Learning Spaces for Knowledge Generation

Nuno Oliveira[1], Maria João Varanda Pereira[2], Alda Lopes Gancarski[3], and Pedro Rangel Henriques[1]

1 **Universidade do Minho**
Braga, Portugal
{nunooliveira,prh}@di.uminho.pt
2 **Polytechnic Institute of Bragança**
Bragança, Portugal
mjp@ipb.pt
3 **Institut Télécom, Télécom Sudparis CNRS UMR Samovar**
Évry, France
alda.gancarski@it-sudparis.eu

Abstract

As the Internet is becoming the main point for information access, Libraries, Museums and similar Institutions are preserving their collections as digital object repositories. In that way, the important information associated with digital objects may be delivered as Internet content over portals equipped with modern interfaces and navigation features. This enables the virtualization of real information exhibition spaces rising new learning paradigms.

Geny is a project aiming at defining domain-specific languages and developing tools to generate web-based learning spaces from existent digital object repositories and associated semantic. The motto for Geny is "Generating learning spaces to generate knowledge". Our objective within this project is to use (i) ontologies—one to give semantics to the digital object repository and another to describe the information to exhibit—and (ii) special languages to define the exhibition space, to enable the automatic construction of the learning space supported by a web browser.

This paper presents the proposal of the Geny project along with a review of the state of the art concerning learning spaces and their virtualization. Geny is, currently, under appreciation by Fundação para a Ciência e a Tecnologia (FCT), the main Portuguese scientific funding institution.

1 Introduction

Learning spaces are generally associated to classrooms within academia [4, 7]. They are commonly seen as physical places where groups of persons (typically students) discuss a theme and there exist someone (typically a teacher) that leads the discussion by organising the ideas and sums them up, creating knowledge. However, it is a fact that a great percentage of what a human knows is not learnt within a classroom. Discussions with other persons during a simple walk or on a break for a coffee and visits to museums or libraries are also means to learn. Therefore, any physical space where there is knowledge to be shared may be regarded as a learning space.

The advances in the internet and associated technologies made possible the port of physical learning spaces into virtualised versions. eLearning was the term coined to these spaces, but again, intrinsically related with academia. However, with internet, the information is largely spread and accessible anywhere to anyone. Libraries, Museums and similar Institutions are preserving their collections as digital object repositories to make their associated information available as Internet content. Portals equipped with modern interfaces and navigation features enable the virtualisation of real information exhibition spaces and give rise to new learning paradigms. Summing up, these resources across the internet allow for a large range of persons—not only students—to generate knowledge; and eLearning shall not be applied in this generalised view to avoid misconceptions.

In this context, we regard a learning space as a site where a certain piece of information is exhibited in a way that the visitor learns with it. A web-based (virtual) learning space is similar to a traditional one but it is implemented as a web site where a collection of information pieces is exhibited so that the site visitors can learn with it.

To acquire new knowledge, a visitor needs to have access to organised data, but he also needs to be enrolled in the learning process. This is precisely the purpose of web-based learning spaces we intend to build automatically from their formal descriptions.

We propose Geny as a project aiming at defining domain-specific languages and developing tools to generate web-based learning spaces from existent digital object repositories and associated semantic. Geny's motto is "Generating learning spaces to generate knowledge"! Our objective within this project is to use (i) ontologies—one to give semantics to the digital object repository and another to describe the information to exhibit—and (ii) special languages to define the exhibition space, to enable the automatic construction/generation of the learning space supported by a web browser. With the obtained learning space we intend to give the visitor a more active role in the learning process. Quoting Saint Exupèry: "Each one that passes in our life takes a little from ourselves, but he also leaves something of himself", we argue that visitors should be participative actors by completing each learning space with their personal knowledge and assets for that theme. Moreover, learning spaces and the associated technological gadgets and widgets shall (i) stimulate the visitor for knowledge acquisition; (ii) trigger the visitor's imagination and his will to contribute and (iii) capture the visitors' feedback.

We dream with learning spaces where the global story (the message to pass there) is made up from smaller stories; a democratic location where not only the story-teller has permission to talk.

Outline. In this paper we briefly discuss a project proposal and focus on the related work/state of the art. In this context, Section 2 presents the state of the art with respect to the Geny project. We discuss several projects and compare their features with those we propose. Then, in Section 3 we briefly present our proposal for Geny, by showing the general architecture and workflow with the intended features. Finally, in Section 4 we close the paper, by providing a summary of the discussion undertaken in the other sections.

