artificial. [10] The same line of distinction was carried further to the "scientific" (empirical) study of the use and behavior of ITS and their design, what resulted in a somewhat unfortunate separation of the analysis of their users' problem solving activity, discovery, and the functional, technical, or even the didactic design of ITS. [3] The latter is an area that is itself somewhat distant from the main field of Learning Design (LD) even today.[2]

The turns and crossroads in the development of learning design methodologies, the gradual changes in e-learning specifications, as well as several studies reflecting upon the historical development of the field show parallel changes of direction with design thinking in general within the narrower area of LD [12, 13]. The prominent journals of the 1980s (e.g., *Design Studies*, or *Design Issues*) reflect the dominance of 'object oriented' design of *forms*, *signs* and *artifacts* both in the general theory of design and in the discussion of cognitive styles. Similarly, the goals and interests of the main trends of LD initially took a Learning Object (LO) oriented approach in the "good" old days of e-learning. It was a tendency that influenced the

[2] The meaning of LD varies on a wide spectrum from the strictly defined IMS LD to softer theoretical conceptions, methods or practices of historically changing scope (see, the *Introduction* of [11] and James Dalziel's *Reflections on the Art and Science of Learning Design and the Larnaca Declaration* in [11, pp. 3-15] for the different approaches). In this paper LD is intended as a collective noun; a particular approach is only identified when needed.

standardization and functionality of Learning Management Systems (LMSs) through its content packaging keeping the (in fact rarely realized) ideal of reusability in focus. [Cf. 17, 18]

The developments of the abstraction mechanisms of programming languages also provided support for modeling new, activity oriented, application domains. The Educational Modelling Language, EML, the precursor of IMS LD is demonstrably building on early computational modelling languages in the era of e-learning 1.0. Universal Modelling Languages, such as UML are recurring suggestions (in addition to their already existing educational adaptations, such as coUML) even today, as an alternative general notation that can be used by 'designers for learning' to describe use cases of 2.0 learning environments (VLE) or the personal (PLE) based learning activities of the networked learner. [13, p. 132-134]. *Activity design* that influenced IMS LD and the practice of focusing on the "procedural aspects of design thinking" flourished after the Methodologist, and Design Science movements, partially in result of the spreading new managerial aspects of design which extended gradually from architecture to a wide range of contexts including the educational one. [12, 15]

There were, and are, several attempts to adopt Business Process Management technologies to educational workflows, with or without Business Process Execution Language, e.g., along the lines of the Taverna workbench. [16, 20, 21,] They represent a crossroad with e-science, and, especially in the Life Sciences, raise issues of parallel needs and developments with respect to the networked nature of scientific research and discovery learning.

The constructivist line of instructional design following Piaget's, Bruner's, or Pappert's initiatives shifts the problem of learner management and the integration of connectivist learning experiences to a *process-oriented networking* context that can be contarsted with *content-oriented* formal education. This shift has far going consequences at different levels of activity planning from the microcosmos of tutoring math problem solving to higher levels of group activies or connectivist course design. As the Introduction to the output of the recent ADSL Workshop formulates "[a]dopting a designer mindset means using empathy and observation to understand where the learners are, and creating the things that will help them get to where you want them to be, be those tasks, resources, social configurations or tools." [11, p. ix] Although the Workshop well represents the complex challenges that can be derived from this formulation (which itself reflects a move away from former conceptions of sequencing content or step-by-step activity design), LD is still influenced by an attitude originating from former standards: the *pre-design* of learning curves leading to pre-set goals, and pre-worked learning pathways. In the spirit of this attitude, planning *someone else's* actions and cognitive processes still plays a more crucial role than designing architectures which lend themselves for *self-organizing, user directed learning*, and for the *social construction of knowledge*. Being similar to the ASCD promoted Understanding by Design this formulation still reflects an attitude that prompted Stephen Downs to remark reading the Larnaca Declaration on Learning Design that we "should rather call it 'teaching design', since the focus is on the teacher as, if you will, maestro." [22] The analogy may be apt concerning the (gradually changing) "maestro" attitude, however, it limps concerning the attempt to create a metalanguage that is able to play a similar role in describing the teaching/learning process as music notation plays in composition. A proper notation may serve the description of learning paths or the *creation* of the learner's own knowledge architectures as well as the conduct or documentation of prescriptive teaching patterns.

