Smithsonian Center for Education and Museum Studies
Digital Learning Resources Project

Volume IV

Technical Specifications Document

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Smithsonian Center for
Education and Museum Studies

CROSS & JOFTUS

PUBLIC DOMAIN

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Technical Specifications Document

I. Overview of Smithsonian Digital Learning Resources Project

The mission of the Smithsonian Center for Education and Museum Studies is to increase the Smithsonian Institution's impact as a national educational organization.

The Smithsonian Institution is the world's largest museum and research complex, with vast collections and expertise in history, science, the arts, and culture. Its expanding digital presence represents its commitment to broadening access to people everywhere. Focusing on digital outreach to educators and students, the Smithsonian Center for Education and Museum Studies (SCEMS) launched www.smithsonianeducation.org, the main feature of which is an indexed collection of learning resources that are aligned to all state, national, and now, Common Core standards of learning. The site's 2,000-record collection of resources including lesson plans, video and audio clips, and interactive instructional games is one of several Smithsonian finding aids such as its Collections Search Center (7.89 million catalogue records, 779,100 images). Other Smithsonian websites offer digital collections and tools in specific subjects and collections, the Center's unique goal is to provide access to all Smithsonian resources that are designed for classroom learning in the most useful and relevant ways. The impetus for the *Digital Learning Resources Project* was to help the organization better understand educational uses of Smithsonian digital resources and provide a roadmap for future digital development. The specific research objectives focus on educators' ability to identify, analyze, and extract digital content, with the ultimate goal of enabling all users to achieve their own personal learning objectives through the Smithsonian's resources.

Project Goals

The project has three sets of goals--short-, medium-, and long-term. Each was addressed in four phases of teacher engagement, investigation, prototyping, and research. In the short term, teachers would be able to more effectively identify, analyze, and extract specific Smithsonian digital learning content. In the medium term, teachers would increase their skills in making strategic use of digital media and visual displays of data to express information and enhance understanding. The long-term objective is to increase users' creativity in developing resources for their teaching. Ultimately, SCEMS would like to see online users become active creators and sharers of digital resources personalized for learning in their own classrooms.

The Digital Learning Resources Project was guided by intended learning outcomes inspired by a competency framework for teacher instructional analysis and development based on the Next Generation Science standards (http://www.nextgenscience.org/).

With this framework in place, there was a need for an approach to best analyze how teachers might move along this continuum of evolving skills. Inevitably, the designated approach needed to operate as a means to surface ***the types of features an electronic environment needs*** and ***the types of exchanges a set of digitally enabled tools could provide*** in order to accelerate teacher proficiency in the above outcomes.

II. Overview of Prototype Development Process and Findings

The work was segmented into four distinct phases focused on (1) research gathering and review, (2) use-data trends and analysis, (3) teacher identification and testing, observations, and annotations, and (4) iterative design and implementation cycles.

The research team developed a series of challenges and activities for participating teachers in order to

Phase 1:

- Review existing literature and sites to identify best practices in the world of digital learning resource development and dissemination.
- Research existing use-data on the existing SCEMS collections through SCEMS and California's Brokers of Expertise user-community data.
- Recruit initial teacher-subject teams from within the California Brokers of Expertise user-community for preliminary testing.

Next Generation Science Standards Digital Learning Resource Framework

Original short-term outcomes:

- Increase teachers' skills in **identifying** specific Smithsonian digital learning content
- Increase teachers' skills in **analyzing** specific Smithsonian digital learning content
- Increase teachers' skills in **extracting** specific content from Smithsonian digital learning resources

Medium-term outcomes:

- Increased skills to make strategic use of digital media and visual displays of data to express information and enhance understanding (common core)
- Increased creativity

Long-term outcome:

- Online users will become active creators of digital resources personalized for learning in their own classroom.

Here is a sample of use-data of SCEMS materials from California's Brokers of Expertise community:

Displaying **1-100** *of* **1648** *objects*

title ▲	View	Full Access
Hats Off! A Salute to African Headwear	36	6
In the Presence of Spirits: African Art from the National Museum of Ethnology, Lisbon	42	1
James Luna: Emendatio	0	0
Playful Performers	28	2
Smithsonian Education Online Conference: Problem Solving with Smithsonian Experts	0	0
The Fabric of Moroccan Life	26	2

Phase 2:

- Create a testing regimen to generate data on user-preferences with various digital environments and tools when interacting with common existing SCEMS collections.

- Assemble initial California teacher-subject teams and execute the training regimen as a series of direct, researcher-led group workshops and, as follow-up, individual field-based classroom implementation activities.

- Collect data and utilize information to develop initial prototype designs for reporting to the Smithsonian Advisory Panel and SCEMS leadership team for use with Phase 3 teacher-subject teams. These teams were given an overview of the project, the outcomes, and ultimately the role their actions and resulting information would play as part of the process directive.

During one month in spring 2012, teacher-subject teams were engaged in identifying and using Smithsonian resources in their own classrooms. Feedback was generated in both face-to-face meetings and interviews, as well as through an online collaboration portal to monitor use and needs with the digital resources. Information derived from the research, the literature, and the data generated from the teacher-subject teams provided ample information and ideas for some of the early prototype designs.

Message from the Smithsonian Center for Education and Museum Studies (SCEMS) team to California Educator Research Group:

Our goal is to understand what would be required to give educators a new online "resource-creation" toolset that would enable them to use Smithsonian digital content in a way that is responsive to a constructivist framework that recognizes the learners' active participation in the learning process.

The Smithsonian's existing digital resources are important to educators as the raw materials of instruction. These resources include images, collections, video and audio clips, interactive games, datasets, lesson plans, websites, and brief written overviews of topics and themes that convey our expertise and authority in many disciplines.

This Project will create, test, refine, and finalize a new access-and-use model (or "resource-creation toolset") that can be applied to the Smithsonian's digital resources. The Project is specifically designed to support teachers in underperforming schools to meet the needs of their students by enabling them to easily construct relevant resources. Through our development process, participating educators will create resources (which may be similar to those educators at the Smithsonian are already creating, or may vary widely depending on subject, intended use, and content) personalized for their own classrooms and students, and they will participate in the process of creating an online toolset they—and teachers everywhere—can use again and again to create what they and their students need.

In the following inserts, the early designs that came from Phase 1 and 2 activities and research can be seen in figure1 while figure 2 shows first-evolution prototypes as initially developed for Phase 3 participating teacher-subjects.

