

## ABSTRACT

**The Linked Data for Professional Education (LD4PE) Project.** We seek IMLS support to develop an online Linked Data Exploratorium based on a Competency Index for Linked Data (“Index”) to provide students, professionals, and instructors in the GLAM (galleries, libraries, archives, and museums) field with structured access to learning resources about Linked Data technology. This project realizes a vision refined in our 2011 IMLS planning grant. Learning resources elucidating specific professional competencies will be described and indexed according to skills and knowledge and clustered for discovery and exploration. While the Exploratorium environment will focus on supporting development of professional competencies related to Linked Data, the resources, toolkit, and website developed in the project will also exemplify the use of Linked Data principles and practices.

The Index at the center of the project will be a cohesive, stakeholder-developed set of RDF-modeled statements enumerating competencies, knowledge, and skills needed for using Linked Data in the GLAM environment. The Index will be published as Linked Data in both human-readable and machine-processable forms. Individual statements in the Index will be assigned globally unique Web identifiers (URIs) that connect aggregated learning resources about Linked Data practice from across the Web for discovery and exploration by both learners and instructors.

In addition to providing metadata about learning resources, the Exploratorium will supply a toolkit, adapted from existing tools and services, enabling the creation and subsequent discovery of: (1) education-standards-based RDF metadata and semantic Web pages about relevant learning resources on the Web; and (2) learning maps expressing curricular structures or personal learning trajectories superimposed over the competency framework. These learning maps, also published in RDF, will provide learners and instructors with cognitive scaffolding for approaching the topic of Linked Data.

While the Exploratorium is intended to harvest and aggregate resource descriptions created by others in RDF and RDFa, the LD4PE Project will initially seed the environment with project-generated descriptions to demonstrate the site’s service potential and allow for formative assessment and refinement of the competency framework, toolkit, Web environment, and best-practice documentation. This “seeding” will include creation of learning resource descriptions for existing resources and for resources created by project partners to exemplify the focused, recipe-like resources the Exploratorium will feature going forward.

The Exploratorium website will also support social recommendation to highlight the best aggregated learning resources and their alignment to the Index. The environment will provide built-in broadcast and responsive communication channels for community engagement and continuous feedback.

**The need.** The Semantic Web will play significant roles in GLAM institutions of the future. Demand for professional expertise in the deployment and use of Linked Data is already diffusing from leading cultural memory institutions and starting to color professional practice. The rapid adoption of Linked Data technologies challenges practicing professionals, teachers, trainers, and students to keep up by updating competencies, knowledge, and skills. This project can play a significant role in supporting GLAM professional development from initial education to career-long learning.

**Project outputs.** (1) an RDF modeled “Competency Index for Linked Data”; (2) a toolkit to support the generation of RDF metadata, Web pages with embedded RDFa descriptions, and learning maps; (3) a set of cataloged learning resources, with some developed as exemplars by project partners and others discovered from across the Web; (4) an Exploratorium website for the learning resource metadata, toolkit, learning maps, and supporting resources; and (5) onsite best practice documentation for all processes, from competency framework development through learning resource development and description to learning map generation.

**Project partners.** University of Washington (Lead), Kent State University, Dublin Core Metadata Initiative (DCMI), Access Innovations, OCLC, Elsevier, Sungkyunkwan University (Korea) and Synaptica.

**Timeframe.** December 1, 2014—November 31, 2016

## Assessment of Need

Understanding Linked Data standards and practices has become a key requirement for information professionals in galleries, libraries, archives and museums (GLAM). Major national libraries and bibliographic services are leading the trend to: (1) publish authority files, catalogs, datasets, and bibliographic standards as Linked Data; and (2) gather Linked Data from diverse external sources such as dbpedia, Freebase and MusicBrainz<sup>1</sup> to enhance their local discovery and retrieval systems. A snapshot listing of these efforts, along with an analysis of the costs, benefits, and technical challenges of expressing GLAM information sources as Linked Data, was published in a September 2011 report from the W3C Library Linked Data Incubator Group.<sup>2</sup> The successor standard to the Anglo-American Cataloging Rules—Resource Description and Access (RDA)—has been published as an RDF vocabulary. The Library of Congress has created the LC Linked Data Service for Authorities and Vocabularies and is currently leading a Bibliographic Framework Transition Initiative (BibFrame) (Library of Congress, 2012), which aims to replace the MARC format for library catalogs with data structures based on Linked Data.<sup>3</sup> The BibFrame report, *Bibliographic Framework as a Web of Data*, highlights related initiatives by national libraries (British Library, Deutsche Nationalbibliothek), bibliographic services (OCLC), major search engines (Schema.org), publishers (ONIX), and library standardization committees (RDA, FRBR). Broad initiatives such as LODLAM and OpenGLAM are pushing the boundaries of Linked Data integration across galleries, libraries, archives and museums.<sup>4</sup>

Professionals in cultural memory institutions find themselves on shaky ground as this seismic paradigm shift pushes the need for competent professionals from national centers toward local institutions. Indeed, the challenge to professional preparedness goes deeper, affecting the teachers of the next generation of professionals and the trainers who provide continuing professional development.

This urgent need to develop Linked Data competencies in the professional workforce is driving major initiatives to provide learning resources about the underlying standards and data model, e.g., the EU's Euclid project, LOD2, School for Data, PlanetData, Open Data Institute, Lean Semantic Web, Cloudera, GATE, *Linked Data Cookbook*, and *Cookbook for Translating Data Models to RDF Schemas*.<sup>5</sup> The products of these initiatives range from curricular structures and full courses to simple “recipes”—brief packages of “how-to” videos and step-by-step instructions targeted to specific learning outcomes. These scattered initiatives and their resources can be easy to find by those who already know what they are looking for, but everyone else struggles to put the available resources into a context.