Diana Laurillard's conception of TDS moved explicitly in the direction of becoming learner centered, without sharing Downs' preference of learner's control. The Pedagogical Patterns Collector (PPC) of the London Knowledge Lab serves the articulation of best practice pedagogical patterns including conceptions of Instructivism, Social Constructivism, Experiential, or Inquiry Learning, Constructionism, or Collaborative Learning along the lines of

Dewey, Vygotsky, Piaget, Gagné, Bruner, Papert, Marton, or Bransford, as well as the analysis and modeling of different learning experiences and their redesign. [2]

It shares the more holistic approach of Learner Experience Design (LXD) that shifted the focus of design thinking to the *learner* and put less emphasis on instruction and more on the learners' perception of their learning experiences, which became at least as important in the rise of LXD as content and learning objectives. The essential insight of the User Experience (UX) movement in design that fed on R. S. Wurman's conception of Information Architecture, was that "[t]he creative organization of information creates new information" [23] and that "[t]he primary choice of which way you organize something is made by deciding how you want it to be found." [24 p.17] His 'LATCH' principles (Location, Alphabet, Time, Category, Hierarchy) of organizing information influenced UXD by his slogan "Allow the information to tell you how it wants to be displayed" but did not address the issue of *how to find*, and how to promote instrumentally the discovery of the organizing patterns of problem solving considered as a design process. As far as the 'compositional' conception of LD is concerned, Wurman, influenced by his teacher, Luis Kahn and his background in Constructivist Architecture, anticipated some insights of both the Larnaca Declaration and the conversational conception of the London Knowledge Lab, arguing that "architecture is 'frozen music', information architecture is 'frozen conversation'." [*Ibid.*]

Both Laurillard's theory-based reflexive framework for co-creating the learners' learning in a human readable conversational framework and the Larnaca Declaration reflects drawing the lessons from the low degree of penetration of IMS LD into actual educational practice because of its technical sophistication. [17] The IMS LD specification attempted to provide a formal metalanguage for educational modeling that is able to serve as a standard way of describing the learning process, but paid the price of adapting to current machine executable formalism. In result of its basic metaphor, a "Script of a Theatrical Play" that is translatable to XML code, it struggled with the requirement of interoperability in order to remain executable by the LD Players of the LMSs. The IMS Global Learning Consortium detected the didactic need of a rich expressive meta-language, which goes beyond the SCORM specifications (v1.2, and even version 2004), but the developers of the IMS LD specification did not consider the insight of the New London Group (NLG): "Any metalanguage to be used in a school curriculum has to match up to some taxing criteria. It must be capable of supporting a sophisticated critical analysis of language and other semiotic systems, yet at the same time not make unrealistic demands on teacher and learner knowledge, or conjure up teachers' accumulated and often justified antipathies towards formalism. The last point is crucial, because teachers must be motivated to work on and work with the metalanguage." [25, p. 24] If we accept that this point also applies to the self directed networked learner we can extend some further insights of NLG to Networked Learning to the unfolding age of the Internet of Things and the Semantic Web.