Notice. Geny is, currently, being reviewed by Fundação para a Ciência e a Tecnologia (FCT), a scientific funding institution. This article is a summary of the Geny project proposal, where we deposit the main ideas to improve the current state of the art on virtual learning spaces. No further outcomes are available.

2 State of the Art

Several projects have been proposed and accomplished which addressed the analysis and creation of virtual spaces where learning is enabled for a broader range of persons rather than just for students as happen with eLearning. The following paragraphs describe some of these projects and relate them with Geny.

The Spaces for Knowledge Generation project [11][1] develops a broad study on learning spaces for students within universities. Learning spaces, in this perspective, are seen as physical places where students generate knowledge. The main idea of the project is to provide principles for the creation of learning spaces capable of being reconfigurable according to the students needs. These principles include comfort, aesthetics, flow, equity, blending, affordances and repurposing. The

[1] http://www.skgproject.com/

project members stress the importance of a social interaction by blending students, teachers and technology, for a successful knowledge generation within learning spaces.

This project diverges in a large part from Geny. Its focus is set on both physical learning spaces within universities, where students may collaboratively and socially generate knowledge, and in the principles used to improve these spaces. The aimed public is limited. However, the ideas discussed in the project's produced book [14] for physical learning spaces may clearly be taken into account, within Geny, for generating virtual learning spaces, which are thought to serve a broader range of potential users.

Recent emergence of virtual imitation of the real world, e. g, with Second Life®, makes possible a new way of providing virtual learning spaces[3, 10, 9]. In these cases, information is modeled in 3D and delivered as part of virtual worlds where users (by means of avatars) may learn new things by freely (with no cost or risk) move around such artifacts. In [9], authors explore the advantages and benefits of virtual worlds as immersive and social learning spaces. Their point is to allow teachers (or teaching institutions, in general) for transferring real world learnt lessons to the virtual cost- and risk-free worlds (and vice-versa). This enables students to acquire knowledge about certain aspects difficult to explore in other settings.

The generation of learning spaces within these virtual worlds is mainly a manual task. Although a semantic coherence may be defined in the availability of the informational resources, users may not navigate through them following conceptual and semantic approaches. Moreover, users may be easily distracted by other objectives (e.g. online social acquaintance of other users) rather than focusing on learning the provided thematic. More discrete approaches (like that of Geny) make more sense for capturing the visitor's attention to the single objective of learning. These approaches for 3D learning spaces may also be limited in two aspects: first the aimed public may be reduced due to the used technology—clearly, it is more suitable for younger users—and second, it reduces the possibility of collaborative enrichment of the knowledge embodied in such learning spaces. Both aspects are intended to be treated in Geny.

The Domus Naturae project aims at developing a web-based virtual museum application taking advantage of tools for managing heterogeneous and structured knowledge. Such knowledge is represented on ontologies, using the emerging Semantic Web standard technologies. In [6], the authors propose the use of a ontology for constraining, expressing and analyzing the meaning of concepts and relations in the domain of knowledge subjacent to the project. The authors stress out that using such ontology upon a collection of digital objects, the user may navigate through the virtual exhibition taking advantage of queries closer to the domain of discourse.

This project is similar to Geny, in the sense that ontologies are superimposed over a repository of digital objects allowing for navigation upon such objects. However, in the context of Geny, a ontology is to be used also as a means to make the automatic generation of a learning space closer to the knowledge the visitor intends to get. Moreover, the combination of Social and Semantic Web in Geny is in order to provide a new and sustainable experience on learning about a theme and completing it with visitor's knowledge.

PATHS: Personalised Access To cultural Heritage Spaces [15][2] is a recently approved FP7 with strong similarities to the project we are proposing. The PATHS project would rely on the European Digital Library (Europeana) contents to create a system that will act as an interactive and personalized tour guide through the Europeana's collections. The idea behind this system is to create virtual thematic paths through the objects of all available collections in Europeana. The paths may be either pre-defined or user-defined. In this context, users have a very important role in this system as they may create their own path through the digital objects. In fact, this is the authors' claim of innovation

[2] http://www.path-project.eu

in the user-driven information access experience.

