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1. A MULTI-DIMENSIONAL SPACE FOR LEARNING DESIGN REPRESENTATIONS AND TOOLS

INTRODUCTION

One of the core activities teachers perform as part of their professional practice is conceptual preparation of educational interventions of whatever type and at whatever level of granularity: single learning opportunities and activities, sequences, lessons, units, modules, courses or even whole programmes. A longstanding pillar in the constant quest for didactical efficacy, this preparation and planning is a field of study in its own right that is attracting renewed attention. This is thanks in large part to innovation brought about by the use of digital technologies throughout the educational sphere. The field is known by various names but perhaps the most commonly adopted, at least in Europe, is learning design (LD). This fast evolving field has become quite broad in scope and is now characterised by considerable diversity and complexity. For many, this rapid development is disorienting, making the field somewhat difficult to get to grips with. In an effort to address these challenges, and to contribute to a more systematic view of the field and its multitude of facets, this contribution illustrates and explains learning design in terms of one of its central tenants, namely design representations and tools. The chapter illustrates a set of different representation types and tools and proposes a multidimensional framework for positioning different approaches to learning design.

To this aim, it should be noted first of all that educators adopt a wide variety of methods, processes and tools for planning and preparing the activities they intend to enact for and with learners. However, there is a common thread running through this tapestry: the production of an artifact of some kind, whether it be just a few informal notes or a more elaborate and detailed form of representation. Elucidating, shaping, crystallizing and expressing intentions in this way is a process of design, in the sense that it concerns the formulation of the conceptual basis of an educational intervention in anticipation of its subsequent enactment. Representing one's thinking in a design artefact (of whatever form) can be regarded first of all as having a maieutic function, in that it calls on the teacher/designer to externalize, reflect on and assess her ideas. The design artifact then stands as a record of the author's (or authors') intentions, serving as a useful reference before, during and after enactment. Indeed, re-examing this record in the light of the experience gained from enactment can yield valuable insights: about initial assumptions, about the processes set in motion, about actors' performance, about outcomes and so on. As well as contributing to the practitioner/designer's professional efficacy and growth, these insights may be utilised for optimising the original design and for refining it for possible reuse, either by the author/s or by others. Indeed a key affordance of design artifacts is that they can be used to share information and knowledge about professional practice, especially among peers. This is a vital factor in a sector where practitioners have traditionally operated in relative isolation, even when working in adjacent classrooms day in day out.

So in the light of the above we can say that the essential role of the design artifact is to capture and communicate ideas, to the benefit of oneself and of others. Of course the advent of Information and Communication Technologies (ICT) has had a profound effect on all aspects of social communication, and the fields of endeavor addressed here are no exception, dependent as they are on reflection and communication processes. The use of ICT has opened up new didactical opportunities within education, while at the same time introducing a heightened degree of complexity both in learning processes and in their management. This in turn calls on practitioners to reconsider and perhaps change the approaches and tools they adopt for design, in a quest for more informed, methodologically sound and effective practice (Conole, 2012; Mor & Craft, 2012; Earp & Pozzi, 2006; Persico, 2006). The result has been increasing interest (and innovation) in the field of learning design, an endeavour that, for the most part, is identified with the employment of digital tools, resources and accompanying methods to support a systematic approach to design (Bottino et al., 2008).

This trend towards computer-supported learning design has helped to enrich, diversify and extend the possibilities for communicating design ideas both at an individual, maieutic level and as part of social processes. Depending on their priorities, practitioners may want to adopt digital tools for various learning design purposes: organising and retrieving design ideas for personal reference/reuse; conveying those ideas to (other) actors engaged in the enactment process (learners, facilitators, collaborating peers); passing them on to other practitioners and designers for discussion and possible adaption/reworking, towards reuse in other settings and contexts; sharing them with researchers as part of pilots devoted to educational innovation of some kind.

Design artefacts can be expressed in languages and forms of different kinds, ranging from simple outline sheets to machine-readable representations that automatically configure a digital learning environment in which the design is deployed and activities enacted. Currently, there exists a wide variety of representational forms conceived for different purposes, users and contexts, and this may make it difficult for non-specialist practitioners, especially novices, to get to grips with the learning design field. This paper is an attempt to provide a systematic view of existing design representations, even though the borders between the various categories proposed can be rather blurred.