3 The dynamics of meaning emergence and the need of meta level notations

Today networked learners just type in Heron's formula, or Pythagorean Theorem and their browser returns a multitude of information including various visual or algebraic proofs, conceptual relations, videos, and historical material. A learning designer, reflecting on the alternatives of open or guided inquiry learning [28], has no choice but to decide that he wants the networked learner to discover these theorems for herself without knowing about their existence or that he is going to influence the way she is to find them in already existent forms. The two choices may lead to different generalizations and require different (open or guided) pedagogies. [28, 31] His knowledge and use of terms will depend on his pedagogic decision and the initial problem setting. "Nominalisations are used to compact information —whole conversations—that we assume people (or at least 'experts') are up on. They are signals for those in the 'game' and thus are also ways to keep people out."[25, p. 28] This formulation of the NLG connects didactics to problems of networked learning in the era of the Semantic Web when gradually, even the solutions to higher (already elaborated) math problems can be found within a minute's search. The NLG interpreted learning, just as our contemporary networked learning designers, as a personal and collective "goal directed, problem solving activity that results in the creation of something useful [in their terms: 'meaningful'] that did not exist before" [Cf. 26 with 25]. Dynamic Learning is an organic problem solving oriented process of invention, discovery, and planning not accumulation and memorization of facts. It is "self initiated, involves engagement over time, occurs in a social context, has personal meaning, and goes beyond knowledge to influence the attitudes, behavior, and even the personality of the learner." [27, p. 86] It builds on Piaget's and Bruner's assumptions about the multiple intelligences of the mind and the idea, that learning *changes* the learner's beliefs *and* behavior. Processes resulting in such a change are *a fortiori* dynamic by their very nature and rely on multimodal representations afforded by the digital environment. [29]

Networked learning can be *dynamic* in several senses: (1) the objects or even the subject of study may not be given (e.g., as a linearly sequenced SCORM module in a learning environment, or as a recorded melody). Both of them can change in result of the formation of the learning process, because the problems have to be discovered in a motivated, intention (but not necessarily goal) oriented inquiry. (2) The *problems* and the *conceptual space* have a temporal evolution; just like in a game: after every step new questions may arise for the learner in result of consulting resources, peers and others. Consequently, instead of pre-designing learning activities a co-construction of search strategy, and pool of heuristics are needed along the lines of didactic conceptions of *learning as search and inquiry*. [30] (3) The difficulty of planning dynamic networked learning process lies in the dual nature of design: "The term […] has a felicitous ambiguity; it can identify either the organisational structure (or morphology) of products, or the process of designing" [25 p. 20]. The same applies to metalinguistic descriptions of both guided and open student driven inquiry depending on the tools, affordances of the environment. [31] A proof of Heron's formula has a morphological structure, but it is not the same as designing a process of/for finding it. The latter also depends on the tools used by the student and/or teacher in the learning environment of the abstract problem solving process. The NLG emphasized the importance of the already existing elements of Available Designs, ringing a bell again in harmony with Wurman's slogan, "You can only understand something relative to something you already understand." [23] Just as the beginning of the process of Designing, and the critical point for the meaning-making function of the Redesigned components, all playing a role in finding solutions in a problem space, is exploring what it is that you don't understand: "»The only way to communicate is to understand what it is like not to understand.« It is at that moment that you can make something understandable." [*Ibid.*] That is the point which determines what should be the components of Redesign. Because Design and Redesign are shaped not just by the conceptual composition of these components, but the affordances of the environment, the latter, consequently, has to become part and parcel of the design problem. This is why Networked Learning embraces an indirect approach to design as opposed to the idea that it can be designed directly (e.g., in the spirit of [1]), an opposition that lead to the distinction of "design *for* learning" and "design *of* learning." Given the multimodal nature of networking environments, the NLG called for the development of explicit metalanguages that can describe meaning emergence in different modalities and their combination already in 1996. It is a call, still today, that remained unanswered in spite of the urgent needs of Networked Leaning.