Building on our earlier IMLS planning grant (Crandall *et al.*, 2013), we now seek to address a key part of this Linked Data learning resource challenge. The proposed Linked Data for Professional Education (LD4PE) Project will develop a Web-based *Linked Data Exploratorium* (hereafter, Exploratorium) to support the structured discovery of the learning resources available online by open educational resource (OER) and commercial providers. At the heart of the Exploratorium will be a competency framework for Linked Data that supports indexing learning resources according to the specific competencies, skills, and knowledge they address. To do this, the Exploratorium will itself leverage Linked Data technology by assigning global identifiers (URIs) to statements of competency, then citing those URIs in metadata descriptions of learning resources. The University of Washington will lead the development of the Exploratorium and underlying technical and data infrastructure in partnership with Kent State University, the Dublin Core Metadata Initiative (DCMI),<sup>6</sup> Sungkyunkwan University Institute of Information and Management<sup>7</sup> (Korea), OCLC,<sup>8</sup> Elsevier,<sup>9</sup> and Synaptica.<sup>10</sup>

## Target Audiences Served

1. Teachers and trainers in LIS, museums, and archives as users (and contributors) of learning resources indexed in the Exploratorium;
2. Learners engaged in formal education and in continuing professional development;
3. Employers of professionals engaged in Linked Data activities; and

4. Content providers of Linked Data educational resources: curricula, tutorials, webinars and best practice recipes.

### **National Impact and Intended Results**

The LD4PE Project will support the education and training of GLAM professionals in the use of Linked Data technology. The project will do this by providing an online Exploratorium where instructors and learners can find online learning resources through an index that links available resources to a structured and evolving framework of specific and concisely stated competencies, skills, and knowledge, broadly advancing the IMLS strategic goal of supporting exemplary stewardship of museum and library collections. The project will also promote the use of open technology to facilitate discovery of knowledge and cultural heritage across national memory institutions, as well as smaller institutions at a local level.

***Contributing to Innovation in GLAM Education:*** By applying a competency-based approach more typical of K-12 instruction, the LD4PE Project will leverage widely validated methods in support of professional education. This innovative adaptation of the competency-based approach to higher-education instruction and professional training has the potential to inform not just professional practice, but also scholarship in GLAM professional education. By reporting on its progress in peer-reviewed journals, scholarly outlets, and relevant professional publications, the LD4PE Project is well-positioned to make a significant contribution to this discourse.

***Achieving and Maintaining Professional Competence:*** GLAM institutions will leverage the benefits of Linked Data technologies only where and when current and future GLAM professionals receive effective instruction in their development and use. Such education and training spans formal degree programs and ongoing professional development. LD4PE will help GLAM professionals discover and make sense of current technological changes in Linked Data by providing a conceptual map of the terrain and by linking points on that map to available learning resources. This structure will support the creation of flexible university courses, professional training programs and personalized plans of independent study.

***Generalizable Framework for Far-reaching Impact:*** While LD4PE will focus on skills, knowledge, and professional practice in the area of Linked Data, nothing precludes the extension of its competency-based approach to other areas of LIS, archives, and museum curricula. Similar competency frameworks could be developed describing knowledge organization systems, cataloging practice, and organizational management. This framework will be appropriate whenever the goal is for learners to achieve competence within a defined set of knowledge, skills, and habits of mind. DCMI is participating and is committed to sustaining the products of this work moving forward because it sees the project's framework and outcomes (including best practice documentation related to the framework itself) as generalizable to all areas of principled metadata design and best practice, while also providing a guiding template for future development of DCMI's education and training agenda.

### ***Summary of Project Deliverables:***

1. **Competency Index for Linked Data (the “Index”).** The Index will state and describe a set of learning objectives: relevant skills, practices, and knowledge. Learning objectives will be assigned global identifiers (URIs) and published on the open Web in machine-readable RDF schemas (i.e., as Linked Data).
2. **A suite of Web-based tools customized for use in the Exploratorium:**
  - a. **An editor for creating RDF metadata about learning resources.** For tagging content, the project will adapt the Learning Resource Metadata Initiative (LRMI) standard,<sup>11</sup> which in turn extends the schema.org vocabulary used by Google, Yahoo, and Bing to enhance their search results. An editor based on LRMI metadata and adapted from the existing Gateway to 21<sup>st</sup> Century Skills<sup>12</sup> metadata editor provides functionality for describing learning resources and aligning the metadata record to statements of skills and knowledge in machine-readable competency frameworks, thereby allowing customized alignment with the LD4PE Project's Index.

- b. **A tool for creating learning trajectory maps.** A learning trajectory map arranges a set of learning objectives into a pedagogically effective sequence. Such maps can represent the curricular structure of a course or a highly personalized learning path. The Achievement Standard Network (ASN)’s existing tool for map development would be adapted to save maps as RDF data, which can be published as Linked Data for others to use.
3. **Metadata for a set of third-party learning resources.** Cataloging a set of resources with reference to the Index will allow the LD4PE Project to test the LRMI metadata schema and tools to assess their utility for discovery and enhanced retrieval, identify gaps in the Index, and seed the Exploratorium.
4. **An exemplary set of targeted learning resources (“recipes”).** LD4PE project partners will create a number of exemplary learning resources targeted at specific competencies – “recipes” – as demonstrations of best practices in resource design and development.
5. **An Exploratorium pilot website.** The project website (the Linked Data Exploratorium or LDE) will primarily provide competency-based access to learning resources. In addition, it will provide a publication venue both for learning resources (such as the “exemplary” set above) and learning trajectory maps. Developed and managed by the LD4PE Project, the website will mature to become part of the Dublin Core Metadata Initiative’s freely available toolset. Out-of-the-box social media functions, including broadcast and recommender systems, will foster the engagement of domain experts, teachers and trainers, learners, and resource providers.
6. **Best-practice documentation.** Best-practice documents will cover:
  - a. Guidelines for the principled development and management of competency frameworks;
  - b. Guidelines for creating metadata about learning resources and for aligning those resources to competencies/skills and knowledge; and
  - c. Guidelines for the creation of learning resources targeted to specific competencies.