There are a number of dimensions along which it is possible to classify existing representations, tools and approaches in the field of design for learning. Gibbons et al. (2008) identify 7 continuums along which it is possible to position the various design languages: complexity – simplicity; precision – non precision; formality – informality; personalization – sharedness; implicitness – explicitness; standardization – non standardization; computability – non computability.

Agostinho (2008) and Conole (2010) also provide an overview of the range of representations used to describe learning designs and other outcomes of the same process, showing how they can be used to foreground different aspects of design development.

The present contribution builds upon previous work in this area to propose a multi-dimensional framework that is intended as a conceptual tool for classifying different design approaches and representation forms, thus also shedding light on areas where further research work is needed[1].

FORMAT AND TYPES OF DESIGN REPRESENTATIONS: A FIRST OVERVIEW

Design representations can vary in format and type. Broadly speaking, formats fall into two main categories: textual representations (languages) and visual representations. According to Conole (2012), textual representations are expressed in either artificial/formal or natural language (narratives), while visual representations basically rely on a graphical format. In the following these types are described in general terms; concrete illustrative examples are introduced and examined in the Discussion section.

In LD, artificial textual languages are generally used to encode and convey a design in a highly formalized way, usually so that it can be processed by a computer. This makes it possible to deliver relevant components of a learning activity directly to learners or provide for automatic configuration of a suitable computer-based learning environment in which the activity can take place. Describing a design through such formal languages is usually a fairly technical matter. Consequently, it may call for a professional with the necessary technical competences to act as a ‘bridge’ between teacher-designer and computer. More commonly, a high-level interface is adopted to ‘mask’ the technicalities, thus allowing the teacher to focus mainly on design considerations.

Textual representations based on natural language, instead, are largely ‘narratives’, i.e. descriptions of designs, plans or experiences based on words. As such they typically have a low degree of formalism. However, they are often based on a pre-defined skeletal structure or template proposing an organized schema of descriptors/fields for expressing the various aspects of the design. This scaffolds the author through the design process, suggesting what choices and decisions are to be made, and what information is required at what level of detail.

Some narrative forms place the accent on essential context-independent information at the expense of more detailed context-related data, which may even be excluded altogether. This bias towards abstraction is partly an endeavour to foster (efficient) communication of a design’s essence, but more importantly it is an (informal) attempt to facilitate reuse through generalisation. It must be

[1] We acknowledge that many of the considerations made herein derive from the work carried out by the ‘Learning Design Grid’ (LDG) STELLAR Theme Team, which was active from Autumn 2011 to Spring 2012 and produced a Practitioner’s Guide to Learning Design.

recognised, however, that these do not in themselves constitute a guarantee of enhanced reuse capability.

Other kinds of narratives, as explained further hereunder, are intended to include more detailed information, which may be related to the pedagogical rationale behind the intervention and/or the details of the “enactment” phase. In a sense, the latter “fleshes out” the design skeleton with tangible description of the way the learning activity has been or can be used, the context that the activity is intended for, the target population to be addressed, the prerequisites, etc.

Let’s now turn to visual representations. These generally take the form of diagrams or graphs, which convey an overall view of the design or specific aspects thereof, such as the structure of the intervention, the learning objectives, the contents to be addressed, the roles of the people involved, etc. Diagrams or graphs are a means for schematically representing the main entities within a design and the relationships between them; common examples include flow charts, content maps and swim lanes.

Charts, on the other hand, are visual representations of quantitative data from the intervention. Typical examples here are bar or pie charts representing features of the learning process, based on suitable indicators. These charts can foster reflection by focusing the author’s attention on specific the aspects of the design shown in the representation (San Diego et al, 2008).

As we shall see in the following, textual and visual representations may in principle be used autonomously, but more commonly than not they are used in conjunction with each another. This is useful, perhaps enven necessary, for fulfilling the dual purposes of a design representation, namely capturing salient design concepts and conveying that information effectively to others (Falconer et al., 2007).

AUTHOR AND END-USER

A learning design representation may be authored by an individual educator or by teams of teachers and/or designers. Unless ‘average teachers’ have recourse to a high-level tool, dealing with artificial languages is unlikely to be cost-effective for them; they would probably feel more at ease with narratives. As already mentioned, the (present) inavailability of such tools beyond prototype status means that artificial language use requires the intervention of an intermediary to transform the teacher’s design into some sort of runnable code.

Visual representations are typically adopted for the intuitive, user friendly qualities they can bring to design and, provided the formalisms within them are not too obtuse, they can generally be used by any author, be they a teacher and/or a designer. Indeed this is usually the very reason why recourse is made to visual representation in the first place.