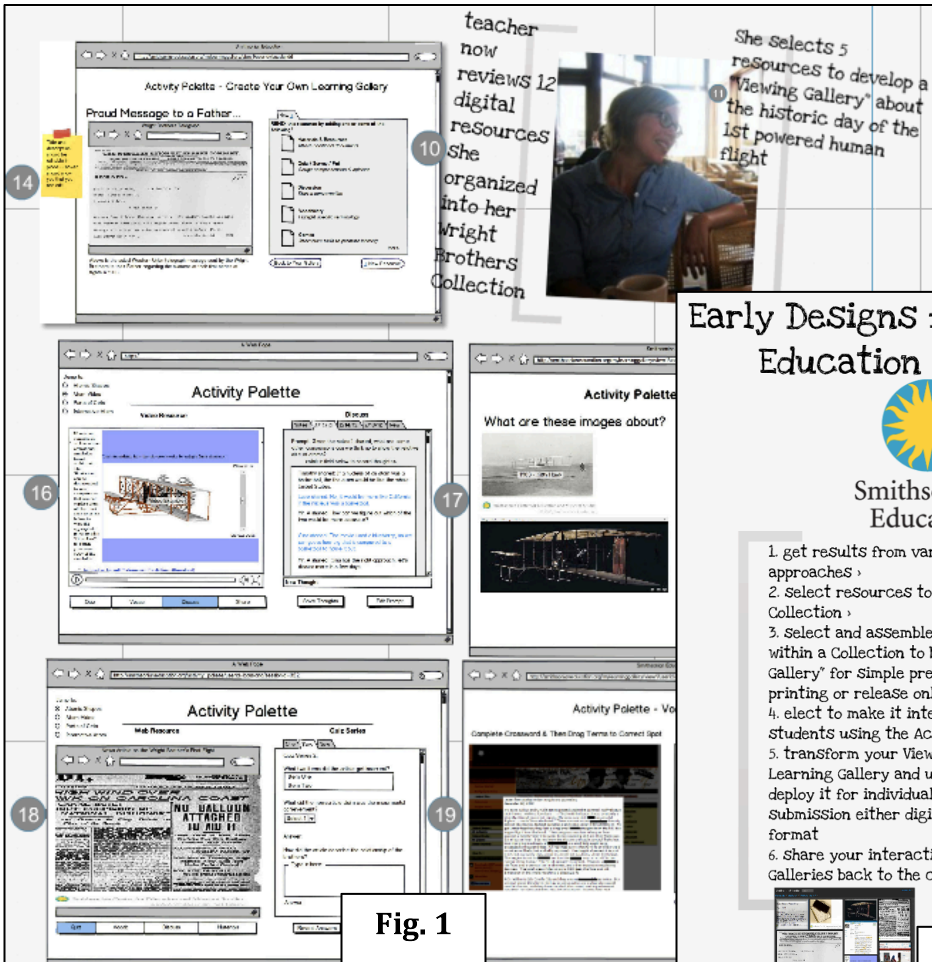


Fig. 1

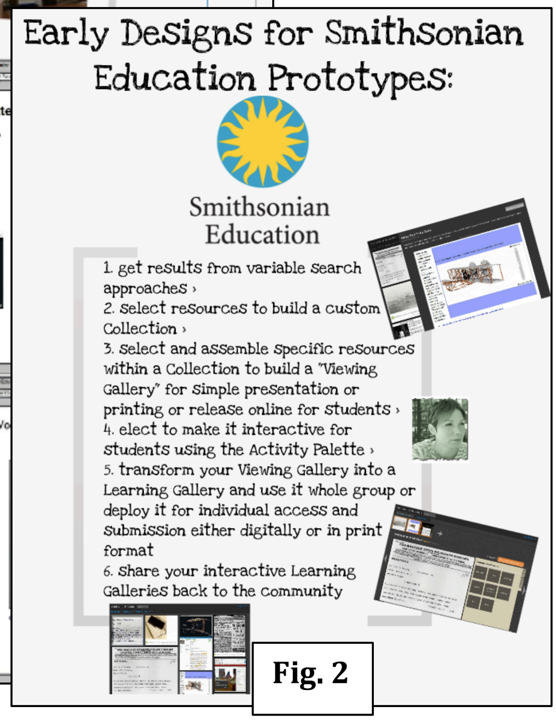


Fig. 2

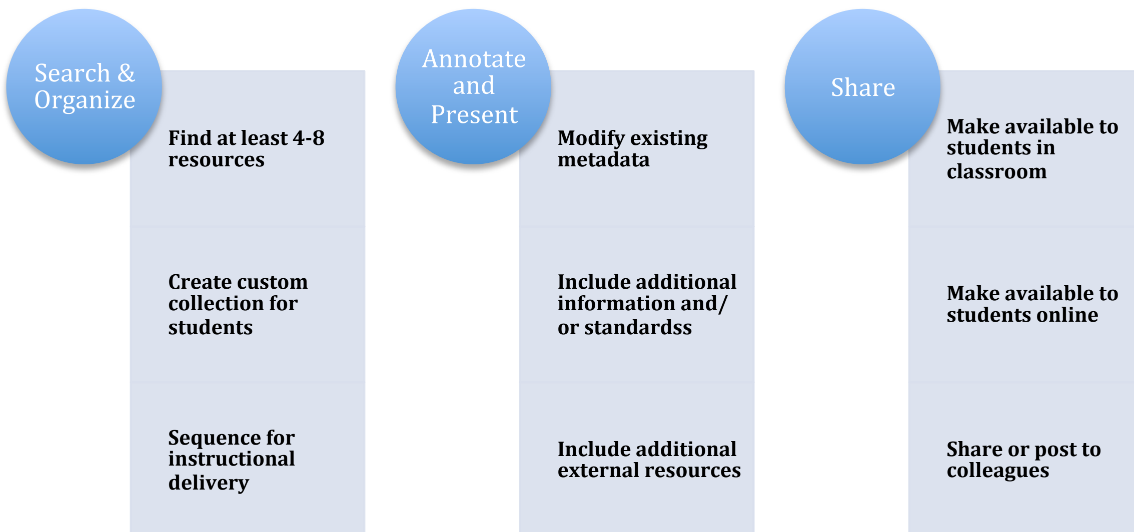
With some beginning constructs in place, the technical research and development team created a planned process that would expose the Phase 3 teacher-subject teams to a series of iterative prototype components. The information gathered during these next rounds of activities, with a different group of teacher-subjects, would be used to further refine the types of exchanges and tools. This would lead to a set of tools and technical approaches to help educators achieve the overall guiding project outcomes.

> *Teachers should be able to build learning experiences which:*
>
> *-**Connect** and are **coherent** (i.e. organized around core explanatory ideas or questions that kids use to make sense of the world around them)**
> *-Are **multidisciplinary***
> *-Are **relevant** to students' lives*
>
> ** Ideas should have a disciplinary significance, generate understanding and investigation, be relevant to peoples' interest, be teachable and learnable for k-12.*
>
> ***In summary, learning is considered building connections, not modular.***

Phase 3:

Working in coordinated teams, the Cross & Joftus technical design team and the SCEMS lead team and researchers were given access to three different national teams of teachers for approximately one hour per day over the duration of a week. (Teachers were mainly Council of Chief State School Officers (CCSSO) State Teachers of the Year, or designees participating in a joint project with Smithsonian and Pearson.)

The research team, in working with these teacher-subject teams, processed many decisions and considerations pertaining to the prototype tools and functions by continuously referencing the extended teacher design framework guiding the overall project. The teacher testing regimen and observation process worked to expose teachers to various pieces of the prototype to perform tasks to search and organize resources, annotate and prepare to present resources, and share findings:



Some of the data collected from these types of exchanges and activities are summarized below and led to a series of day-to-day and week-to-week revisions of the prototype tools as the development team synthesized this information and the tools themselves into a common digital interface.

Teacher Action	Observation/Findings
When searching for and initially identifying content, teachers preferred:	To search by entering a general search term tied to their unit or lesson topic.
	To filter a large return of results further if needed.
	Gallery view creating dominant visual display of resources.
	Meta-data describing resource as a secondary item available on demand.
	Intelligence integrated into their search such as grade level filters tied to their profile, auto-complete for common terms, suggest similar items.
	Diversity of items from various sources synthesized into single search.

