

D. Project Description

I. Introduction and Goals:

The ComPADRE digital library^{1,2} is an excellent candidate to be an NSDL Pathway project because of its support for physics and astronomy education, a broad STEM domain not currently supported by an NSDL pathway. Pathways serve a leadership and sustaining (*Stewardship*) role in the NSDL for a specific audience of the national STEM education digital library. In two and a half years of operation³, ComPADRE has developed the infrastructure, procedures, and experience necessary to fill this role. The ComPADRE Pathway will meet the needs of NSDL users for physics and astronomy educational resources.

The goals of the ComPADRE Pathway are to:

- Support our audience through content, communication, sharing, and professional development,
- Provide services to content developers by organizing, reviewing, disseminating, and sustaining resources,
- Collaborate with the NSDL, other libraries, and service providers as a representative of physics and astronomy education,
- Promote the usage of the NSDL and its projects by the physics and astronomy community.

To achieve these goals, the ComPADRE Pathway will:

- Select and organize quality learning resources from many sources,
- Create collections focused on specific topics or communities,
- Support faculty development in best practices for effective teaching,
- Engage students in the community of science and support their learning in the classroom, laboratory, and beyond,
- Archive resources that might otherwise be lost, and
- Collaborate in the efficient and effective growth of the NSDL.

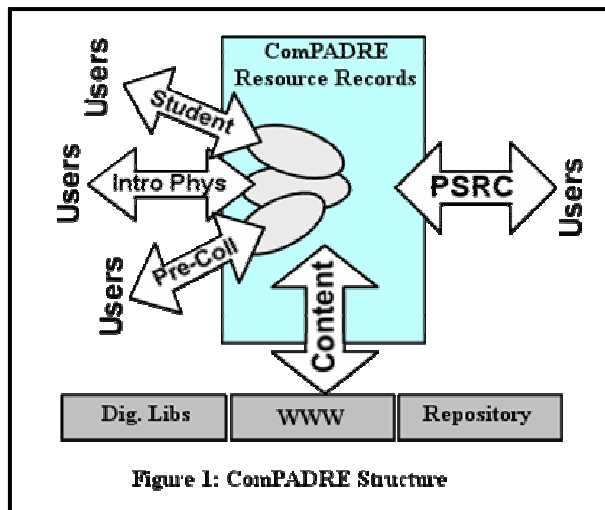
The ComPADRE Pathway is built on the expertise of the collaborating partners, the American Association of Physics Teachers⁴ (AAPT), the American Astronomical Society⁵ (AAS), the American Institute of Physics⁶/Society for Physics Students⁷ (AIP/SPS), and the American Physical Society⁸ (APS). The societies are dedicated to the health and growth of their disciplines and are recognized nationally and internationally for their leadership in science and education. They can bring together authors, publishers, faculty, and students to help build the library. ComPADRE is a new aspect of the societies' efforts to leverage the web for education and outreach. The professional societies are also crucial for sustaining the ComPADRE Pathway through the development of the sources and methods of funding now and into the future.

Target Audience

The ComPADRE Pathway audience consists of those engaged in physics and astronomy education, with collections being built for grade 9 through graduate school, informal education, and public outreach. This *disciplinary* focus, similar to the existing Math Gateway⁹, addresses a vital part of science and STEM education that is underrepresented in the NSDL. The ComPADRE Pathway has particular interest in four groups: new high school and college faculty

who need help to survive and thrive in their first years, authors of learning resources who wish to disseminate their work, students whose sole introduction to science is through an introductory physics or astronomy course, and students who will be the future leaders in science and science education. ComPADRE also provides content and services to experienced teachers and mentors to help support these groups.

The ComPADRE digital library is designed to handle many different types of users through the central database/specific collection structure shown in Figure 1. The database holds standards-compliant¹⁰ records linking to physics and astronomy learning objects and teaching resources that are either on the web or in the ComPADRE repository. ComPADRE will also work with the Core Integration team to select records from the NSDL and other libraries. The Physical Sciences Resource Center (PSRC) provides access to *all* records. However, to better meet the needs of its users, the library is organized into specific collections



covering subject areas (e.g., quantum physics, introductory astronomy) or specific groups (e.g., students). Each collection creates an organization and vocabulary, based on existing standards, that is natural for its community. The ComPADRE Pathway will use this architecture to grow and serve the entire physics and astronomy education community. More details, including discussions of communication, user, and library workflow tools, are provided in Section IV.