As already mentioned, design representations may be intended primarily for communicating with other authors and/or educators, but they may also be intended as a way of conveying design information directly to learners themselves.

Lastly come those representations whose main or sole mission it is to scaffold the author and foster their reflection through the design process. These representations can be seen as half-baked artifacts whose principal beneficiaries are the individual authors themselves. However, in a truly participatory culture of learning design, they could also function as knowledge-sharing synapses that facilitate the exchange of emergent ideas and practice. Once consolidated, these could then serve to enrich the final learning design artefact. By the same token it should be recognised that authors can be quite reluctant to share early drafts of their work, as substantiated by Pozzi and colleagues (Pozzi, Persico & Sarti, 2014).

‘CONTINUUMS’ FOR LEARNING DESIGN REPRESENTATIONS

In an attempt to map existing representation forms, it is possible to identify two dimensions or ‘continuums’ along which any representation can in principle be placed. One is the degree of *formalism;* some representations are characterized by high levels of formalism, while others are fairly informal. The other is the degree of *abstraction;* representations can provide very concrete or very abstract information.

The degrees of formalism and abstraction are strictly interrelated and often the level of one dimension influences the level of the other. Furthermore, these two dimensions impact on the malleability of a learning design *in toto,* i.e. the degree to which a design can be reshaped, remixed and reappropriated in new situations. In the following the two dimensions are briefly described.

Degree of formalism

A representation’s level of formalism regards the degree to which its use entails observation of fixed syntactic and semantic ‘rules’. Some representations have very strict rules and are therefore highly formalized. Others impose no such rules, granting the author freedom of expression but at the same time leaving ample space for ambiguities.

Typically the degree of formalism is high for artificial languages such as in the case of the IMS-LD specification (Koper, 2006) but low for natural languages.

Graphical representations typically have a moderate degree of formalism, although there is a degree of variance. For example, some schematic diagrams feature elements that are defined in absolute terms and are therefore highly formal. Others, such as CompendiumLD, adopt symbols whose semantics are not formally defined, and thus leave space for a degree of subjective interpretation.

However, we should not forget that, as already mentioned, visual representations rarely provide exhaustive design information and so more often than not they are accompanied by narrative. This, of course, limits the degree of formalism of the resulting representation.

The degree of formalization is also proporortionally related to the ease of automation; generally speaking the higher the former, the higher the latter. It is also associated to some extent to the reusability of the design, which is generally higher for more formal languages. However, it should be noted that reusability does not depend on formalization alone, far from it.

Degree of abstraction

Another interesting dimension is the degree of abstraction. Butturi and Stubbs (2008) distinguish between ‘sketch-oriented representations’ that provide an outline, and representations that enable details to be specified. In principle, the idea is that the more abstract the design, the greater the scope for reusability. At the same time, however, when details are missing, automation becomes impossible.

As already mentioned, natural language representations may provide considerable detail (encompassing information about the enactment phase, for example) or may be focused at a more general level, providing only an abstract picture of the proposed activity (Conole et al., 2011).

Graphical representations tend to give rather abstract information, but it is not unusual to see graphs of different kinds, like concept maps, used in conjunction with texts. The graph provides an overall idea of the design but it may also embed detailed narrative information that can be accessed interactively, for example by clicking on a single node/symbol to display related text.

Artificial languages are usually created to convey quite detailed information, so the level of abstraction in these cases is low.

Since the two dimensions (formalism and abstraction) are ‘continuums’ of sorts, it is possible to see them as axes, along which one may locate the various representations commonly adopted in the field. For the sake of simplicity and immediacy, we have chosen to group these into general representation types, as shown in Figure 1. Of course this is an over-simplification, but the idea here is merely to show that any representation can in principle be mapped along the two axes.

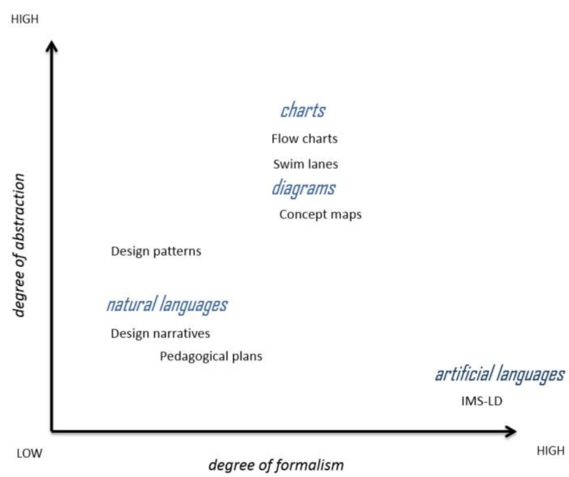

Figure 1. Representation types mapped by ‘abstraction’ and ‘formalism’ dimensions

PURPOSES OF REPRESENTATIONS

Generally speaking, ‘design languages can be used to generate designs and as a mechanism for interpreting and discussing them’ (Conole, 2012).