Teacher Action	Observation/Findings
When analyzing content, teachers wanted:	to save resources in a preliminary stage for further review before organizing into instructional groupings.
	the flexibility to organize and annotate resources to emphasize specific concepts and create more accessible information for their students.
	suggestions or indicators of the value other educators placed on the resources.
	the ability to allow students to access and use the site and its tools as much as the teacher.
	content that is aligned, or close-to-aligned, with Common Core Standards.
When extracting content to create curricular activities or lessons, teachers:	wanted flexibility in the types of viewing methods available: whole-class, teacher-led viewing and progression, individual student viewing and progression, student-generated sequences and organization.
	expressed an interest in a variety of tools for instructional interaction that included prompts and explanations for their use.
	engaged the use of "interactive modules" with the resources found in the Smithsonian collection and generated ideas for further interactive features.
	wanted to upload resources from other sources to augment their collections.
	wanted more intuitive design and flow between tools and facets of the prototype.
	found that emailing URL links to others is a viable means to share quality resources.
	felt that publishing URL links to other online communities in which they already participated was a growing need.

III. Overview of Final Prototype Features/Functions as Aligned to Goals

The impetus for this project was not just a simple analysis and update to the interface of the existing Smithsonian Education website, but an effort to better understand the vast changes in digital resource development and distribution that have occurred in education over the last five years. The methods that educators employ to find and access resources have become less a series of rote-memorization and simple bookmarking of resources and more integrated with intentional communities of practice and sharing around precise standards. In this new era, downloading a PDF of a highly polished lesson does have value. However, the ability to modify a resource specific to the needs of one's own students, glean instructional practice strategies and ideas from others using the same materials, and redistribute materials into external, digital learning environments are all desired features that lure more teachers to more actively engage content and materials on a personal level. In short, we see a more discriminating consumer who wants *quality* content, wants to locate it *easily*, and wants to *modify it* to match classroom and student needs.

VII. Technical Implementation Plan

Successfully deploying a large scale project such as this does not depend solely on system development and technical expertise, but also requires:

- an understanding of pre-established communities and content in which the project will be integrated
- a sense of the existing culture and political environment of the organization that will manage the system and resources within it
- recognition of the time and budget constraints that exist
- clear expectations of end-users and external evaluators in both quantitative and qualitative structures with room to grow and modify as new needs surface
- a plan for the continued life of the system after initial development concludes

In general, recognizing that this *system* lives within other systems and communities, and should work to promote the continued efficacy of those systems, highlights the importance of development decisions at project inception.

Development Component Layers

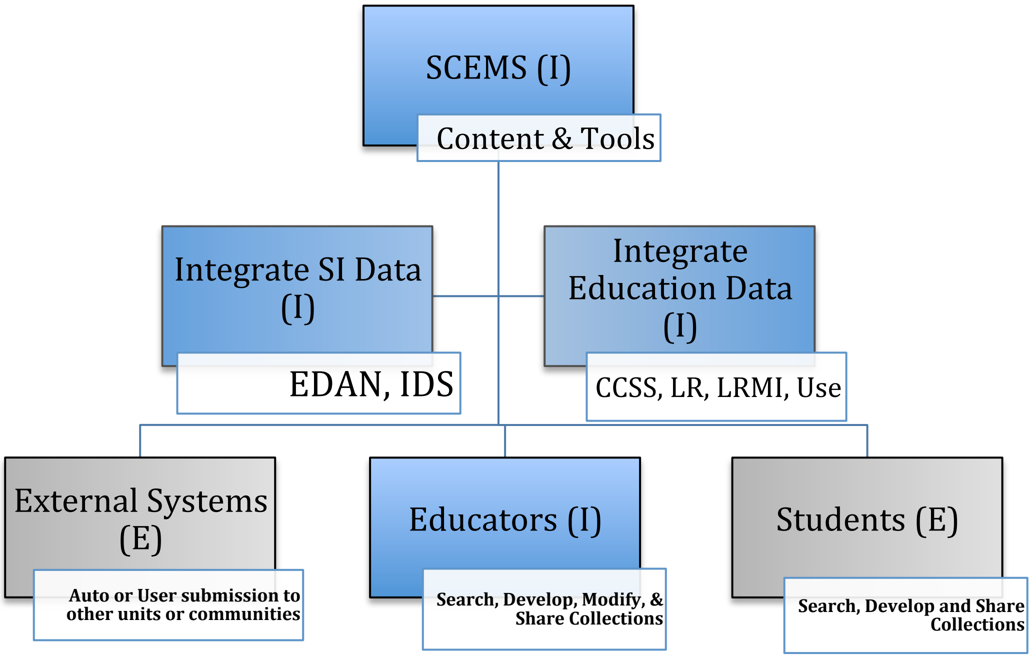
The following layout represents the major components that will operate in creating a new educator experience at the SCEMS site.

The initial phase **(I)** of development will focus on integrating SCEMS with both internal Smithsonian data-services and external education data frameworks and specifications to provide educators a new system of searching, building, and sharing instructionally relevant experiences for learners.

An extended phase **(E)** of development will focus on further extending the tools and resources in ways to support students as independent and coordinated learners of the Smithsonian's assets. Additionally, the system will include facets to actively push metadata on existing collections and paradata on experiences with those collections out across pan-Smithsonian digital environments and social and educational networks in use across education as well as make it possible for external developers and partners to easily assist in the creation of new interactive modules.

It is important to note that the initial phase and the extended phase can be executed concurrently if adequate resources and time are available at the outset. If that is not possible, this design will allow SCEMS to begin development of one layer that will produce core services and features that can be published and assessed. Other extended facets can be added in time.

Audience and Services Component Layers



SCEMS (I): This access layer is the public-facing location for existing and to-be-developed SCEMS instructional resources at www.smithsonianeducation.org. Additionally, it will be the primary access point for hosting the search, browse, and instructional collections and activity development tools for educators, as well as for search-and-discovery tools for students and others interested in accessing both the SCEMS materials and general collections from other Smithsonian museums and research centers.

Educators (I): This consumer layer represents the educator consumer and the utilities found at the SCEMS site designed to provide them with means to search, discover, organize, develop collections, integrate activities, and deploy and share custom learning experiences. Some features will require log-in/authentication; others, focused on searching and exploring, will not.

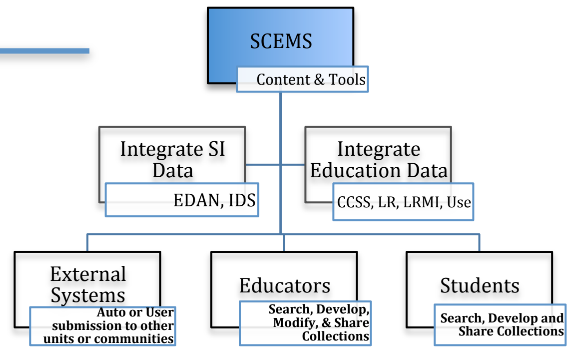
Students (E): This consumer layer represents students' ability to search and explore collections for their own inquiry. Additionally, it will pertain to students who have been given accounts (generated by their teachers) for access to and engagement with given instructional collections and integrated activities.

External Systems (E): This layer represents the ability to push out/publish trace data from within SCEMS to external systems or user communities. This will include the SCEMS administrative team pushing centrally authored instructional collections out to various Smithsonian departments, a consumer publishing materials to their own site or community portals, or data feeds out through the Learning Registry.

Integrate Smithsonian Data (I): This layer represents the integration of the existing Smithsonian Enterprise Digital Asset Network (EDAN) architecture running asset information and controls as powering the current Smithsonian Collections system.