This proposal is structured as follows: Section II describes products and services to be provided by the ComPADRE Pathway, Section III lists collaborations between ComPADRE and other projects, Section IV outlines previous results, the infrastructure, and growth plans, Section V covers approaches to sustaining ComPADRE, Section VI details the project’s evaluation efforts, and Section VII provides a timeline for the project, including tasks and responsibilities.

II. The ComPADRE Pathway:

To achieve its goals, the ComPADRE Pathway will pursue three tasks:

- A. ComPADRE will expand its content and the number of user groups it serves through new and existing collections. The Pathway will create new collections for introductory undergraduate physics and upper division topics courses and expand current collections. Editors will work with experienced teachers and content creators to select high quality learning resources, provide information about their use, connect resources that supplement each other, and recommend resources for archiving. Resource records will be checked for correct links and web site changes to ensure continued quality.
- B. ComPADRE will foster professional development through e-mentoring, workshops, and conferences. Professional development is a core mission of the ComPADRE collaborating organizations¹¹. ComPADRE will assist their efforts through web and content services, at the same time increasing community awareness of ComPADRE and the NSDL.

- C. ComPADRE will collaborate with content developers and other digital libraries to bring the broadest range of quality resources and services to its users. ComPADRE will host select materials in an online repository.

A. Content and Collections

The ComPADRE Pathway will grow through the development of focused collections. New collections will be added to support the full range of users from early high school to early graduate school. The steps to build a new ComPADRE collection are:

1. The PIs and content experts (or ComPADRE partners for collections sponsored by external organizations) decide on the collection focus and select an Editor.
2. The Editor works with the ComPADRE staff to create a vocabulary, organization, and interface for the collection. This development is based on the expertise gained in creating the current ComPADRE infrastructure.
3. The Editor works with a volunteer editorial board to solicit, select, and review content for the collection. The PSRC is used to create library records while the collection is under development.
4. The collection undergoes user testing and is moved onto the production web server. Editors approve content and the collection goes public.
5. The collection grows as items are submitted by users and editors, resources are reviewed, and the community shares its experiences using the materials.

The ComPADRE content collections fall into three general areas.

Introductory Physics & Astronomy – ComPADRE supports the high-enrollment, high impact introductory courses through collections for High School Physics, Introductory Undergraduate Astronomy, and Introductory Undergraduate Physics. Faculty, and in particular new teachers, can use these collections to find resources and tips to improve their teaching. These collections provide resources that can improve the educational experience for students who may only have one or two classes in the physical sciences. All these collections feature high quality learning resources, research-based curricular materials, and materials that have been assessed for learning effectiveness. Collection editors and editorial boards select resources and curricula that support large classes and make novel and effective use of technology.

- **The Physics Front** – This existing collection for pre-college physics, developed with the AAPT (<http://www.thephysicsfront.org>), places a major emphasis on meeting the needs of new and cross-over high school physics teachers. The material includes classroom activities and labs, lesson plans, teaching tips, and professional development opportunities. This collection provides several unique services to its audience:

1. Resources are identified for four different course levels: conceptual physics, algebra-based physics, AP or calculus based physics, and K-8 physical sciences activities.
2. Search tools let users select resources by course, usage, and subject simultaneously,
3. Experienced teachers select the best and most easily adaptable materials for inexperienced physics teachers.
4. Select material is organized into topical pages that link lesson plans, activities, and labs into ready-to-use instructional units.

Although operational, this collection will need to expand greatly to cover the full range of high school physics. We are collaborating with the Physics Teachers Resource Agents (PTRA, a highly successful 20 year program for teacher development¹²) to host their content

and provide online mentoring. In the coming year, this collection will focus on Conceptual physics, a high-profile need.

- **Astronomycenter.org** - The "Astronomy 101" collection, under development with the AAS, (<http://www.astronomycenter.org>) is a collection for instructors and students of introductory college-level astronomy. Records for more than a thousand resources, including curricula, curricular support materials, simulations, images, and data are being processed into the database. As a special service, peer review will be used to highlight the highest quality resources, and items assessed for learning effectiveness receive special recognition. In coming years, the collection will expand to approximately three-thousand items but emphasis will shift to reviewing. At least 15% of this collection will be peer reviewed. Editors, authors, instructors, and reviewers will promote its use and share their teaching experiences.
- **Introductory Undergraduate Physics:** The ComPADRE Pathway will create a new collection for introductory undergraduate physics, developed with the AAPT and APS, using the experiences gained from the astronomy and high school collections. Three levels of introductory physics courses, conceptual, algebra-based, and calculus-based, will be supported. The initial core of this collection is calculus-based course materials and resources presented at the 2004 Conference on the Introductory Calculus-Based Physics Course¹³ and other recognized research-based curricula. This collection will also contain information about effective teaching and learning strategies,¹⁴ and results of physics education research.