## Project Design and Evaluation Plan

### *Deliverable 1: Competency Framework—RDF & Linked Data*

A competency framework provides a structured map of the knowledge and skills needed to work in a given domain. Building on the work of our IMLS planning grant, we will flesh out our nascent *Competency Index for Linked Data* (hereafter “Index”). The Index will be: (1) modeled based on Resource Description Framework (RDF);<sup>13</sup> (2) serialized using tools available from the ASN<sup>14</sup>; and (3) published in the ASN-US Linked Data repository as part of over 1,450 competency frameworks (including an RDF version of the WebJunction’s *Competency Index for the Library Field*<sup>15</sup>). The ASN was originally developed between 2001 and 2009 with NSF funding to the Information School of the University of Washington and has been subsequently supported with funding from the Bill and Melinda Gates Foundation. The ASN-US repository is among the 32 education-related Linked Data datasets listed in the *Linked Education Cloud*<sup>16</sup> of the Open Knowledge Foundation’s DataHub and is listed in the *LinkedUp Data Repository* of education-related data sets.<sup>17</sup>

Using the RDF schema and software tools of the ASN to publish and maintain the LD4PE competency framework will ensure that every statement of skill or knowledge in the Index is identified by a globally unique URI, dereferencable over the Web, and thus fully usable for linking learning resources to relevant competency nodes in the Index. The Index will be publicly available both for download in various RDF formats (serializations) and through the SPARQL endpoint, or RDF query interface, of the ASN-US repository. In other words the Index, a competency framework about Linked Data as a topic, will itself be expressed using globally unique identifiers (URIs) and published on the Web in machine-readable RDF schemas (i.e., as Linked Data). The URIs for specific competency statements in the Index will then be cited in metadata describing learning resources. This metadata, also published on the Web in RDF (i.e., as Linked Data) will have the effect of “linking” competency statements to learning resources. The effect will be to make learning resources discoverable through a structured index – using the very method that the learning resources are meant to teach (i.e., Linked Data).



**Process:** The IMLS planning project identified topical clusters for the Index: an inventory of learning topics.<sup>18</sup> In LD4PE, an Editorial Board including Sam Oh, Tom Baker, Stuart Sutton, and personnel from Access Innovations will further develop and refine this topical index. The Editorial Board will formulate statements of skills and knowledge (competency) on the basis of a content analysis of existing online learning resources. The Board will systematically assess existing statements for further refinement in accordance with a multi-staged, iterative process generally based on the *Tuning* method,<sup>19</sup> which was developed for defining competencies and learning outcome frameworks for degree programs. The method is widely used in Europe and is gaining traction in the U.S. Key to the method is input from LD4PE stakeholders: RDF and Linked Data experts, teachers, professional trainers, employers, and learners.

To bootstrap this process, the Editorial Board will review existing Web-based education and training sources and derive a draft set of statements about the skills and knowledge reflected in the sample resources. This sample will include: (1) exemplary learning resources to be developed by project partners Access Innovations, Elsevier, Synaptica, and Sungkyunkwan University, and (2) the growing array of resources provided on the Web as mentioned in the opening paragraphs of this proposal. In addition, the Editorial Board and graduate student research assistants will monitor and analyze questions submitted to relevant online Q&A services<sup>20</sup> serving users of Linked Data such as semanticweb.com, the OKF School for Data, and occasionally StackOverflow.com. This input will assist further refinement of the Index by improving our understanding of the domain from the perspective of learners.

In the second phase of Index development, graduate student research assistants at University of Washington and at Kent State will create metadata descriptions for a set of learning resources from the collections previously examined using the Learning Resource Metadata Initiative (LRMI) schema. Metadata generation will include alignment of these resources to statements in the Index. The protocol followed for aligning resources to statements will be developed iteratively, then captured in a best practice document and published as a deliverable on the LD4PE website. The students will identify and record “competency gaps”—competencies discovered in the learning resources that have no alignment points in the Index. The Editorial Board will systematically review the competency gaps, assess the need for inclusion in the Index and, if needed, update the Index with suitable statements.

**Evaluation:** Iterative rounds of assessment and refinement of the Index will continue until the Editorial Board considers the Index to be stable. Assessment data will be obtained through online surveys of stakeholders (Linked Data experts and teachers/trainers) starting with our planning grant participants, representatives from the analyzed repositories of learning resources, and employers of Linked Data professionals. Early formative assessment and refinement will focus on the Index alone to identify obvious gaps in the coverage of competencies in the Index. In subsequent iterations, ongoing assessment of the Index will examine its metadata about learning resources in order to establish an appropriate level of granularity.

### ***Deliverable 2: Toolkit Adaption and Implementation***

The technical infrastructure for LD4PE will use publicly available tools and components created, tested, and deployed with public and foundation funding. This includes tools for creating learning resource metadata, for aligning Index competency statements to learning resources, and for generating learning trajectory maps. The project will also create adaptations of select tools where their direct use in the proposed LD4PE context is not supported.

#### ***2(a)—Tools for Creating Metadata Descriptions of Learning Resources***

The Gateway to 21<sup>st</sup> Century Skills (GCS) toolset provides an existing and well-tested infrastructure for creating metadata about learning resources. This toolset can be adapted to create an LRMI-based cataloging toolset for the Exploratorium. The GCS toolset was developed with U.S. Department of Education funding to manage the generation of metadata descriptions in RDF. The machine-to-machine programming interface (API) provided by the ASN-US competency framework repository will make the Index accessible to applications.

Based on the popular open-source content management system Drupal, the toolset natively uses a Dublin Core Education application profile that has been mapped to LRMI through a Drupal module.

While the Gateway toolset was created for use in a professional metadata generation environment, the goal of customizing the toolset for LD4PE will be to provide a light-weight tool that empowers content creators and learning resource providers to create metadata records in RDF or to use RDFa to embed RDF descriptions in Web pages.

## ***2(b)—Learning Trajectories for Cognitive Scaffolding***

While the Index defines a set of competencies, it neither prescribes any competencies as “core” nor defines a logical sequencing of its components. In other words, the Index does not in itself define a curriculum by prescribing a single learning trajectory or pathway through the set of competencies expressed as Index graph nodes. The LD4PE project will use and customize an online tool provided by ASN that enables teachers, trainers, and learners to map their own pathways through the Index graph. These pathways can be expressed and saved as named graphs that traverse, or overlay, the competency nodes of the Index. The named graphs for learning pathways may be identified as formal curriculum structures or as personalized pathways created by instructors or learners as records of progress. They may also function as suggested paths forward in the learning process or as guides to other instructors or learners in creating their own pathways. When published by LD4PE, such named graphs will be usable by others to explore learning resources, just as shared playlists support exploration of music. Personal named graphs, and their accompanying competency nodes, may also serve as bases for awarding digital badges and other evidence of accomplishment that are emerging as important markers in modern online learning environments.