Little information is available at this moment for the PATHS project. However, it is easy to trace similarities to our own. From the description produced at this moment, a path (considered the perspective to learning spaces) is a user creation by selecting a set of nodes—pointing to repository objects—and annotating and linking them to create a coherent narrative. Although our approach is similar, we do not intend to create paths based on a selection of objects (which may be semantically unrelated). Rather, our learning spaces are defined taking into account the semantic relations between the repository objects, enabling a single learning space to involve all the preserved objects. Moreover, visitors will have the ability to perfect the learning spaces, the ontological layer upon the repository and the repository itself based on their own previous knowledge and private assets.

In [8], MuseumFinland is presented as a semantic portal for publishing heterogeneous museum collections based on the Semantic Web. The system is based in a set of ontologies, showing that it is possible to make semantically interoperable collections and provide visitors with intelligent content-based search and browsing services to the global collection base. Some technologies like XML, RDF, OntoViews and Prolog (logic predicates for reasoning over static information) are used. Since MuseumFinland is based on a central repository and uses ontologies to navigate through meta-information, it is possible to mix information from different resources (including different museums). Moreover, the system also allows for showing implicit relations between contents and semantic browsing. It also enables the create of end-user's viewpoints. The collection items are represented as web pages, linked with each other through semantic associations. The system layout is based on different views and facets.

Geny follows a similar approach. However we add value in two fronts. First we intend to allow for feeding the knowledge base with information collected from users and their own knowledge on the theme; secondly, we intend to enable the automatic generation of virtual learning spaces, which are not focused on museum assets.

The Art Project[3], powered by Google, is a website that allows for an interactive and completely virtual exploration of some well known museums around the world. This experience provides access to art collections through a rich and intuitive interface. Besides browsing art collections, the user is invited to actually explore the museum, navigating in a 3D world that mirrors the physical building, following the same approach as in Google Street View.

This project has many social advantages. It allows visitors for accessing art and related information, without the need of having to actually going there, which can be very expensive and not affordable in many cases. Also it enables the user to access information at his own time and need, since the information is always available and users are more prone to get interested. With beautiful and appealing interfaces, this project is sure to attract the attention of people that would normally not spend their time visiting museums and exploring art collections.

These advantages clearly emphasize the use and benefits of virtual learning spaces and exhibitions that can be explored by anyone, anywhere. Although this project approach produces rich interfaces for information exploration, it lacks a social-based feedback and user-centered approach for improving these virtual learning spaces. In particular, it lacks the possibility for users to access the information to create personalized and focused views of these learning spaces. Although showing the museums as they are is the objective of this Google's project, it could take more advantage on the exploration of the information technologies to create more dynamic and interactive user-experience within such learning spaces, re-inventing the way museums are explored. Our approach, not centered on museum objects and exhibits, intends to provide the visitors a way of navigating through the objects in a repository via their semantic relations and aspects, allowing for focused acquaintance of

[3] `http://www.googleartproject.com/`

knowledge on a desired thematic.

A more systematic and amusing way of information access via on-the-fly generation of virtual learning-spaces is Qwiki[4]. Qwiki is a search engine web application, which presents a summary of interactive information about millions of topics. The interactive summary (the learning-space), also called qwiki, is automatically generated, without human intervention, from static content available in several sources and machines like Google, Wikipedia, Fotopedia and Youtube. The generated content of a qwiki is a subtitled and narrated movie where text, images, maps, videos and any other multimedia content are merged together, focusing on the most important details about the searched topic, in order to produce a readable and meaningful summary.

Qwiki offers three main functionalities: (i) Movie visualization by topic search and related topics. During the movie, the subtitles present links for related qwikis and the user is also allowed to interact with the multimedia content by viewing photo details, movies or navigating in maps. (ii) Static content visualization. In this functionality, the user may read the text used as subtitles or browse the multimedia artifacts, where some of them point to related qwikis. (iii) Movie construction collaboration. This feature allows the user to submit new photos or movies to complete a qwiki, and also lets the user rate the narration voice. Qwiki is also connected to social web applications from where users can comment and provide feedback about the system.

Qwiki authors are starting to provide means (API and associated framework) for authoring qwikis. This way, companies and individuals would be able to create their own qwikis.

Qwiki presents an interesting approach for information visualization from where we may borrow some ideas. Nevertheless, the features we are aiming at providing are beyond Qwiki's. Qwiki uses the content or some meta-data information of displayed objects to decide about their relevance to the topic. In Geny, we plan to use resources semantic descriptions to guide the user during the knowledge acquisition process, taking advantage of Semantic Web technologies. Another weak point of Qwiki is that its social component is limited. We envisage to allow users for providing more feedback and changing the ontological layer upon the repository and the contents of the digital objects repository via Web 2.0 and Web 3.0 mechanisms.