In a similar vein to the proposal made by Botturi and Stubbs (2008), who distinguish between ‘finalist communicative languages’ and ‘representative languages’, we contend that representations can be viewed in terms of *purpose*. In some cases representation is oriented more towards the actual design process, while in others communicating design ideas through the sharing of design representations is the main aim. A third type of purpose is that of supporting automatic configuration of ready-to-use learning environments.

Generally speaking, we can distinguish between ‘representations for personal use’ (i.e. representations keyed to the designer’s authoring and reflection processes), ‘representations for social use’ (when the designer’s main concern is to communicate ideas to peers) and ‘representations for institutional use’ (when the designer wants to deliver the design to learners). Even if the borders between these categories are rather blurred, and representation forms are often blended to meet multiple purposes, some representations seem better suited – and more effective – for supporting one or the other.

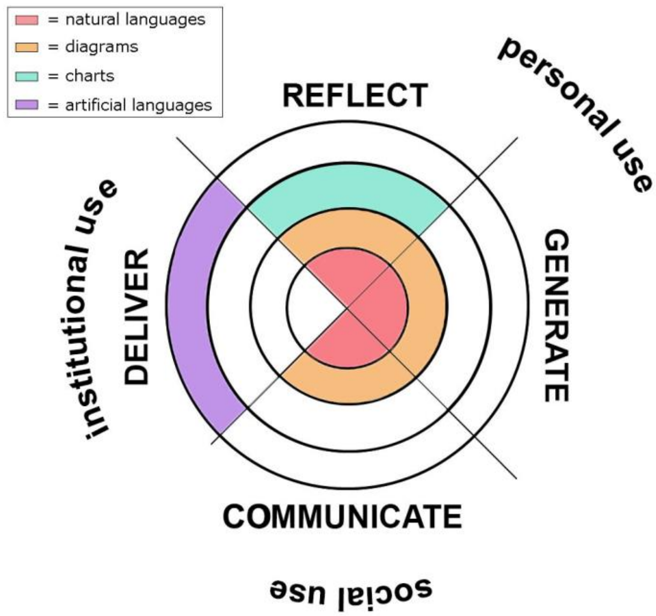

Figure 2. Representation types and purposes

Figure 2 sets the main representation types against the main purposes. While representations based on natural languages generally serve the purposes of generating, reflecting on and/or communicating the design, artificial languages for design representation mostly have the purpose of delivering an activity to students. Diagrams can be used to generate, reflect on and communicate the design to others, while charts are often used as *a posteriori* tools to reflect on design choices.

Again, it is worth stressing here that different representation types are commonly combined and thus serve multiple purposes.

DISCUSSION: MAPPING REPRESENTATIONS WITHIN THE FRAMEWORK

Summarising the considerations made thus far, the framework adopts four general representation types (natural and artificial languages, diagrams and charts) and positions these bi-dimensionally in terms of varying degrees of formalism and of abstraction (fig.1). Additionally, the framework sets the four types between poles of purpose and sections them according to four general functions (generate, communicate, reflect, deliver) (fig.2). The relations between these dimensions may be viewed from different directions and at different levels, and this aspect is briefly examined in the conclusions.

In the following, we discuss the proposed framework using examples of existing representations (or tools implementing specific representations) and position these within the proposed dimensions. The list of representations chosen for this exercise is not exhaustive; the selection has been made mainly on the basis of the representations discussed within the LDG Theme Team, which inspired this work.