Several decades of research has shown that such maps reveal the macrostructure of the body of information or knowledge within a field, making the context of that information or knowledge more apparent and useful to learners (O'Donnell *et al.*, 2002; Hall & O'Donnell, 1996; Hall & O'Donnell, 2010). Similarly, learning map overlays contextualize competencies and learning outcomes in a “larger picture” of learning expectations, outcomes, and progressions. The strands maps of the American Association for the Advancement of Science (AAAS), as deployed in the National Science Digital Library, illustrate the form and substance of such maps.<sup>21</sup>

Thus, LD4PE stands in sharp contrast to other projects in not prescribing a single curricular point of view but in providing instead the means for instructors and learners to chart multiple, diverse pathways for learning – pathways defined as public or private, individual or collective, prescribed or exploratory. Each named graph provides a different roadmap for discovering and traversing lesson plans, how-to recipes, webinars, and tutorials that have been described and aligned to the competency nodes of the Index graph. The diverse set of project partners has been carefully chosen to ensure that a wide variety of learning and instructional perspectives will be served through the structure and content of the Index, and is a strength of this proposed project.

While the ASN has established the core architecture for graph mapping needed to create learning trajectories, further development will be necessary to integrate visual components that will facilitate more intuitive views for traversing the conceptual terrain. Novel graph comparison capabilities will need to be developed and integrated.

***Tools Evaluation:*** The evaluation of the LD4PE toolkit has two aspects: (1) assessment of how well the individual components accomplish their goals in terms of functionality and performance in generating useful resource descriptions and learning maps according to specification; and (2) user experience studies of how well the individual components provide an effective experience. Formative evaluation of the user experience with the individual components of the project toolkit will be led by Marcia Zeng, using “persona” methodology and the Kent State Usability Lab, with its equipment for eye tracking, multi-camera views, and software for detailed analysis as each of the application components are completed. Given that the toolkit applications will be adaptations of fully developed and previously tested applications, the major focus of toolkit component usability will be on the affordances of individual applications for use by an expanded range of users (personas). Findings

from these formative assessments will inform further development of the application both within the project itself and through further development post-grant.

### ***Deliverable 3: Cataloged, Tagged, and Aligned Learning Resources***

Project graduate students at the University of Washington and Kent State University will handle the discovery and cataloging of learning resources as noted above in Deliverable 1 along with the conceptual alignment of those resources to the Index. The students will also assist in the development of best practice materials for metadata creation processes.

***Process:*** During the first months of the grant, the graduate students will work with project personnel to identify appropriate resources as part of a content analysis to inform the draft Index competency development. Once the GCS tools have been customized, the graduate students will create a test set of LRMI metadata records with alignments to the Index. This test set of records will be used for internal assessment of the tool and to fine-tune best practice documentation both for descriptive cataloging and for the process of alignment. Based on these reviews, a best practices handbook on resource description and alignment will be iteratively updated and refined in a project wiki. The students will also log competency gaps in the Index that are discovered during the cataloging process. These gaps will then be reviewed and discussed by the Editorial Board described in Deliverable 1, driving appropriate updates to the Index. This form of competency gap analysis and Index update will continue over the course of the project and will inform the development and documentation of best practices for maintenance of the Index.

Once analysis of the test cataloging and alignments has been satisfactorily completed, the students will begin cataloging as many of the learning resources on the source sites noted in Deliverable 1 as possible as well as the learning resources developed by project partners.

***Evaluation:*** As part of the assessment of the Index in Deliverable 1, the stakeholders will have examined the Index's effectiveness in terms of scope, detail, and coverage in expressing competencies important to successful professional practice. During that process, the alignment between resource description and the Index will be examined as a means of improving the Index with respect to competency gaps. While the metadata generated will also be examined based on typical indicators of metadata quality (Bruce & Hillmann, 2004; Gasser & Stvilia, 2001), the most difficult aspect of metadata generation and evaluation in this context will be the appropriateness of the alignments between resource description and the Index (“strength of fit”). Since LRMI supports extensions through additional properties, we will add an ASN property and controlled vocabulary to capture that strength of fit. Throughout the early stages of the metadata generation process, frequent tests of intercataloger consistency will be performed to assist in the development of both alignment and quality of best-practice guidelines.

### ***Deliverable 4: Exemplary Resources—“Recipes” and Data***

Project partners Synaptica, Sungkyunkwan University, Elsevier, and Access Innovations will create a set of exemplary learning resources—what LD4PE calls “recipes” because of their “how-to” nature and the fact that they target fairly discrete knowledge and tasks. Along with development of the resources themselves, best-practice documentation will be developed and published in the Exploratorium on how to create competency-based recipes and how they relate to larger instructional units.

Rather than create recipes across all of the topic clusters of the Index, the exemplary set of partner recipes will focus primarily on the topic cluster identified in the IMLS planning grant as “Creating, publishing and manipulating RDF.” This will allow us to build a critical mass of recipes in one area to better illustrate the full capabilities of a mature Exploratorium.

The typical running time for an LD4PE-generated recipe will be in the range of 5 to 15 minutes. This focus on recipes does not preclude the inclusion of learning resources that serve as “overviews” and provide practical “glue” for a set of related recipes targeting learning outcomes that support specific competencies in the Index.

Exemplary recipes from project partners may be comprised of any of the following combination of forms.

1. a single non-interactive MPEG-4 AVC/H.264 screencast recording of an instructional presentation (e.g., PowerPoint recording);
2. a single Web-based interactive application (widget) that puts a learner through the paces of accomplishing a discrete task, possibly with performance evaluation feedback;
3. a non-interactive screencast recording or interactive application (or set thereof) with additional HTML-encoded supplemental resources such as: (a) step-by-step instructions, (b) links to data sets used in the recipe, (c) specifications or standards referenced or supportive of the recipe, and (d) relevant support readings;
4. a step-by-step, illustrated, HTML-encoded explanation of a task or set of tasks to be learned without interaction.

Project partner OCLC will provision the Exploratorium with exemplary datasets scoped for use in all phases of the Linked Data life cycle from data cleansing to reconciliation, providing a powerful incentive for others to further develop datasets (and references to datasets) that can be leveraged in instruction and practice by learners. As the student research assistants search for learning resources for description, they will also be alert to openly available datasets on the Web such as the Powerhouse Museum Collection<sup>22</sup> that can be included in the Exploratorium either literally or through description using the schema.org dataset schema.<sup>23</sup>

### ***Deliverable 5: Linked Data Exploratorium (LDE) Pilot Website***

The pilot LDE will be developed during the grant period on a University of Washington research server. On successful completion of the grant, the website will be brought up publicly in a subdomain of the Dublin Core Metadata Initiative (DCMI) as part of its ongoing metadata education and training agenda.