Summing up, the projects discussed above are representative of what exits in this area of learning spaces as virtual places in the web for knowledge generation. While some projects already resort to modern technologies and mechanisms, all the presented projects lack some features that we, with Geny, intend to fulfill. The main aspects where Geny will innovate is on (i) the automatic generation of learning spaces from space specification, taking into account an ontology that organizes the information persisted in a repository and (ii) the social and semantic features for content navigation and for spaces enrichment with the visitor's knowledge.

3 Geny

We count on a long experience working from Language Processing techniques (grammar-based formal specifications, and automatic code generation from the specifications) to the area of annotated documents (or, in more general terms, to digital objects) and after that working with archives and museums. A careful review of the state of the art in the area of virtual exhibition and teaching spaces was here carried out to launch us into a still fresh research area.

This study led us to propose Geny and identify four main topics to which we intend to contribute with Geny's approach and tools:

[4] http://www.qwiki.com/

- C1 - a Ontology driven Semantic Digital Object Repository (SemDOR), that aggregates heterogeneous information sources using an ontology;
- C2 - a Domain Specific Language to describe Learning Spaces (GenySL);
- C3 - a Learning Spaces Generator (GenyEngine), that automatically creates the learning spaces from a GenySL specification (a description of the space and its navigability), and resorting to the SemDOR;
- C4 - the Learning Spaces generated with capabilities for user feedback and improvements.

Figure 1 presents the main workflow and general architecture of Geny approach, where the four outcomes highlighted are embodied.

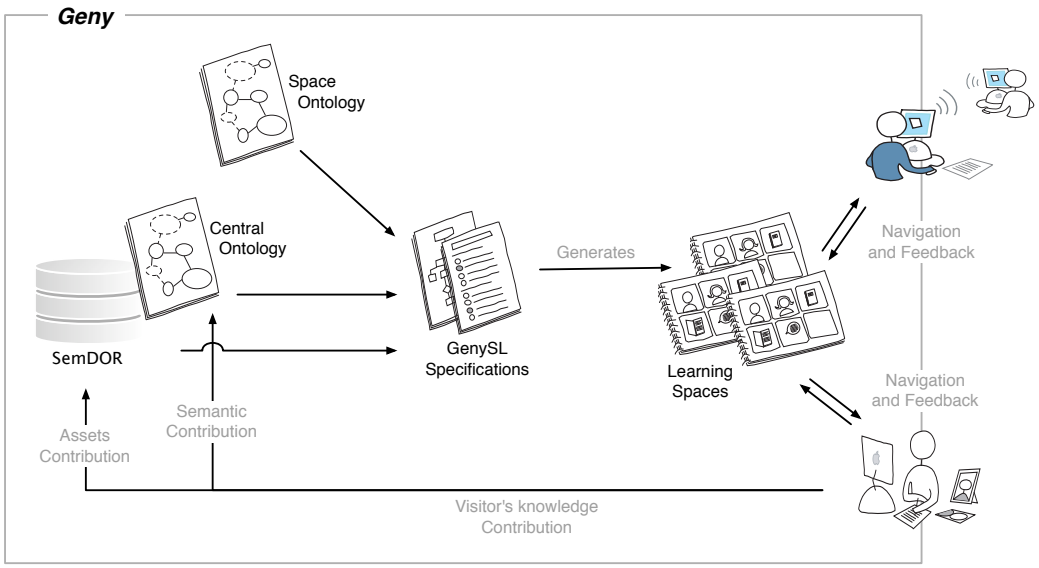

Figure 1 Geny's Workflow and General Architecture

3.1 Methodology

To reach the objectives we decided to rely on a set of well known and sound approaches that we are used to apply in the context of language processing and eLearning systems. We overview the main frameworks, underlying each contribution.

3.1.1 Ontology driven approach to knowledge representation

Knowledge has known several ways of being represented in a computer. However, ontologies have been accepted as the most generalized approach for such requirement. It allows for constraining, expressing and analyzing the meaning of concepts and relations in the domain of knowledge subjacent to a given discourse. Moreover, when superimposed upon a collection of digital objects (as we intend to do in Geny) it gives semantic to the repository and therefore may allow for a more intuitive navigation on the virtual exhibition taking advantage of queries closer to the domain of discourse. This ontological approach for knowledge representation would also enable the automatic generation of learning spaces closer to the knowledge the visitor is looking for.