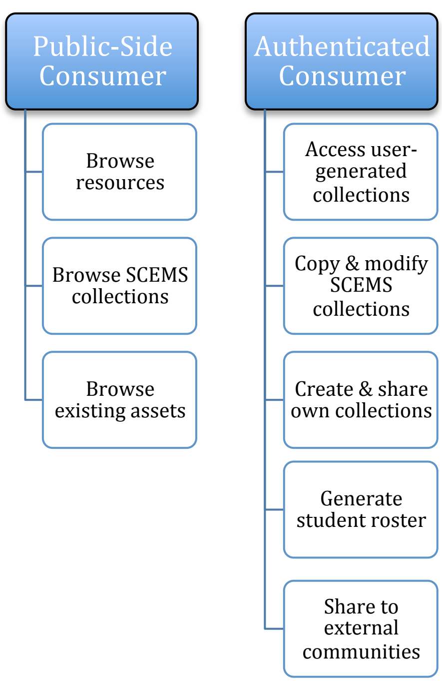
Integrate Education Data (I): This layer represents the integration of structured data-sets for the Common Core State Standards, Learning Resource Metadata Initiative, and Learning Registry as auto- and user-generated controls for all materials published by SCEMS. (See information beginning on page 17 for a review of these educational data initiatives.)

Development Specifications for System Layers



SCEMS Entry Layer (initial phase)

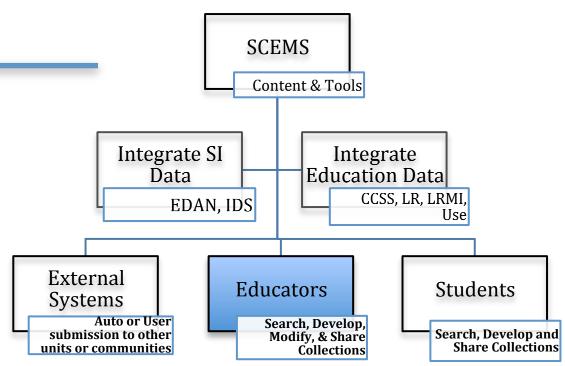
The existing instructional materials currently available as educator assets found at www.smithsonianeducation.org can be redeveloped and deployed with the instructional collections and interactive tools to be launched. Using resource instructional organization tools with additional content authoring enhancements, existing SCEMS content can be regenerated and deployed in the instructional collection format as structured and conceptualized in the prototype. The treatment for processing the existing materials will provide the lead team valuable experience in the regeneration of content that will serve as a service model for potential support of other units and their content in the same manner. Some items might be more appropriate to remain as single-download, print-based commodities (PDF) and can be archived and stored as searchable materials along with new materials being developed.



The new search, organizing, and instructional collection tools will require the development and integration of a user interface or dashboard that provides well-aligned management of the above tasks. It is recommended that passive consumers of materials, such as those just wanting to search existing records queried and served by the Smithsonian Institution's collections data, and organized materials and instructional collections authored by SCEMS administrative staff, do so without need for authentication. When accessing and viewing these publicly available materials, users are presented with trace data on other consumer-authored collections as related to the returns they are viewing and are prompted to generate an account if they attempt to access those auxiliary materials.

Additionally, when a passive consumer elects to save items found in a search, or create a copy of an existing instructional collection for modification, they will be prompted to generate an account of their own. (The screen to the right illustrates the sign-in prompt.)

Once logged into the system, educators can perform a number of tasks such as saving resources into instructional collections, integrating activities, including external materials/resources in collections, and generating student rosters for sharing of collections directly. Additionally, logged-in users can make copies of existing collections shared by both the SCEMS administration team and other users that have had their materials posted for public consumption, allowing them to create modifications on those models. Authenticated users can also elect to promote found resources or their own collections to external systems via integrated links to common social community sites such as Facebook, Twitter, LinkedIn, Pinterest, etc., or to their own websites/portals or online communities via a link/embed code.

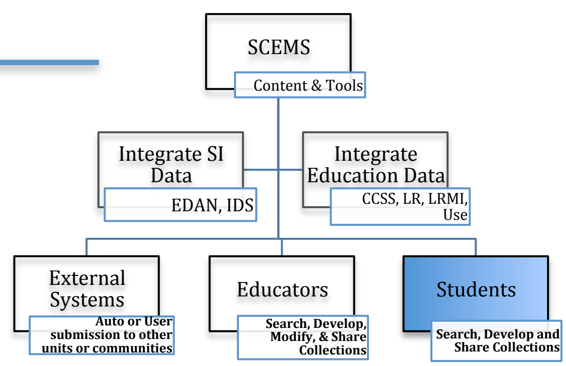


Educator Layer (initial phase)

Educator-consumers, once authenticated, will be provided access to search, save, and organize features specifically designed to accommodate instructional filtering against topical subjects, instructional strategies, and national education standards (CCSS). They will also be provided advanced tools for assembling individual assets and learning objects into custom collections. They will be able to sequence these materials, modify and annotate metadata of the assets/learning objects, create and integrate activities, modify display options, and publish links and related metadata to external systems. Using data gathered from the Phase 3 participating teacher-subjects, five key instructional interactive integration tools should be the lead focus for initial development to include the concept cloud, quiz, discussions, map, and additional resources along with an additional five other appropriate instructional interactive tools as solicited from Advisory Team members or even other Smithsonian education departments as a means to leverage their interest and early participation.

Teachers wanting students to directly interact in the SCEMS learning environment with the collections they have created during the initial phase of development can provide their students access to their collections via a unique URL where students will engage as anonymous users. As such, students will be able to comment within discussions, and answer questions, or search for locations related to the subject, etc., but will not be authenticated, identified, or be traceable by the teacher. As a component of the extended phase of development, a student-layer will allow a teacher to set up their own "virtual Smithsonian class" and support more precise, managed exchanges with student-users who have logged in and have accounts within the same environment.

Educators can also elect to share their collections back to the SCEMS community and access other collections already published in the SCEMS community by other educators that have had their materials shared by the SCEMS team back to the site. Once instructional materials are generated and deployed within the SCEMS system, educators can opt to share links to their materials with other educators through their own online sharing and collaboration communities, or back to the SCEMS community at large. Finally, educators will have the ability to create full copies of other shared collections whether from the centrally authored processes by Smithsonian staff or those shared by other educators. Once copied, educators can edit those for specific deployment in their own classrooms. Tracking data on which collections are copied and modified will help to identify those that are most regarded and used in the field from within the published materials.

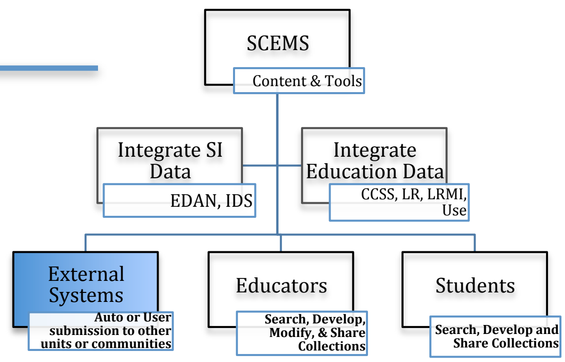


Student Layer (extended phase)

Students will access the SCEMS site as a definitive research-and-discovery destination. As independent learners, students can freely utilize the browse and search engine to create rich visual displays of thousands of collections items with expert supporting metadata. Students (over 13 years of age) can create individual user accounts or others can locate their participating teacher and request to join their virtual Smithsonian class.

Students, upon having an account, are encouraged to create their own collections and share them to their instructors. Students' collections can be viewable to their teachers and peers in their virtual Smithsonian class by selecting to submit to their virtual Smithsonian classmates. However, students are also provided single, unique URLs to their own collections to send to parents, friends, or post to their own social or education communities.