As already described, some exemplary learning resources will be developed by project partners and published directly through the Exploratorium, while others will be included by reference through metadata descriptions. The Exploratorium LRMI tagging tool and “recommender” mechanisms will facilitate crowdsourcing of initial discovery and competency mapping as new learning resources are created and published across the Web. In sum, the DCMI-supported Exploratorium will provide a trusted discovery hub for learning resources hosted across the Web, tied through Linked Data principles and practices to the specific skills and knowledge in the Index and to other competency frameworks to be developed through the Exploratorium.

In addition to learning resource descriptions aligned to competencies, the Exploratorium will provide built-in broadcast and responsive communication channels for community engagement and continuous feedback, informing further development. In this regard, we will build on the well-developed communication assessment approach<sup>24</sup> of our colleagues in the EU-funded EUCLID project (EdUcation Curriculum for the usage of Linked Data). We will also evaluate and incorporate relevant engagement aspects of the Khan Academy’s competency-based work mapping learning resources to the U.S. (K-12) *Common Core State Standards*.<sup>25</sup>

***Evaluation:*** In the final stages of evaluation of the project and the complete Exploratorium pilot site, assessment will be conducted via survey instruments targeting two types of communities: (1) stakeholders involved in Linked Data implementation and research—for example, DCMI members, LODLAM, and code4lib as well as large implementation projects such as Europeana, national libraries, and museums; and (2) stakeholders in teaching and training of information and knowledge professionals, including schools of library and information science, iSchools, and related academic and professional programs in information architecture, computer science, and data science. Questionnaires will be sent through professional mailing lists likely to reach those involved in linked open data (LOD) related training at professional associations such as ALA, SLA, and VRA. These surveys will explore the utility of: (1) the Exploratorium’s support of teaching, training, and learning; (2) open tools for learning resource metadata and learning maps creation; (3) discovery of learning resources and other assets such as data sets; and (4) built-in broadcast and responsive communication channels, including social recommender functionality, supporting community engagement and continuous feedback on the quality of content and of the Exploratorium itself.



### ***Deliverable 6: Documenting and Publishing Best Practice Resources***

Throughout the LD4PE grant period, project personnel will be generating, reviewing, and revising best practice documentation for publication and maintenance on the Linked Data Exploratorium website. The documentation will touch on all aspects of the Exploratorium including: (1) processes for development and maintenance of a competency framework; (2) creating metadata descriptions for learning resources using the Exploratorium's LRMI tagger; (3) analytic and technical processes necessary to effectively align a learning resource to a competency framework; and (4) creation of a learning trajectory.

#### **Project Resources: Budget, Personnel & Management**

***Budget and Management:*** We propose a two-year project with staged development of each of the six project deliverables spanning the two years. The project budget of \$249,526.36 (\$454,148.61 with matching funds) reflects the time and expertise committed to the six project deliverables which together will constitute a useful product for the intended audience and an online environment sufficiently developed for DCMI to immediately launch a fully functioning Linked Data Exploratorium website.

The institutional responsibilities for the project, including financial and regulatory management, institutional collaborations, deadlines, and reports rest with the University of Washington.

***Key Personnel:*** Along with prescribed areas of project leadership, all lead personnel will participate with project colleagues (including student personnel) in the processes of continuous, collaborative scanning and assessment of the rapidly developing Web environment of learning resources in RDF and Linked Data in particular, and metadata design and best practices in general.

**Michael Crandall** is a Senior Lecturer in the Information School of the University of Washington (UW) and Director of the iAffiliates program. Prior to coming to the UW, he was technology manager for the US Library program of the Bill & Melinda Gates Foundation. Prior to the foundation, he worked on search technology and knowledge organization for the intranet at Microsoft (MSWeb) and on information architecture and online library services at Boeing. He has served on the Dublin Core Metadata Initiative (DCMI) Governance Board since its inception in 2001, and is the current Chair. He also chairs the annual Taxonomy Boot Camp track at KMWorld, a gathering of practitioners in the field of taxonomy and metadata. He is interested in public access computing, ICT in developing countries, metadata and knowledge organization, social dimensions of knowledge transfer, and large scale information systems. ***Duties:*** *Crandall will serve as Project Director, overseeing project budget, deadlines, reports, and general administration. He will also work with Stuart Sutton, DCMI Managing Director, on the preparation of project outcomes for permanent hosting and operations as part of the DCMI education agenda.*

**Marcia Lei Zeng** is a Professor of Library and Information Science at Kent State University. She currently serves a Chair of the DCMI Advisory Board. She holds a Ph.D. from the School of Information Sciences at University of Pittsburgh (USA) and M.A. from Wuhan University (China). Her major research interests include knowledge organization systems (taxonomy, thesaurus, ontology, etc.), Linked Data, metadata and markup languages, database quality control, multilingual and multi-culture information processing, and digital libraries for cultural objects. She has chaired and served on standards committees and working groups for the International Federation of Library Associations and Institutions (IFLA), Special Libraries Association (SLA), Association of Information Science and Technology (ASIS&T), the U.S. National Information Standards Organization (NISO), and the International Organization for Standardization (ISO). Zeng was Project Director for an IMLS National Leadership grant from 2011 to 2013. ***Duties:*** *Zeng will provide expertise and oversight of project evaluation in general and usability assessment in particular.*

**Thomas Baker** has served on DCMI administrative committees since 1998, from May 2005 to January 2009 as the DCMI Director of Specifications and Documentation and currently as the Chief Information Officer. He is the chair of the DCMI Usage Board, which he founded in 2001, and co-chair of the DCMI Architecture Forum. He has previously worked as a digital library researcher at the German National Research Center for Informatics, GMD (later Fraunhofer Society) in Bonn and the State Library in Göttingen. He holds an M.L.S. in

library science from Rutgers University and an M.A. and Ph.D. in anthropology from Stanford University. He taught for two years at the Asian Institute of Technology in Bangkok and has worked as an activity lead in projects funded by the EU (e.g., SCHEMAS, CORES, DELOS Network of Excellence) and the German National Science Foundation, DFG (KIM). From 2006 to 2009 he co-chaired the Semantic Web Deployment Working Group of the World-Wide Web Consortium (W3C) and subsequently co-chaired the W3C Library Linked Data Incubator Group. Since 2006 he has been a member of the W3C Semantic Web Coordination Group (recently renamed the W3C Data Activity Coordination Group) – a strategic planning group of the World Wide Web Consortium. **Duties:** *Baker will co-lead the Editorial Board with Stuart Sutton in developing the competency framework, with special focus on policy and best practice development and documentation.*