As a first example let's take so-called Design Narratives (Mor, 2011), which are accounts of critical events in a design experiment from a personal, phenomenological perspective. Design Narratives are usually focused on design in the sense of problem solving, describing a problem in the chosen domain, the actions taken to resolve it and their unfolding effects. They provide an account of the history and evolution of a design over time, including the research context, designated tools and activities, and the results from users' interactions with these. The level of abstraction is fairly low in this representation but, by the same token, the degree of formalism is also low. The purpose of this text-based representation can be both personal and social, as it can be used both for reflection and as a communication artifact. In the latter case, though, one should consider that the level of reusability of narrative-based designs *per se* is not particularly high. However, they can be used as inspirational objects for the design of new artifacts, as in the case of the SNaP! framework (Mor, 2013), where narratives were used as raw material for constructing 'patterns'.

Among the textual representation forms that lend themselves best to communicating overall design and sharing it with others for reuse, one that figures prominently is the so-called 'Pedagogical Pattern' (Anthony, 1996; Bergin 2002; Eckstein et al., 2002; Laurillard, 2012). While patterns are also written descriptions and are based on a precise descriptor schema (Problem, Forces, Solution, etc.), the aim here is to leave aside any contextual information and consider the design as a general - and generalizable - approach to a commonly occurring problem, thus facilitating application/reuse in multiple contexts. Pattern forms related to Pedagogical Patterns include e-learning design patterns (Kohls and Wedekind, 2010) and Collaborative Learning Flow Patterns. The former were first proposed in the E-LEN European project (AA.VV., 2005) and later developed further by McAndrew, Goodyear and Dalziel (2006) amongst others. The latter capture and propose techniques that practitioners typically adopt for structuring activities in collaborative learning situations (Hernández-Leo et al., 2005).

So, comparing the positon of Design Narratives and Pedagogical Patterns in the proposed framework, we see that even if they are both text-based representations, they embody different levels of abstraction and have different purposes (reflection for the former and sharing and reuse for the latter).

A textual format combined with a predefined descriptor schema can also be used to scaffold the design authoring process. Examples are provided by systems that present the author with a set of empty fields that are to be filled with relevant information such as intended learning objectives, features of the target population, tools required, etc. Hints, prompts or suggestions may be on hand for completing the data. In some cases the system may also present a closed set of values from which to choose, e.g. target population = primary / secondary / higher education. The user is thus guided through the design process, with the help of prompts intended to crystallize design decisions and stimulate reflection. In this sense the descriptor schema (through its structure and attendant prompts/values) acts as a maieutic tool (Olimpo et al., 2010) that helps the author fashion initial (and perhaps as yet ill-defined) ideas into a detailed, systematic description of the learning intervention (Britain, 2007): how it is structured, what the objectives are, what the learning outcomes may be, what tasks learners will carry out in pursing the objectives, what materials are to be used, what time schedule is foreseen, etc. Examples of such descriptor schemas can be found in the Pedagogical Plan Manager[i] (PPM), in Dialog Plus[ii] or in Learning Designs[iii]. Although there is some variation in the descriptor schemas that these tools propose, they all support the design process through the definition of more-or-less common elements: learning context, intended outcomes, rationale, tasks for learners to perform, required resources, chosen educational approach, assessment methods, etc. These kinds of representation clearly have a low level of abstraction and – as they are based on natural language – the degree of formalism is also fairly low. Such representations are fairly easy for the 'average teacher' to handle as they do not require specialised technical knowledge. Indeed, they are largely aimed at the sharing of design ideas among a cohort of teachers, even though they may also be shared with students as well to scaffold the learning process.

Learning design tools provide tangible support for the generation and communication of design ideas and, in some cases, represent a conduit for enactment with learners. Many of those currently available generate designs centred on visual representation, where graphical design forms, swim-lanes and flow-charts may be used to visualize overall structure (or aspects thereof). The main advantage here is that the design can easily be shared with other authors, or communicated directly to students. Notable examples of flow chart use are LAMS[iv] (Dalziel, 2003) and MOT+ (Paquette et al., 2008). Swim-lane learning designs represent salient elements such as tasks, actors involved, learning objectives, and contents. Examples of tools handling swim-lane representations are: CompendiumLD[v], a very flexible tool that manages swim-lanes of different kinds; CADMOS[vi], which allows both swim-lanes and flow-charts so as to afford different perspectives on the same design; and LDSV (Agostinho, 2011). Hierarchies or tree structures can also be used to display and communicate the overall structure of an envisaged intervention. Such representations are implemented in the Pedagogical Plan Manager (PPM). While in these cases the primary purpose of diagrams and graphs is to communicate the design to others, some also provide scaffolding for the authoring process and for reflection.