Students with teachers who have set up a "Virtual Smithsonian Class" attached to their account will complete a "student-roster," a simple, form-based method of generating student-user accounts. We recommend a single-page form that requires students' first name, last name, and a parent/caretaker email for account approval. Once both the teacher account and the student roster are established, educators can use their "Virtual Smithsonian Class" to share their instructional collections with integrated activities to students and solicit participatory responses to quizzes, notes, exchanges, etc. In addition to an email sent to the student's parents/caretakers, teachers are also provided a single, custom URL that they can then send out to students to allow them to quickly join their virtual Smithsonian class.



External Systems Layer (extended phase)

The design of this layer is intended to publish and promote the types of activities taking place within the SCEMS learner portal out to other strategic web environments to draw increased interest and use of the SCEMS tools and community derivatives. There are three specific distribution models the system will be designed to target and process for advanced metadata promotion outside of the SCEMS web environment.

> **Published Metadata Elements**
> - Resource title,
> - Descriptive data,
> - URL to resource origination point on SCEMS site,
> - Thumbnail of first resource in collection,
> - Date of creation,
> - Author of collection, and
> - Rights of use consistent with Smithsonian's citation and use policies

First, instructional collections generated by the SCEMS central team will have the option of being auto-submitted to the Learning Registry under the SCEMS contributor key for aggregation with all subscriber agencies and portal communities. LRMI auto-tagging is also an option that can be turned on for each instructional collection authored and published to the SCEMS site so that general search engines and aggregators can easily locate and surface these materials as relevant returns to educational queries.

Second, user-generated instructional collections developed by educators using the SCEMS online tools can be shared by users through single-click, embedded social community feeds. The first-time users elect to surface data on a given instructional collection they have created on Facebook, Twitter, LinkedIn, Pinterest, etc. They will be given the option to make it a one-time occurrence upon authentication with the third-party community, or to create the sharing option as a default profile setting within their SCEMS user-controls. Additionally, users will be given a simple means to post a link to their collection within an external, online educator community they actively use outside of SCEMS, or send as a simple email to colleagues and peers. An embed code will also allow them to post external to SCEMS in a number of different environments, including their own student portals or their own class webpage. When publishing space allows, all data configured for external publishing should contain specific metadata that includes the title, description, link to resource on SCEMS site, thumbnail, author, use rights, and SCEMS/Smithsonian logo.

Third, where SCEMS instructional collections developed internally or those developed by educators have incorporated objects from a museum or archive collection, a paradata stream can be provided to those contributors. This data can surface to an internal Smithsonian entity as a simple administrative, online dashboard identifying the materials being used, the collection in which they are used, and the degree to which those collections are shared or copied. Also, a special feed can be enabled (leveraging the Learning Registry data network) that would allow units to embed composites of these activities on their own educational sites as integrated within their outward-facing web environments.

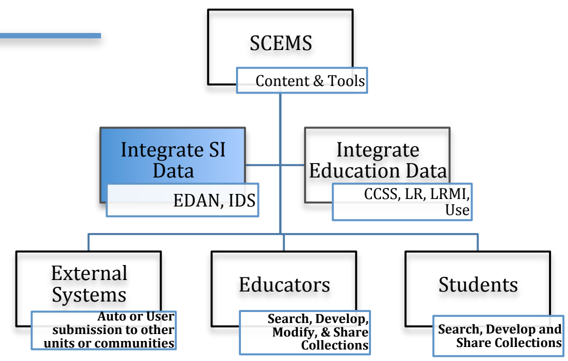
The launch of these new SCEMS utilities will open up an entirely new set of tools for educators to make use of the wealth of resources that the Smithsonian Institution houses. For the benefit of all of Smithsonian museums' education and web departments, the SCEMS tools can be easily integrated with other institutional websites. Content developed within these tools can be accessed through multiple methods, facilitating collaboration, and providing a better means of consolidating pan-institutional teacher resources, while also allowing participants online autonomy. Additionally, building the tools on a service infrastructure with portable data will provide a variety of other display options to be employed in the future, such as kiosk displays to be used within museums or museum educational centers.

We anticipate that this could evolve into Smithsonian museums and education departments seeing perspective value in making mutual use of the SCEMS educational tools to create more deliberately designed educator and learner consumable collections to further surface within their own web environments as well as on the SCEMS system. This strategy will further position SCEMS as an institutional leader in the arena of extending the Smithsonian as a national educational organization and change agent in both the formal and informal education arenas.

One further method for interconnecting systems that has caught hold with developers in recent years is the inclusion of a plug-in infrastructure, which would allow external developers to easily develop tools to integrate their functionality and content into the SCEMS system. The modular nature of the interactive modules and the wide array of possible tools that could be built make it a perfect candidate for opening up to outside ideas. By creating documentation for and interfacing with these external developers, the

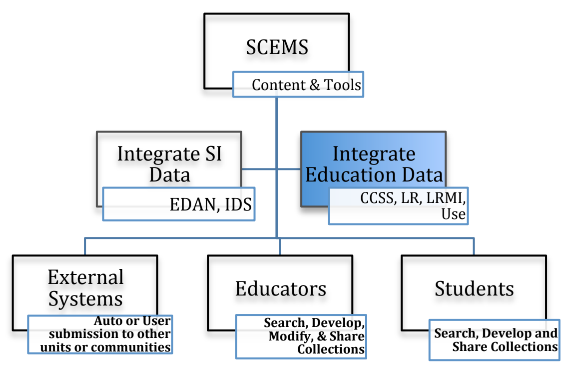
SCEMS system will be more adaptable for working with content partners and other systems. For instance, Learning Registry developers could create an interactive to display activity data for selected activities, a Google indoor map interactive could highlight where certain pieces are currently on exhibit, or Pearson could offer connections to activities cited in their textbooks.

Integrate SI Data Layer (initial phase)



It is recommended that the proposed SCEMS system make full use of the existing, robust data-services provided within the Smithsonian through the Enterprise Digital Asset Network (EDAN) as managed by the Internal Data Services division.

With this approach, the SCEMS system can instantaneously leverage and surface 7.89 million digitized records for educators, students, and general learners wanting to access a wealth of the nation's artifacts online. Conclusions taken from the prototype testing would suggest that a filtering intelligence could be added to return results that would promote full educational assets and collections above individual objects in the database. A clear delineation could be visually made between items such as SCEMS-authored materials and individual collection items. Further, the data could be parsed to recognize that, within vast numbers of general collection items, those items having supporting visuals and/or direct image files can be rendered more prominently than those that do not. The search and data presentation schemes that surfaced in the Phase 3 research findings can initially be developed as the internal SCEMS processing of these data-services. In later development, they could be managed as a service out to other units to display on their educator enabled portals as well.



In addition to EDAN services, the SCEMS system should be set up to leverage whatever pan-Institutional services are available and determined to be useful, while also working with the Office of the Chief Information Officer (OCIO) to expand available services. Upcoming possibilities include a unified log-in/profile system through the mySI project, and video-processing services similar to what Internal Data Services provides for images.

Integrate Education Data Layers (extended phase)

The proposed SCEMS system should have data layers integrated for the Common Core State Standards (CCSS), Learning Registry (LR) publishing and consumption specifications, and all instructional assets tagged in accordance with Learning Resource Metadata Initiative (LRMI) common metadata framework.