**Stuart Sutton** is Managing Director of Dublin Core (DCMI) and Associate Professor Emeritus in the Information School of the University of Washington. At the University of Washington, he teaches advanced online courses about semantic metadata. He has served as Senior Scientist with the ASN project since 2003 and is an expert in data modeling for competency frameworks. He led the development team for the ASN schemas, controlled vocabularies, and application profiles. As Managing Director of DCMI, he leads an international metadata community of researchers and practicing professionals dedicated to innovative metadata design and best practice. **Duties:** *Sutton will co-lead the Editorial Board along with Tom Baker in developing the competency framework and best practice and policy documentation on competency framework creation and long-term maintenance. He will also coordinate the technical activities to integrate the data environments of the Drupal-based data generation toolkit and the WordPress public interface to the Linked Data Exploratorium. Along with Michael Crandall, Sutton will assist in preparation of project outcomes for permanent hosting and operations as part of the DCMI education agenda.*

## Communication Plan

To widely disseminate project results, LD4PE will leverage the communication platforms of the Dublin Core Metadata Initiative (DCMI), an established global community of metadata researchers and implementers. The DCMI community reaches metadata implementers and professionals with mailing lists, publication repositories, Twitter feeds, and wikis. Its established working groups meet at conferences and workshops, annually hosted for the past seventeen years by universities and national libraries in the U.S., Europe, and Asia, as well as at smaller regional meetings, most recently at the British Library and at the 2013 IFLA meeting in Singapore. DCMI holds regular webinars on emerging topics of interest to the LAM community. The LD4PE project lead and several project participants of both the previous planning grant and this proposed implementation project are actively engaged with DCMI as members of its governing committees.

At the close of the grant period, the Exploratorium website will have a distinct presence as a DCMI subdomain with its own mailing list, blog, news channel, and publication space as described above under Deliverable 5. LD4PE will organize workshops at DCMI's annual conference and, as opportunities arise, at DCMI regional meetings. Inasmuch as DCMI events typically attract many participants from groups targeted by this project, it is anticipated that participation in DCMI will ensure a high profile for the Exploratorium within the GLAM education community.

The topical focus (Linked Data) and innovative, competency-based approach will be relevant to a wide audience. Potential venues for presenting results to the GLAM education and training community include the Association for Library and Information Science Education (ALISE) and the Association for Information Science & Technology (ASIS&T). To reach GLAM-oriented implementation technologists, software developers, and learning resource providers, the project may participate in the Internet Librarian International, KMWorld, Computers in Libraries, and Code4Lib conferences. In order to broaden its audience of potential implementers, the project will seek opportunities to participate in events of the Public Library Association (PLA) and the Digital Public Library of America (DPLA). Participation in any of these events will be publicized with blog postings, tweets, and news items. The project will aim at polishing selected papers prepared for these events for publication in relevant peer-reviewed academic and professional journals. Where possible, project partners will also present at local professional gatherings to reach regional and local audiences.

## Sustainability

Sustainability of the LD4PE work as set out in this proposal is dependent on two factors: (1) an organizational willingness to maintain and further develop the technical architecture and operations of the Linked Data Exploratorium; and (2) an active community interested in sustaining the effort. The Dublin Core Metadata Initiative (DCMI) is partnering in the LD4PE project with the intention of using the resulting pilot and best practice documentation as the base for further development of its education and training agenda. On assumption of management and future development of the Exploratorium at the conclusion of the grant, DCMI will immediately begin development of the needed recommender services that will support the metadata community and other stakeholders in crowdsourcing recommendations of new learning resources for inclusion—first through mechanisms that place discovered learning resources in an open Exploratorium “queue” followed by the social privileging of those deemed best through its built-in social recommender systems.

From its beginnings in 1995, DCMI was among the very first online communities to crowdsource expertise and was committed at that time to making the nascent Web amendable to resource discovery. The Initiative’s significant work since 1995 has included the creation of one of the most widely used metadata schemas on the Web that now plays a key role in Linked Data deployment. The Initiative continues to support innovative metadata design and best practice through appropriate specifications and educational activities.

DCMI has deep roots and ongoing commitments to service in the GLAM community with Dublin Core Communities and Task Groups focused on libraries, archives, networked knowledge organization systems (NKOS), cultural heritage metadata, and bibliographic metadata. DCMI is ideally positioned and resourced to assume the hosting, management, and further development roles of the Linked Data Exploratorium on successful completion of the grant.

Today, DCMI is a project of Association for Information Science and Technology (ASIS&T) and shares with ASIS&T a common goal to advance the “research that drives and the practices that sustain new developments.”

<sup>1</sup> <http://dbpedia.org/About>, <http://www.freebase.com/>, <http://musicbrainz.org/>

<sup>2</sup> <http://www.w3.org/2005/Incubator/lld/XGR-lld-20111025/>

<sup>3</sup> <http://id.loc.gov/>, <http://www.loc.gov/bibframe/>

<sup>4</sup> <http://lodlam.net/>, <http://openglam.org/blog/>

<sup>5</sup> <http://euclid-project.eu/resources/curriculum>, <http://lod2.eu/BlogPost/webinar-series>, <http://schoolofdata.org/handbook/>,

[http://videolectures.net/planetdata\\_training\\_curriculum\\_linked\\_data/](http://videolectures.net/planetdata_training_curriculum_linked_data/), <http://theodi.org/courses/open-data-practice>,

<https://github.com/baojie/leansemanticweb>, <http://cloudera.com/content/cloudera/en/training/certification/ccp-ds/essentials/prep.html>,

<http://gate.ac.uk/conferences/training-modules.html>, [http://www.w3.org/2011/gld/wiki/Linked\\_Data\\_Cookbook](http://www.w3.org/2011/gld/wiki/Linked_Data_Cookbook),

<https://joinup.ec.europa.eu/community/semic/document/cookbook-translating-data-models-rdf-schemas>