3.2 Domain Specific Languages and Generative Programming approaches

GenySL is biased to a well-defined domain, which enables the use of domain specific languages (DSL) development approaches to define its design goals. We enrich such approach with the notion of templates for a more beneficial framework.

The major pros of such framework are that the expressive power and ease of use of DSLs reduces the time and background required to write programs that solve problems in a specific domain, when compared with a general purpose programming language [16, 12]. And the use of templates along with DSLs increase system efficiency (less things to be described), and increases the number of heterogeneous results [1].

A similar approach using template-aware DSL and a generative approach for creating embedded applications has already proven useful in Navegante, where a DSL allows the specification of an application written in a small number of statements, based on a previous created template [5].

In the overall, the adoption of such approach will raise several benefits. The following list presents some of them:

- a previously created set of templates can be shared by many applications, which means that improvements made to templates, improve all applications;
- learning spaces may be created automatically, once the DSL program is written;
- learning spaces may be easily created and maintained even for someone without the required knowledge to perform such task.

3.3 Social and Semantic Web development approaches

In the context of Geny, we want to take advantage of Web 2.0 (Social) and Web 3.0 (Semantic) to enable social interaction and structured information exchange. Web 2.0 offers new opportunities for collaboration between users having the main role the user as producer. O'Reilly in [13] argues that the network effects have an important role in the user involvement (in our case in virtual exhibitions and learning spaces) in terms of collaboration and knowledge exchange. To support automatic information processing by computers, Tim Berners-Lee [2] proposes the Semantic Web, where machines can read Web pages much as humans do. Intelligent agents have a key role in the transition from Web 2.0 to Web 3.0, transforming the unstructured information of Web 2.0 in structured and interrelated semantic information, which is the aim of Web 3.0. In the context of Geny, we will take profit of these technologies for user interaction in two aspects. On the one hand to allow for the introduction of new knowledge to the system and, on the other hand, to enable sophisticated navigation based on semantics.

3.4 Plans

Considering the workflow and the general architecture of Geny, presented in figure 1, and after describing the methodological support, we decided to partition the work into four technical tasks plus one for validation:

- T1 - Construction of a Central Ontology to describe the knowledge base embodied in the Digital Object Repository;
- T2 - Design of a Domain Specific Language, GenySL, to specify Learning Spaces;
- T3 - Automatic Construction of Learning Spaces based on GenySL specifications;
- T4 - Feeding the Knowledge Base with the information collected from the Learners and sharing learning experiences using social media;
- T5 - Approach Validation using real Case Studies.

Task T1 is responsible to deliver contribution C1; task T2 clearly will produce the DSL that we identify above as contribution C2; task T3 is aimed at building the tool that we consider as the main result of Geny project, referred to as contribution C3; contribution C4 is obtainable from the tool produced by T3 and enriched with the outcome of task T4. Task T5 has a crucial influence in all the four contributions; it provides the motivation for project, the requirements for C1 and C2, the usability tests for C3, and the effectiveness assessment of the last contribution C4.

Due to the fact that T5 has as main duty the pragmatic (or case-study based) validation of all the project deliverables, it is the tail of the list of tasks. But actually T5 will be the provider of requirements for all the other tasks.

Clearly T1 involves the analysis of a specific DOR and the design and implementation of a case-oriented Ontology. Notice that the ontology is composed of two parts: a semantic network with the concepts and relations (taxonomic or not) among them describing the case domain; and the instances network, mapping the concepts into their occurrences, i.e., the objects stores in the DOR. To create a concrete ontology, ontology representation schemas must be studied compared and one out of them must be selected.

T2 is also basilar for the remaining tasks. T2 deals with the design of GenySL which embodies two main concerns: the capability to refer (in conceptual terms) to the digital objects that will be exposed and explored in the learning spaces; and the capability to described the space itself, how it is structured and what objects will fit in each part. For that a space ontology will be defined.

Task T3 is concerned with the development of the learning spaces Generator. This work completely relies on the GenySL. The objective of this task is the definition of an approach, and the work on its implementation, to build a website that realizes a virtual learning space, given a definition of that learning space written in the GenySL specification language (outcoming from T2). The basic idea is to plan and develop a language processor (similar to a compiler) that transforms a GenySL specification into that website.

The aim of T4 is to improve the Learning Spaces specified with GenySL and generated with GenyEngine (created in task T3) with gadgets to increase the interactions of the visitor with the space and the collection of feedback that can enrich the DOR or the Central Ontology.