In any case, these diagrams have a fairly high degree of abstraction, given that information is provided in a synthetic way, and so they are often accompanied by additional textual data. Indeed, all the tools listed above make use – in one way or another – of textual information to integrate the overall view provided by graphs. In the case of tools based on 'double representations' (visual + textual), positioning within the proposed framework is more complex and hence somewhat problematic. This aspect is examined in the conclusions below.

Representations that scaffold decision-making also include content maps, which may not only serve to provide an overview of contents, but also to reason and make choices about the content domain that a design addresses. Similarly, teachers also use rerpersentation tools like concept maps or Petri Nets during the design phase to elicit key elements in the design and the relationships between them. These representations may also be used later on for sharing purposes, given that they are based on symbols and signs that can be easily interpreted by others (intermediate/high level of formalism).

Furthermore, diagrams are sometimes used as representation tools for describing the theoretical approach or framework underpinning a design. One prime example is the well-known Activity Theory diagram (Engeström, 1999), which is often used as a basis for representing learning activities inspired by that approach. Other representation forms adopted to illustrate the implementation of a specific approach include the 4Ts model[vii] for online collaboration and the 4SPPIces model (Sanagustin et al., 2012) for blended learning. Schematic diagrams are also used to describe to map out a course or the overall structure of an intervention; two tools that adopt representations of this kind are Collage and Web Collage (now Web Instance Collage), which represent pedagogical patterns such as Jigsaw and Pyramid[viii] in visual form.

Another kind of representation capable of scaffolding reflection on data is the chart. Charts are generally used to analyse and reflect on aspects of a design *a posteriori*, i.e. after the design has been completed or even deployed. Pie charts may be employed, for example, as a means to reveal the balance between different kinds of learning strategies adopted within a given intervention. The final aim may be to fine tune the design or evaluate the learning experience. Examples of these charts are implemented and used in the Learning Designer[ix]. Here again, formalism and abstraction are at an intermediate level.

A last category of representation, mainly aimed at enactment, is the artificial language: machine-readable artificial languages like IMS-LD, E2ML and LDL (Martel et al., 2006) have the explicit purpose of supporting the authoring of designs as computerized artifacts for delivery to learners. In these representations formalism is of course at the highest levels, while abstraction is usually low, because details needed for implementation are included.

CONCLUSIONS

This contribution proposes and discusses a multi-dimensional framework for positioning different learning design representations. The main aim of the framework is to help practitioners gain a better understanding of the field and how different representation forms might suit their purposes. The framework may also serve researchers and tool developers by highlighting areas for further investigation and potential for tool development. An overarching ambition is to provide a sound systematic basis for the process of designing for learning, and for developing effective design tools that not only support design authoring, but also scaffolf the critical decision-making typical of the design process.

In order to illustrate the framework from both the conceptual and functional viewpoints, an attempt has been made to position common representation types within the proposed dimensions. The results suggest that this approach constitutes a basis warranting further development and refinement.

One aspect for further investigation is the case of representations that make joint use of two (or more) representation types (typically textual + visual). Single, distinct representation types are fairly easy to position within the framework, while instances of variegation are more problematic. So one emergent research question is how, and how best, textual + visual forms can be adopted to meet the range of purposes falling within the personal vs. social polarity, in accordance with the formalism and abstraction sliding scales. This touches on quite complex questions of semiotics that are beyond the scope of this paper but offer interesting paths for future investigation. Another area for further investigation is the multiform relationship between the different dimensions adopted in the framework and how best these might be captured in single graphic form that embodies the necessary simplicity with sacrificing (intrinsically complex) meaning.

Clearly, the need emerges for further work in the mapping/classification of representations and perhaps some degree of integration among the tools that reify those representations, possibly within in a single environment. This need, together with that for a more structured view of design tools, is the starting point of a project called METIS[x], funded by the EU under the Lifelong Learning Programme. METIS aims to develop a learning design environment based on the integration of existing tools and methods so as to ultimately provide more effective support for practitioners in the field of learning design.

NOTES

i http://ppm.itd.cnr.it
ii http://www.dialogplus.soton.ac.uk/
iii http://www.learningdesigns.uow.edu.au/
iv http://www.lamsinternational.com/
v http://compendiumld.open.ac.uk/
vi http://cosy.ds.unipi.gr/cadmos/
vii http://www.ld-grid.org/resources/representations-and-languages/4-ts-model
viii http://www.gsic.uva.es/collage/
ix https://sites.google.com/a/lkl.ac.uk/ldse/
x http://metis-project.org/index.php

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