<sup>6</sup> <http://dublincore.net>

<sup>7</sup> <http://www.skku.edu/eng/>

<sup>8</sup> <http://oclc.org/home.en.html>

<sup>9</sup> <http://www.elsevier.com/>

<sup>10</sup> <http://www.synaptica.com/>

<sup>11</sup> <http://www.lrmi.net/the-specification>

<sup>12</sup> <http://www.thegateway.org/>

<sup>13</sup> <http://www.w3.org/RDF/>

<sup>14</sup> <http://asn.jesandco.org/>

<sup>15</sup> <http://asn.jesandco.org/resources/D2527589>

<sup>16</sup> <http://datahub.io/group/linked-education?q=&sort=name+asc>

<sup>17</sup> <http://data.linkededucation.org/linkedup/catalog/browse/>

<sup>18</sup> <http://lld.ischool.uw.edu/wp/learning/inventory/>

<sup>19</sup> <http://tuningusa.org/TuningUSA/tuningusa.publicwebsite/b7/b70c4e0d-30d5-4d0d-ba75-e29c52c11815.pdf>

<sup>20</sup> <http://answers.semanticweb.com/tags/linkedata>, <http://ask.schoolofdata.org/questions/>, <http://stackoverflow.com/questions/tagged/linked-data>

<sup>21</sup> <http://strandmaps.nsdlib.org/>

<sup>22</sup> <http://data.nsw.gov.au/data/de/dataset/powerhouse-museum-collection-simplified-dataset>

<sup>23</sup> <http://schema.org/Dataset>

<sup>24</sup> <http://euclid-project.eu/sites/default/files/EUCLID%20D2.1.3%20Online%20community%20engagement%20plan.pdf>

<sup>25</sup> <https://www.khanacademy.org/commoncore>

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- O'Donnell, Angela M., Donald F. Dansereau & Richard H. Hall (2002). Knowledge Maps as Scaffolds for Cognitive Processing. *Educ. Psychol. Review.* 14(1):71-85.



### **Key Project Staff and Consultants**

1. Michael Crandall, Project Director
2. Dr. Marcia Zeng, co-Investigator
3. Dr. Stuart Sutton, co-Investigator
4. Dr. Thomas Baker, Consultant
5. David Talley, Consultant
6. Joseph Chapman, Consultant

## SCHEDULE OF COMPLETION

## LD4PE—Linked Data for Professional Education

**DIL** = Deliverable number from Narrative

**LR** = Learning resource

DIL	Year 1 (Dec 2014 – Nov 2015)	D	J	F	M	A	M	J	J	A	S	O	N
1	Gather existing curricular examples for competency content analysis												
1	Analyze, derive and draft competencies from examples												
1	Refine the structure and topical clustering of the Index												
1	Serialize draft competencies in the ASN & iteratively refine												
1	Assessment of competency gaps revealed by cataloging LR; refine index												
1	Stakeholder formative assessment of Index and subsequent refinement												
2a	Adapt Gateway editor for LRMI metadata descriptions and tagging												
2b	Adapt ASN mapping tool for learning map creation; enhance visualization												
3	Discover, inventory and prepare LRs for cataloging/tagging												
3	Catalog, align & assess test set for quality/utility												
3	Catalog, align & assess discovered and Partner LRs												
4	Collaborate with Partners on recipe-generation criteria												
4	Creation of Partner recipes												
4	Review and refine Partner-generated recipes and development guidelines												
5	Install software and initial plugins for pilot Exploratorium website												
5	Evaluate/install theme that accommodates the Exploratorium												
5	Develop data integration between tools and Exploratorium												
5	Develop navigation interface to the Index with links to aligned recipes												
5	Iteratively assess the user experience of the Exploratorium												
5	Iteratively refine based on the user experience assessments												
5	Develop repository infrastructure for Best Practice repository												
6	Develop best practices for Index, recipe and metadata generation												
6	Assess and refine Index, recipe and metadata generation Best Practices												

## SCHEDULE OF COMPLETION

## LD4PE—Linked Data for Professional Education

**DIL** = Deliverable number from Narrative

**LR** = Learning resource

<b>DIL</b>	<b>Year 2 (Dec 2015 – Nov 2016)</b>	<b>D</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>
1	Continue gathering new curricular exemplars for analysis												
1	Continue monitoring for new LR to inform the Index												
1	Continue to serialize any new competencies in the ASN												
1	Continue to monitor for competency gaps revealed by cataloging LR												
2b	Enhance learning map visualization												
3	Continue discover of LRs for cataloging/tagging/aligning												
4	Continue creation of Partner recipes & refining creation Best Practices												
5	Refine Exploratorium user interface												
5	Refine data integration between tools and Exploratorium												
5	Develop navigation interface to the Index with links to aligned recipes & LR												
5	Iteratively assess the user experience of the Exploratorium												
6	Refine best practices for Index, recipe and metadata generation												

<b>DIL</b>	<b>Project Overall Assessment - Year 2 (Dec 2015 – Nov 2016)</b>	<b>D</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>
	Final stakeholder assessment of Index												
	Final stakeholder assessment of toolkit												
	Final stakeholder assessment of LRs/recipes												
	Final overall stakeholder assessment of Exploratorium												
	Final overall stakeholder assessment of Best Practices documentation												

## The Achievement Standards Network

The availability of a common, open competency framework repository is a crucial component for educators and trainers as many of them move from traditional classroom instruction to online or blended models of teaching that require content and assessments that are aligned to professional competency frameworks.

The Achievement Standards Network (ASN) meets this need by providing a framework and an open repository for the description of learning expectations in the form of competencies and learning outcomes. The ASN framework is built on Linked Data principles and includes rich metadata describing these expectations. The ASN's Resource Description Framework (RDF) based repository is freely available for unrestricted use through a Creative Commons Attribution 3.0 license and currently supports competency frameworks for all 50 states including the U.S. Common Core State Standards and the state variations on the Common Core. Currently, the ASN repository for the United States consists of over 500,000 learning objectives (current and historical) with over 7 million data points (RDF triples).

JES & Co., a publicly funded 501(c)(3) education research organization and the University of Washington established the ASN in 2003 through NFS funding. Additional investment in the ASN came through a grant from the Bill and Melinda Gates Foundation.