4 Summary

A learning space is a framework equipped with information resources to educate all sorts of people (not necessarily “students” in the classical sense); it is not restricted to a classroom nor to eLearning. Based in this statement, several works study the learning spaces virtualization. This paper presents a representative state-of-the-art concerning virtual learning spaces creation for knowledge generation. The main drawbacks of the discussed works are the weak user participation in the enrichment of assets repository and the lack of semantic exploitation of the digital resources. In this sense, we propose a novel project, named Geny, for virtual learning spaces creation where semantics and user feedback are the main concerns. Due to Geny’s general application, we believe that it can help in the preservation of cultural heritage, namely oral history, clearly contributing for the well-being of different human communities.

Acknowledgements

The Geny project discussion, definition and proposal would not be possible without the remaining members of the team. Hereby we thank them for their support and enthusiast work: Daniela da Cruz, José João Almeida, Nuno Carvalho and Paulo Alves.

References

1 R. Barrett. *Templates for the solution of linear systems: building blocks for iterative methods*. Society for Industrial Mathematics, 1994.

2 Tim Berners-Lee and Mark Fischetti. *Weaving the Web : The Original Design and Ultimate Destiny of the World Wide Web by its Inventor*. Harper San Francisco, Sep. 1999.

3 Anja L. Blanc, Jonathan Bunt, Jim Petch, and Yien Kwok. The virtual learning space: an interactive 3D environment. In *Proceedings of the tenth international conference on 3D Web technology*, Web3D '05, pages 93–102, New York, NY, USA, 2005. ACM.

4 Malcom Brown. *Learning Spaces*, pages 12.2–12.22. EDUCAUSE e-Books, 2005.

5 Nuno Carvalho, Alberto Sim??es, Jos?? Jo??o Almeida, Pedro Rangel Henriques, and Maria Jo??o Varanda Pereira. PFTL: A systematic approach for describing filesystem tree processors. In Raul Barbosa and Luis Caires, editors, *INForum'11 — Simp??sio de Inform??tica (CoRTA2011 track)*, pages 222–233, Coimbra, Portugal, Setembro 2011. Dep. de Eng. Inform??tica da Universidade de Coimbra.

6 Cristina Ghiselli, Alberto Trombetta, Bozzato Loris, and Elisabetta Binaghi. Semantic web meets virtual museums: The domus naturae project. In *In Proceedings of Digital Culture and Heritage (ICHIM05)*, Paris, France, 2005. Archives & Museum Informatics Europe (AMIE).

7 M. Goos. Creating learning spaces. In *The Annual Clements/Foyster Lecture*, 2006.

8 Eero Hyvönen, Eetu Mäkelä, Mirva Salminen, Arttu Valo, Kim Viljanen, Samppa Saarela, Miikka Junnila, and Suvi Kettula. MuseumFinland-finnish museums on the semantic web. *Web Semant.*, 3(2-3):224–241, Oct. 2005.

9 Laurence Johnson and Alan Levine. Virtual worlds: Inherently immersive, highly social learning spaces. *Theory Into Practice*, 47(2):161–170, 2008.

10 Maged N. Kamel Boulos, Lee Hetherington, and Steve Wheeler. Second life: an overview of the potential of 3-D virtual worlds in medical and health education. *Health Information and Libraries Journal*, 24(4):233–245, Dec. 2007.

11 Mike Keppell, Kay Souter, and Matthew Riddle. *Physical and Virtual Learning Spaces in Higher Education: Concepts for the Modern Learning Environment*. IGI Global, 1 edition, Jul. 2011.

12 Marjan Mernik, Jan Heering, and Anthony M. Sloane. When and how to develop domain-specific languages. *ACM Comput. Surv.*, 37(4):316–344, Dec. 2005.

13 Tim O Reilly and O Reilly Media. What is web 2.0: Design patterns and business models for the next generation of software. *Design*, 65(65):17–37, 2007.

14 Kay Souter, Matthew Riddle, Warren Sellers, and Mike Keppell. Spaces for knowledge generation. Technical report, La Trobe University, 2011.

15 Mark Stevenson and Kate Fernie. Personalised access to cultural heritage spaces - PATHS annual report. Technical report, University of Shefield, 2012.

16 Arie van Deursen, Paul Klint, and Joost Visser. Domain-Specific Languages: An Annotated Bibliography. *ACM SIGPLAN NOTICES*, 35:26–36, 2000.