Datadriven design for learning
Chongtay, Rocio; Johnsen, Lars

Publication date:
2014

Document Version
Early version, also known as pre-print

Link to publication

Citation for published version (APA):
Title of proposal: Data-driven design for learning: multimodality as a service

Author(s): Rocio Chongtay and Lars Johnsen.
Department of Design and Communication, The University of Southern Denmark, Engstien 1, DK-6000, Kolding, Denmark. {rocio, larsjo}@sdu.dk

Keywords: Data-driven design for learning; semantic web; linked data; multimodality; design as a service; semiotic enzymes.

Research questions, project aims and theoretical framework

This paper explores issues related to data-driven design for learning, i.e. the use of structured data in digital design representations for learning, especially so-called linked data exposed on the Semantic Web (also known as Web 3.0 or the Web of Data). It describes ongoing work attempting to develop conceptual as well as technological tools for data-driven designs for learning and, in due course, to investigate the usefulness of such tools in concrete learning materials and in actual learning contexts.

The work is underpinned by the idea of trying to adopt central notions and principles from social semiotics and multimodality (Bezemer and Kress 2008; Van Leeuwen 2005) and multimedia learning theory (Mayer, 2009) in design approaches based on methods and technologies of the Semantic Web. Thus, more narrowly it seeks to examine to what extent the organization of virtual learning content can be made "semiotically explicit" and how this information may be exposed on the Web of Data to enhance the discoverability, reusability, accessibility and adaptability of the learning content.

An important aspect of the project concerns the concepts of mobility and mobile learning content (O’Malley et al., 2005). In the present context, truly mobile learning content is defined as learning resources that can not only be aptly delivered on mobile devices like smartphones and tablets but

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1 The work is part of a larger project recently begun at the Department of Design and Communication at the University of Southern Denmark entitled "Mobile Designs for Learning (MD4L)".
also be moved across media, materials and semiotic modes (text, graphics, layout, typography, colour, etc.) for purposes of learning and teaching.

One central research question of the project focuses on *multimodal meaning making and remaking in data-driven information spaces* and more specifically on how data-driven approaches may facilitate greater multimodal richness and variability in learning designs.

Multimodality is often conceived of as a positive quality in learning materials for a number of reasons: it may support different learning styles among the intended audience (Stull and Mayer 2007); it may provide visual scaffolding for the comprehension of text (Mayer 2009); and it may offer divergent perspectives on subject matter or convey different levels of details in the presentation. Up till now multimodality has most often been "hard-wired" into digital learning materials through the inclusion of (moving) images, diagrams and graphics and the application of fixed style sheets. Increasingly, much multimodality is created via interactive functionality enabling learners to customize various aspects of the content and the user interface (viewing more or less content, setting layout and typography parameters and so on). Dynamic multimodality done this way, however, is costly and is still fixed in the sense that it is constrained by a single programmatic design.

In the project, we propose what we think is a fairly novel approach to the construction of certain forms of multimodality in learning resources. It hinges on the concepts of "multimodal design as a service" and "semiotic enzymes". The underlying idea is that learning materials, enriched and encoded using a common metadata vocabulary as the one mentioned below, may freely be linked to so-called semantic widgets, web-based or local software modules providing means to convey the content in different ways (Haller et al., 2011). The embedded meta(data) in the content thus functions as a kind of latent enzymes ready to trigger transformation processes of various sorts.

The vision is that subject matter experts like teachers and professors can "plug in" design, so to speak. They can concentrate on subject matter and content structure and less on design choices and learners can have a greater say in what design options they want for the materials they study (visual support, interactivity, etc.).

The first part of the project has been to adopt and test a vocabulary for describing, structuring and encoding digital content with a view to its semiotic potential as learning material. The vocabulary allows learning resources to be modelled and represented on the basis of their constituent multimedia objects, their subject matter and any external learning model or taxonomy to which they may be aligned. Using these dimensions, educational technologists and designers can add, and embed, relevant metadata intended to reflect semiotic categories like medium, ideational and textual meaning, genre and so on (Vorvilas et al., 2011). The vocabulary, maintained at schema.org, comprises a set of types, properties and relations used by the major search engines including Google’s, to optimize discoverability and search results. Also, schema.org elements are compatible with current semantic web technologies such as Microdata, RDFa and Json-LD.
The vocabulary is extensible, meaning that its descriptive categories can be extended or specialized for specific domains. Further, it allows for layering learning architecture. For example, an educational video may be specified as being about a certain topic - person, event or place, say. This topic may in turn be described in terms of its relations to other topics or be semantically linked to external resources such as open data stored in Wikidata.

Currently, we are exploring how semantic widgets may be employed to transform educational texts marked up using schema.org metadata. We are experimenting with semantic widgets to carry out transduction, i.e. moving meanings from one mode, or genre, to another. Here we focus on the generation of graphic organizers, synoptic visual genres like info boxes, time lines and concept maps, to facilitate text comprehension. Prior to this work we have tried to describe semantic widgets in more theoretical terms (Johnsen & Chongtay, in press).

In the project, we are also looking into ways of marking up, in a standardized way, visual components in genres like geographical maps, drawings or concept maps making them amenable to processing by semantic widgets and to enable them to be linked to external resources elsewhere on the web.

**Methods/methodology**

The project is first and foremost an analytic "desktop" endeavour ending, hopefully, in a set of technological proofs of concept demonstrating the potential of our ideas for real-world application. These proofs of concepts will in the first instance be based on imagined use case scenarios.

However, we also wish to empirically test some of these proofs of concept in follow-up studies "in the field". These are yet to be planned in detail, though. Right now, the following possibilities are being considered:

One idea is to assess the meaningfulness of the metadata vocabulary to learners in mobile Web 2.0 learning scenarios. The plan is to test if, or to what extent, learners can utilize the vocabulary when creating, tagging, linking and uploading content in specific learning contexts, and once uploaded how this content may exposed on the Web of Data.

Another plan is to investigate the degree to which existing learning materials can be "semiotically enriched" using the vocabulary and how this semiotic enrichment may be put to use in authentic contexts through the application of pedagogically designed semantic widgets in order to enhance accessibility and adaptability and hence learnability.
A third idea is to explore opportunities and constraints in using open data from repositories such as Wikidata as the primary basis for the generation of multilingual, multimodal resources for learning for specific domains or audiences.

**Expected results**

In general, it is hoped that the project will provide insights into how we may go about constructing data-driven designs for learning and, equally importantly, what issues are involved. In more practical terms, we hope to be able to present a conceptual framework for building data-driven learning materials, including mobile ones, which may be communicated to teachers, designers and students alike in a set of accessible guidelines, as well as a set of software tools to support this goal.

**References**