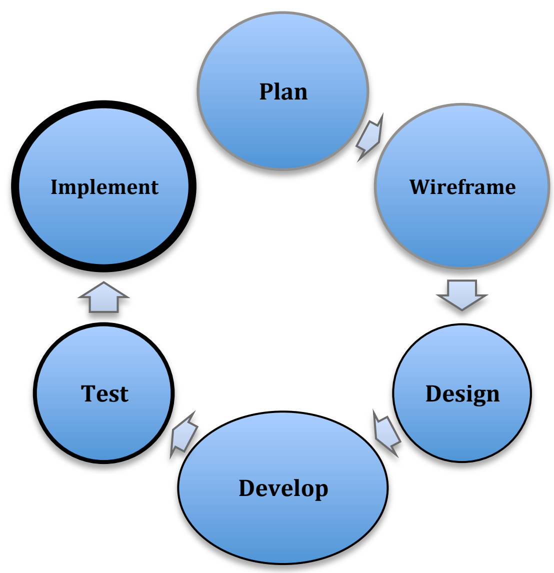
For the near-term, the majority of users will still be accessing Smithsonian digital learning resources through the SCEMS website, using standard desktop web browsers. Current technology trends are moving users away from these traditional methods, with mobile applications and integrated systems of shared data becoming the norm. Developing on a platform that values data portability and a separation of services from traditional web display will ensure greater flexibility and long-term success for these resources. The following are some of the ways the SCEMS system can benefit from employing these design methodologies to be better positioned for connecting to external services:

- **Learning Resource Metadata Initiative (LRMI)**
  In order to make it easier for internet searchers to find what they are looking for, the major search engine companies (Bing, Google, and Yahoo) formed the schema.org initiative in June of 2011. They agreed to recognize a shared markup vocabulary that websites could embed as attributes within their pages, making it easier for seemingly unstructured display data to be machine-processed in a precise manner, better exposing the underlying information for people searching for it. The educational branch of this endeavor, as lead by Creative Commons and the Association of Educational Publishers, established LRMI as a set of attributes created to describe educational resources, and has been submitted to be included as a sub-set of schema.org. The promise of these new methods is minimal data tagging efforts on a web developer's behalf that will expose learning resources and their associated data descriptors (subjects, grades, assessment information, standards alignment, etc.) in a structured manner to search engines and other data processing applications. Additionally, LRMI is being considered as a lightweight metadata schema that could be used to share data between systems, rather than translating metadata into more formally structured schemas like SCORM or Dublin Core.

- **Learning Registry (LR)**
  In 2011, the United States Department of Education Technology developed and launched the Learning Registry, an open network for sharing data about learning resources. The system is designed to facilitate the exchange of data describing what resources are available, as well as usage and rating information about the effectiveness of those resources. The majority of the data in the LR falls into two types: 1) metadata: detailed and structured data describing the resources themselves, in a variety of supported schema, and 2) paradata (use): contextualized usage data about the resources, including ratings, favorites, comments, aggregate view and access counts, standards alignment, and connections between resources. The new SCEMS system should be set up to publish and consume both types of data, broadcasting information about new and updated learning resources, as well as the ways they are being used by educators. The LR then becomes a valuable dissemination point for other systems to open up access to SCEMS resources, as well as a way of closing the loop with external

partners that want to know how their resources are being accessed within the SCEMS system. For instance, when a teacher uses a Smithsonian resource to help teach a concept and aligns it to a Common Core standard, that alignment information should be shared via the Learning Registry so that other educators could benefit from that usage example when teaching to the same standard.

- **Application Programming Interfaces (API)**
  Much of the success of the prototype tools can be attributed to the way they present such a large collection of Smithsonian resources in a visual manner. Implementing this functionality on a short timeline was only possible because the Smithsonian had the foresight to build the Enterprise Digital Asset Network (EDAN). Rather than just create a unified search on a single web page, an API was created and made available to authorized applications to access this valuable set of data from other tools and systems. Using this model, the new SCEMS system should have a set of services to allow Smithsonian teams from various museums to interact with the core EDAN functionality and data. The ultimate reason for offering an API is to provide content or services in a flexible way. As the internet moves towards a variety of devices and interfaces, APIs can provide for the ultimate level of flexibility and control for future technologies, without requiring additional data manipulation and programming in the central system.



Structuring a Progressive Development Schedule

From start to completion, having a structured development schedule with verifiable milestones will help to ensure that all project goals are reached efficiently. Though timelines and priorities will change along the way, being able to map the project's overall trajectory and progress aids in maintaining momentum. Details on each phase of the development schedule are outlined in the *Timeline* section below.

Timeline

Development and deployment of the system will follow the "*Progressive*

Development Schedule" as outlined below. Both initial and extended phases will need to address a cycle that includes planning, wireframe and feature specifications, designing for user needs and UI details, development of data relational structures and system UI hookup, internal alpha testing/review, external beta testing/review, and finally implementation.

These phases are broken out in the following table with estimated weeks and related budgets identified to provide SCEMS an estimate of time and invested funds to be anticipated to create the various layers of the system. Weeks and relative cost-structures identified indicate both those required for initial development and those for extended development. These are estimated amounts based on experience leading development and organizational processes consistent with the framework of resources specified in this document, and an analysis of similar endeavors supporting highly congruent services and utilities including the National Science Digital Library, California's Brokers of Expertise, and the National Archive's Docs Teach Educator Portal.

Phases	Weeks	Budget
Planning Phase: Although the prototype process and this specification provide a layout for what the new SCEMS system should include, there are many choices left to be made that depend on organizational priorities. A plan co-developed by the implementation team, department stakeholders, and project advisors should detail as much as possible how the final system should look and operate. A planning document should be created outlining features to be generated, content areas, tools and their functions, data captured from users, data integrated from external sources, user roles and permissions, grouping structures for users and resources, and base API structure. The plan should offer a detailed vision of the system, but should be flexible enough to allow for changing priorities and functionality along the way.	Initial: 6 Extended: 3	
Wireframe Phase: As helpful as a planning document can be, it can be very difficult to get an exact picture of how users will interact with resources and each other from lists of data and functionality. Creating a wireframe for the system will connect the underlying conceptual features to the visual design of the user experience. Content, navigation, and functionality priorities are displayed and rearranged as necessary based on feedback. At this	Initial: 6 Extended: 3	

Phases	Weeks	Budget
stage, holes in features and functionality should be found and rectified. Although wireframes are generally just basic outlines, purposefully devoid of graphics or color selections, it would be best to create examples that include some content from existing SCEMS resources to see how they will be represented in the context of the new system.		
Design Phase: Using the wireframe as a base, the implementation team should present multiple options for branding and design for the system, focusing on usability and visual appeal. Starting with three or four different ideas, the refinement process should allow for feedback and modifications until a consensus is reached on a consistent look for the final product that will allow for a pleasing user experience. Steps in the process should include: • Initial development of 3-4 ideas for branding and interface elements • Gathering feedback and focusing on 1 or 2 of the ideas • Honing and finalizing of the chosen design • CSS & HTML development of interfaces	Initial: 5 Extended: 2	
Develop Phase: Begun in conjunction with the design phase, core development of the base system and services, solidifying data structures, and creating front-end tools for the majority of the planned features make up the bulk of the programming on this project.	Initial: 12 Extended: 3	
Test Phase: Functional Alpha Although there will typically be some inconsistencies and missing management tools, the alpha version should be functional, consistent with the wireframe and the features outlined in the original planning document. Design and interface should be merged into the functional alpha and checked for compatibility with the user experience before beginning testing.	Initial: 10 Extended: 2	
Internal Testing The first-round of testing is a verification process the project leads and development team needs to	Initial: 4 Extended: 2	