4 Networked knowledge architectures providing multimodal learning experiences

Feeling the need for a complex notation in LD, the NLG's manifesto anticipated an analysis of the *dynamics* of multimodal representation of *meaning-making*, *problem solving* and its *communication* 20 years before the era of smart and ubiquitous learning. They foresaw that today, when we distinguish multimodality from multimediality, and multi-semiotics from multiliteracies [13, 14] what is "becoming increasingly important are modes of meaning other than Linguistic modes, including Visual Meanings (images, page layouts, screen formats); Audio Meanings (music sound effects); Gestural Meanings (body language, sensuality); Spatial Meanings (the meanings of environmental spaces, architectural spaces); and Multimodal Meanings. Of the modes of meaning, the Multimodal is the most significant, as it relates all the other modes in quite remarkably dynamic relationships." [25, p. 28, cf. Figure 1.1 on p. 26 representing Design Elements.] This is so, not because "[a]ll written text is also a process of Visual Design", but because, "[i]n a profound sense, all meaning-making is Multimodal." [*ibid.*]

Looking for tools and standards that support the integration of tools that serve combination of multimodal design elements there are two specifications that play today: IMS Global Learning Tools Interoperability, (LTI) [35] and the Total (originally "Training") Learning Architecture of ADL. [5] LTI is a specification which serves LMS based learning environments, let they be local or in the cloud. TLA is focusing its research efforts on next generation Networked Learning and the application of the Experience Api (xApi). The component capabilities of the TLA include *experience tracking*, *content brokering* of *learning content, 'learner profiles*, and *competency networks*. The Aviation Industry Computer-Based-Training Committee (AICC) joined the initiative of ADL, and the xAPI specification is now developed as a component of AICC's CMI-5, the next generation eLearning interoperability specification intended to replace existing AICC and SCORM specifications. [17] The xApi (or 'Tin Can') is a service API for handling activity streams (e.g., JSON, or Atom) generated by different learning services. It exchanges information about the learning processes and links educational tools incorporating functions of activity tracking. It records the information about learning activities into various Learning Record Stores (LRS). It can work with multiple LRSs, admitting communication with LRS servers in the Cloud, with a corporate LRS, with the administrative information store of educational institutions or a private, personal record locker. Using its communication protocol the LRSs are able to talk to one another and the information can be passed between them storing and requesting activity streams. What the xAPI sets out are the parameters and rules for passing data statements about the user's learning activities from one application to the LRS and back, so that it can make sessions possible with other Apps.

A former study [17] of the author pointed out the need for Networked Authoring Tools, in addition to the spreading use of the xApi for Learning Analytics and Activity Tracking. In light of the analysis above it is even more important to underline that LD needs *tools* for creating *networked knowledge maps*, which are able to serve as frameworks for multimodal learning experiences as well as for their design. Johnsen and Jensen recently scathed the future use of Concept Maps as possible Knowledge Architectures for the designing and playing/executing multimodal web content. [33] They can be combined with such LD initiatives like the Dynamic Learning Maps (a JISC founded project of the University of New Castle). The result would be *executable* Linked Open Data *visualizations* of the process *of meta level concept formation*, which *integrate semantic content with problem solving learning activities.*

Conclusion: the integration of user compiled Apps into multimodal Networked Knowledge Architectures

Both the quasi standard IMS Global Learning Tools Interoperability, (LTI) and the Total (originally "Training") Learning Architecture of ADL offer the integration of web based Apps.

As IMS Global formulates they are "to allow the seamless connection of web-based, externally hosted applications and content, or Tools (from simple communication applications like chat, to domain-specific learning environments for complex subjects like math or science) to platforms that present them to users. In other words, if you have an interactive assessment application or virtual chemistry lab, it can be securely connected to an educational platform in a standard way without having to develop and maintain custom integrations for each platform." [35] A crucial difference between the two specification is that TLA via the xApi supports the arbitrary compilation of such tools by the users themselves, let they be learning designers or self-directed learners composing their own PLE and knowledge organization process. In the form of executable *Concept Maps 3.0*, or Dynamic Learning Maps these combined meta level and content level knowledge architectures may turn out to be remedies for the lack of articulation of networked design practices and methods, and the "shortage of tools and representations to support such practices, a lack of a culture of teacher-as-designer among practitioners, and insufficient theoretical development to substantiate this." [11, p. ix.]

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