### Services Provided by the ASN

1. Web services that assist content creators and developers with the alignment of learning resources to competency frameworks.
2. Delivery of competency framework data in multiple file formats.
3. Open identifiers (URI) that support Linked Data and the exchange of competency-aligned content across disparate systems via a resolution service.
4. A web-authoring tool that enables direct input of competency framework documents into the repository.
5. A crosswalk tool that creates rich and meaningful semantic relationships between sets of learning outcomes, aiding in the realignment of existing competency-aligned content and supporting gap analysis between sets of competencies.

### The Structure of the Framework

An increased push for competency-based teaching and learning and a drive towards adaptive and individualized instruction has amplified the need for digital repositories of learning resources aligned to open competency frameworks. By using semantic technologies, the ASN repository provides a very rich dataset that enables linking concepts, standards and resources across the Web. The nature of the ASN gives consuming systems advantages over more traditional data models including:

- Content discovery through the use of open identifiers.
- Semantic crosswalks that define how particular competencies are related to each other enabling the automatic and semi-automatic mapping of content.
- Connections to external data sources and taxonomies enriching the end user experience through Linked Data principles.
- Ability to create custom learning progressions and scaffolding of competencies that support personalized learning.



## Competency Index for the Library Field

[View](#) [About these standards](#)

### Competency Index for the Library Field

Quick Find:

- Library Management
  - Personal/Interpersonal Competencies
  - Public Service Competencies
  - Technical Services Competencies
  - Technology Competencies: Core Skills
  - Technology Competencies: Systems & IT
    - Digital Resource Technology
    - Enterprise Computing
    - Hardware
      - Installs, configures and maintains computer equipment and peripheral devices
        - Understands in detail the functions of the computer hardware, internal components, and peripheral devices
        - Performs advanced troubleshooting methodologies for computer hardware and peripheral devices
- Network
  - Operational
    - Public Access
      - Server
        - Software
          - Technological
            - Technological
              - Web Development

```

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2 <rdf:RDF xmlns:asn="http://purl.org/ASN/schema/core/" xmlns:cc="http://creativecommons.org/ns#" xmlns:dc="http://purl.org/dc/elements/1.1/">
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7     <dc:terms:created rdf:datatype="http://www.w3.org/2001/XMLSchema#date">2013-12-16T08:08:33-05:00</dc:terms:created>
8     <dc:creator rdf:datatype="http://www.w3.org/2001/XMLSchema#string">JES & Co.</dc:creator>
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12    <asn:exportVersion rdf:resource="http://purl.org/ASN/scheme/ASNExport/3.1.0" />
13  </rdf:Description>
14  <asn:StandardDocument rdf:about="http://asn.jesandco.org/resources/D2527589">
15    <asn:jurisdiction rdf:resource="http://purl.org/ASN/scheme/ASNJurisdiction/WebJunction" />
16    <dc:title xml:lang="en-US">Competency Index for the Library Field</dc:title>
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### ASN Dashboard

#### Metadata Viewer

**ASN URI:** http://asn.jesandco.org/resources/S2528411

**Authority Status:** Original Statement

**Indexing Status:** Yes

**Education Level:** Professional Education & Further Development

**Subject:** Career Education

**Statement Label en-US:** Skills and Knowledge

**Description en-US:** Understands in detail the functions of the computer hardware, internal components, peripherals and external storage drives


**Language:** English

## WebJunction

### Publication Status

Published

Apply

Document Title	Subject	Date Valid	Publication Status	Download
Competency Index for the Library Field	Career Education	2009	Published	





The Achievement Standards Network (ASN) provides **open access** to machine-readable representations of learning objectives published by education agencies and organizations including the Common Core State Standards.

<http://asn.jesandco.org>

## About ASN



### Browse Standards

The ASN repository has over 4 million U.S. learning outcome data points



### Free Downloads

Machine-readable representations of learning objectives in RDF or JSON



### Open Source

ASN data is free to use and share even for commercial purposes

## ASN Toolkit



### Search Standards

ASN Search is a high throughput, low latency web-scale search service



### Crosswalk Standards

Make rich, meaningful semantic relationships between learning outcomes



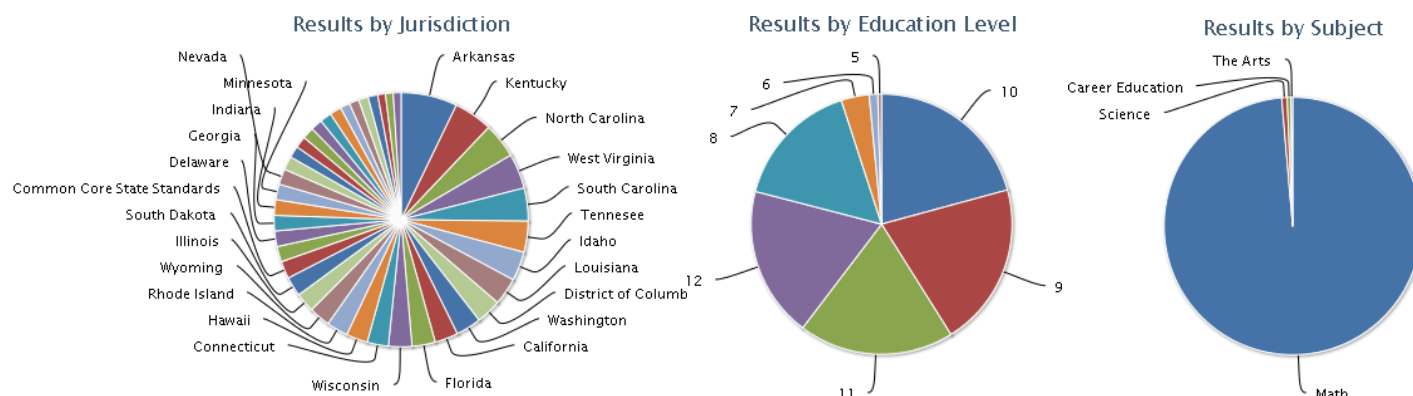
### Powerful Applications

Build amazing applications powered by the ASN open dataset

## ASN Insight

Use the ASN to get easy answers to complex questions.

*Do you know the distribution of the Pythagorean Theorem across U.S. standards?*



The Achievement Standards Network is a JES & Co. program and is funded in part by the Bill & Melinda Gates Foundation