Phases	Weeks	Budget
go through to determine if the system is meeting their expectations up to this point. With the majority of features and functions in place, how close is this product to the initial vision and plans? If there are remaining bugs or missing functionality, will they keep the first round of beta users from fully experiencing the system?		
Public and Invite Alpha Personal invitations should be made to members of the advisory group, other unit development and education groups, and trusted external stakeholders to begin using and providing feedback on the system. Although they are likely to be familiar with the project and its goals, they will provide feedback closer to the general public since they are entering the system with less information than internal team members. It is inevitable that some of the original ideas will need to be reworked or reconsidered, and this is the phase to decide on those changes. A public facing alpha can be launched concurrently if determined appropriate for general solicitation of external input.	Initial: 4 Extended: 2	
Public Beta Given that the existing SCEMS site is a valued destination for educators, the initial launch of the replacement system should be offered as an optional means of accessing the resources, and properly promoted as such. Feedback gathered during this period as well as usage statistics for the two sites running side-by-side will be valuable data points for evaluation. Initial integration with a small selection of other Smithsonian units should also happen at this phase.	Initial: 6 Extended: 2	
Implementation and Evaluation Phase: After responding to the initial feedback, addressing functional issues and glitches, and reworking design and content as necessary, the system should be formally unveiled to the public. After a period of initial use by the public, a feature analysis should be performed, comparing the system to the original goals for the project, the features outlined in the planning document and wireframes, and expectations of the lead team and advisory panel. Documentation for integration	Initial: 2 Extended: 1	

Phases	Weeks	Budget
with external systems should be complete and readily available.		
Update Phase: Making updates to site functionality and processes, and then publishing those changes to the community (as well as administrators of integrated systems) will help them feel connected and involved in the ongoing success of the system. While major changes should be given the necessary time to be completed properly, being responsive to user-generated feedback, especially with glitches, is important in building trust in the system.	Initial: 3 Extended: 1	
Estimated Total Time and Cost of Ownership under an Open Source Model	Initial: 58 Extended: 79	

System Licensing

The educational community has a long history of developing disruptive technologies for organizational projects, and then releasing them as open source in order to broaden their impact on the community at large. The BSD Unix operating system, the Apache web server, the original NCSA Mosaic web browser, and the Sakai Collaboration and Learning Environment are examples of large-scale open source projects that started within educational organizations and then were released to the larger community for continued support and feature development. The federal government has also made moves towards open development with the White House using Drupal for its website, NASA creating a collaborative space for sharing projects (http://code.nasa.gov), and even the NSA developing an Apache licensed project (http://accumulo.apache.org). As stated on the developer section of the White House website, "We believe in using and contributing back to open source software as a way of making it easier for the government to share data, improve tools and services, and return value to taxpayers."

In the event SCEMS and the Smithsonian wanted to take advantage of the growing participation in open source development and an ongoing, open support community that is prevalent amongst many federally funded museum, education, and fine arts agencies across the nation as led by the White House and current Chief Technology Officer Todd Parks, we would recommend an initial analysis and approach to identify the best models in which to partner. With this approach as an option, SCEMS would need to consider an open source license that would coordinated like-minded resources and technical work as generated by other museums and related federal agencies to make full use of the architecture and principal system design while also analyzing and securing related development that has already occurred and can be utilized. Given the prominence of Smithsonian, a true leadership position could be forged in this space with the support of both the federal government's new open data initiatives and the museum and education communities at-large in ways that help them to:

- adopt similar data protocols for extended sharing of their own museums' resources;
- provide a wider development community that would then improve upon the overall system and tools within it, which could be re-grafted back into the source code;
- create an opportunity for other funders and contributors to generate budgets to underwrite these efforts;
- connect more directly to the Smithsonian's expertise in the formal and informal, growing digital education and outreach domain; and
- serve as a model for others in this industry space.

Many established and respected museums have been moving towards open source development in various capacities over the last eight years, following just behind the trends in educational and governmental organizations. Unlike in the commercial space where innovation and change are necessary forces, disruptive changes in process often need more time to take hold in organizations with longer histories. By collaborating with some of the more innovative museums, the new SCEMS system will benefit from the knowledge and experience they have gained from navigating the same institutional hurdles. The following are some key organizations that have made strides in matching various layers of open source code and platform components to their digital museum, outreach, and education efforts and could provide valuable information during the planning phase:

- Indianapolis Museum of Art: Through the IMA Lab, the museum's technical development unit, they are working to enrich the field with quality, shared tools for the benefit of the entire community.
  http://www.imamuseum.org/imalab/about

- Collective Access: CollectiveAccess operates as a GPL open-source licensed cataloguing tool and web-based application for museums, archives, and digital collections. The management system requires little to no custom programming to support a variety of metadata standards, external data sources and repositories, as well as most popular media formats. CollectiveAccess supports sites such as the New Museum of Contemporary Art's Digital Archive (http://archive.newmuseum.org) and the Historical Society of Pennsylvania's PhilaPlace (http://www.philaplace.org)

- Collection Space: A web-based, open-source collections management project in use by a variety of institutions including the Walker Art Center and the Museum of the Moving Image, with development supported by several technology units, including the University of California, Berkeley and the University of Cambridge.
  http://www.collectionspace.org

- Omeka Project: A flexible, open source web-publishing platform for the display of library, museum, archives, and scholarly collections and exhibitions, this project of the Roy Rosenzweig Center for History and New Media is in use by the

European Science Foundation, the Chicago History Museum, and the National Museum of American History.
http://omeka.org/

- Other Smithsonian tech units: Within the Institution, there are several departments and individuals that have embraced the open source ethos and have experience developing within this framework. With internal team members from the OCIO already forging similar efforts such as Chaz Chumley's work with Drupal, Isabel Meyer's experience collaborating on the DAM code with Yale developers, and Ching-Hsien Wang's leveraging of Apache Solr for EDAN all provide perspective on how to get the most out of open source development at Smithsonian.

If electing to develop resources using open source licensing, SCEMS will need to take some initial steps in establishing the publishing and educational use of hundreds of thousands, and eventually millions of items, assets, and artifacts in the Smithsonian's vast collections.

Use Rights of Collections Data and Open Source Licensing

Many of the organizations mentioned above have had to address the key factors surrounding use rights in the development considerations of online collection display systems. There are specific system development provisions that stem from the complicated issues surrounding use rights of original collections and the digital assets and formats generated for the online environment as retained by the Smithsonian. Additionally, derivative works developed by educators and learners when given access to those materials will have to occur under the assurance that all resources, metadata, paradata, and derivative works are being developed exclusively for use within the education fair use policy guidelines as part of a specific terms of use.

In order to mitigate these issues, any solution will have to abide by the data origination and hosting protocols that require all item data, images, and affiliate metadata or records commensurate with the collections served by EDAN to be hosted and secured locally at the Smithsonian. The platform framework will have to be developed as a fully localized subsidiary of Smithsonian and not present a model in which a commercial entity or affiliate third-party system acquires any Smithsonian source data holdings in an offline format or structure. An open source framework provides both a clear approach to creating a services application and user experience layer that can be administered centrally and co-managed by various Smithsonian units atop a secure, localized data layer that is fully integrated, but not transferred. At the same time, licensing provisions still allow the Smithsonian to expose and share the application layer of the system separate from collections data and draw expanded development and feature enhancements from the larger museum community.

When approaching the licensing of the system, which license is selected should be based on how best to engage other developers. In this regard, licenses are categorized as permissive or copyleft, with permissive licenses allowing more liberal use of the code, including mixing with proprietary software, while copyleft code can only be mixed with other open code, often requiring the same licensing. Commercial software companies are more likely to contribute to a code base when their work can also be used in conjunction with proprietary products. While the copyleft licenses benefit the community by requiring future openness, fewer developers may be interested in contributing if their options are restricted. For this reason, we recommend using a widely accepted, permissive license such as Apache 2.0 or the new BSD license.

Technical Infrastructure

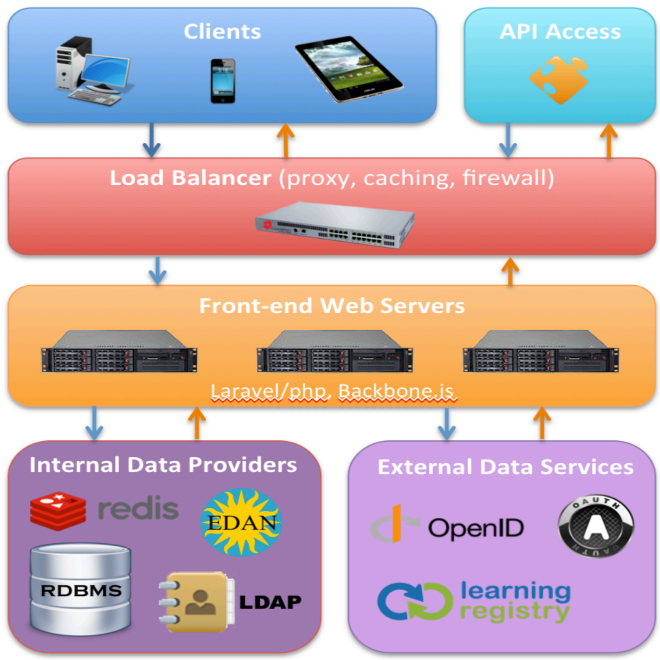
The technologies employed in the building of the prototype system were primarily chosen for their flexibility and strengths in rapid development. Since the majority should also be considered as pieces of the full system, here is a brief description of each package and what they provided in the development of the prototype.

- **Laravel:** An open source, php-based, web application framework, Laravel provided the back-end functionality to the entire prototype toolset. It is lightweight, requires no front-end changes or pre-built views, and there are many third-party bundles to add additional functionality. The only negative to using Laravel in the development of the prototype was the lack of built-in handling of JSON data, but this was easily remedied.
- **Redis:** Maximum flexibility in the prototype's data storage was achieved by using the Redis key:value store rather than a full relational database. Additionally, in many instances Redis provides much better performance for simple data access, handling 60,000 requests per second on basic hardware.
- **EDAN:** As mentioned previously, the EDAN metadata and image delivery services were used within the prototype to access the largest set of available data for Institution collections. Access was provided under contract with the Collection Systems Division of the Smithsonian's Office of the Chief Information Officer (OCIO). EDAN's API provides excellent services for search and retrieval of objects, with authenticated access granted through use of a project-specific secret key. As is the existing protocol with all EDAN delivered data, the prototype created specific pathways to the image files and metadata, however all data remained secure within Smithsonian's architecture. Provisions requiring that all resident data remain securely stored and hosted within Smithsonian's administrative services framework will require that any system developed for SCEMS will need to be a fully owned and integrated institutional asset and does not allow for third-party systems designed to externally host any Smithsonian images, resident records, metadata, or subsequent paradata.
- **Backbone.js:** A powerful javascript framework, Backbone.js was used in the prototype to handle the synchronization of objects between front-end browser display and back-end system. Limited documentation and a steep learning curve were the only drawbacks.
- **Bootstrap:** Created by Twitter developers specifically to look and behave great across desktop and mobile browsers, the Bootstrap design framework helped the prototype maintain consistency while also speeding development time.

System Architecture

In creating the architecture for the full SCEMS system, a clear separation of concerns will help ensure the long-term efficacy of the platform. The technologies used in the prototype illustrate this methodology, with each piece handling a separate layer of the data exchange, allowing any one piece to be replaced without necessitating a rebuild of the entire system. In consideration of the information technology services in place at Smithsonian Institution, it may be necessary for the SCEMS system to make use of more widely supported applications and frameworks. The back-end Laravel layer could be replaced with an application written in Coldfusion or ASP.Net, if that aligned with the goals of the organization. Additionally, as new technologies come along with performance increases or other feature benefits, modularized services are much easier to upgrade.

Proposed SCEMS System Diagram



Data Services Expansions

In building out the prototype system, there were instances where the services offered by EDAN were missing features that could be included and accentuated in ways that are very valuable in expanding the offerings in the SCEMS system and across other Smithsonian units. Keeping in mind that the services can only be as good as the data provided to them by each museum unit and in the interest of documenting for future inclusion in the EDAN services, here are some suggestions for changes and additions:

- Images delivered by IDS do not appear to have any cache-control set so most browsers will not cache the images.

- Images delivered by IDS are not often "web-ready," with sizes inordinately increased by the inclusion of color profiles and metadata, slowing performance. In some instances 100px images had 75k file sizes.

- Location information for objects is missing or inconsistent. Standardizing on a method for including machine-readable location information in object metadata would open up many possibilities for services visitors would find helpful, especially in consideration of Google's recent work creating indoor maps for many SI museums. Further differentiating between geolocation data included describing objects, and the current physical location of the object within the SI inventory would be helpful.

- The overwhelming majority of the object metadata does not include rights or usage information. Giving users clear information on their rights to use and remix media and data found through EDAN services expands use and hinders unauthorized re-publishing.

Hosting Considerations

Within the Smithsonian's Office of the Chief Information Officer (OCIO), there are divisions that support more established infrastructure primarily based on Microsoft technologies, as well as a team that develops primarily open source frameworks. The hosting and support of the SCEMS system will likely be decided based on the architecture decisions made at inception. The backend of the system could be built using any number of Microsoft-compliant technologies, such as ASP.net, SQL Server, or ColdFusion, but given the assortment of open source technologies that made the prototype successful, the recommendation issued here is to work with the OCIO division that supports open source projects to help determine how to best support SCEMS and expand pan-Institutional services. Although there are some SI systems that are hosted externally, in this model, it would lead to more long-term costs, and limit the ability to connect to services such as EDAN that are reserved for internal use and implementation exclusively. As stated in the Use Rights of Collections Data and Open Source Licensing section, developing a locally administered, unit-managed application layer atop the internal data services is a key facet to the inclusion of the Smithsonian's richest, most comprehensive collections and data services while assuring the most consistent, protected rights of use required with all Smithsonian holdings.

Conclusion

This technical plan represents a simple, yet direct approach to better serve educators and learners in both formal and informal pursuits of knowledge. It provides a vision for building out services and experiences to connect educators to an exploration and creation process while also serving as a destination for independent, digital learners. With solid research supporting the initial design and development of the prototype, and direct testing and piloting with a diversity of educators to further the functionality specifications, the SCEMS leadership team has identified key strategies and features to pursue.

As stated, an open source model would both engage a larger segment of developers and inspire a larger consortium of museums alike to consider the technical framework developed and released by the nation's leading institution. As such, the Smithsonian finds itself in a position to not merely embrace the mission to support the increase and diffusion of knowledge across a diverse learner audience, but to also do so as a technical leader within the museum and educational digital environment.