Upper Division Courses – In a recent survey, AAPT members identified the need for resources for upper-division undergraduate courses as important for ComPADRE. Collections for these courses will support target audiences of undergraduate majors and their faculty. ComPADRE will simplify the sharing of resources developed by faculty world-wide through the development of these topical collections. Two existing collections are focused on upper division undergraduate and introductory graduate courses.

- **The Quantum Exchange** – The existing collection for teachers and students of quantum physics (<http://www.thequantumexchange.org>) provides resources to augment standard undergraduate and graduate quantum textbooks. It contains simulations and applications of quantum systems,¹⁵ tutorials,¹⁶ curricula,¹⁷ and relevant education research.¹⁸ The editors add context to resources through annotations and by relating the records of items that can be combined to create a richer learning experience. Under the ComPADRE Pathway, users will help expand the content of this collection. The ComPADRE staff will test and refine this collection to use it as the template for other physics and astronomy upper division courses.
- **The Nucleus** – The SPS-sponsored collection for physics and astronomy students (<http://www.the-nucleus.org>) is designed for and by majors as an information exchange, virtual student lounge, and showcase for web resources. This collection provides services including a listing of summer research positions from more than 120 institutions, discussion threads on a range of topics, and an annotated textbook listing. Few NSDL sites so directly involve undergraduate students and so directly focus on student needs. The ComPADRE Pathway will expand the support and documentation of undergraduate research. The collection will also provide students and parents information on physics and astronomy-specific scholarships and traditional and non-traditional career paths. Most importantly, students will actively participate through contests, polls, surveys, chats, and interviews with famous scientists.
- **New Topical Collections** - The ComPADRE Pathway will create collections to cover the standard physics and astronomy curricula. All of the collaborating societies will be involved

in the development of these collections. Currently planned are collections for classical mechanics, electricity and magnetism, thermodynamics, optics, observational methods in astronomy, stellar astrophysics, galactic astronomy, and extragalactic astronomy. Other new collections will focus on emerging fields in physics and astronomy where standard textbooks do not exist. Courses in these fields benefit greatly from the sharing of resources between instructors. These collections will include the topics of nanotechnology, biophysics, quantum information, cosmology, and astrobiology. Researchers in the fields will help select and organize resources. Two editors, one in physics and one in astronomy, will be selected to manage these upper division collections. They will select and work with assistant editors and editorial boards on these collections. Creation of these collections will start in January of 2006 with three to four collections added each year. Each collection will have a similar structure to help faculty move between different topics.

Informal Education – The ComPADRE Pathway will also have collections for a general audience and education outside of formal classrooms. These collections are:

- **PSRC** – The Physical Sciences Resource Center (PSRC) (<http://psrc.aapt.org>) accesses the full ComPADRE database. Users who want a broad view of all ComPADRE items can use this site. The initial records come from the previous PSRC web resource run by the AAPT,¹⁹ although more than three times the initial content has since been added. A just completed update has improved the content display and inter-collection linking. Future developments include an enhanced search and browse interface to handle the growing database.
- **Physics-to-Go** – The ComPADRE collection of resources for the general public, developed with the APS, (<http://www.physicstogo.org>) supports those seeking physics resources outside of formal educational settings. This collection includes links to: 1) Virtual hands-on experiences with physics and astronomy, many from the web sites of science and children’s museums.²⁰ The resources stimulate conceptual learning through play. 2) Accounts of recent advances in physics and astronomy research written for the general public. ComPADRE librarians have cataloged the award-winning APS website, Physics Central,²¹ for indexed searching. 3) Information about physics outreach programs²² that host live demonstrations or hands-on events. Featured resource reviews are regularly posted on the home page of this collection to provide more information about excellent materials. This collection will expand through collaboration with science museums.

B. Professional Development Services

The services provided by the ComPADRE Pathway to physics and astronomy faculty and students are as important as the content. ComPADRE will partner with professional development activities to provide content and communication tools for their users. Several collaborations are currently planned and more will be developed in the future.

- **Physics Teacher Education Coalition, PTEC-DL** – This project²³ of the physics professional societies and universities is working to improve physics and physical science teacher education through collaboration between physics and education departments. ComPADRE will help develop a collection, PTEC-DL, which will host quality content for both physics and teacher education. Student teachers, new teachers, and their mentors will make use of these resources as well as online forums for discussions and help for new teachers. PTEC-DL will fit squarely between the ComPADRE student and high school

collections. The coordinated collections will support new teachers as they move through the continuum from pre-service to in-service.

- **e-Mentoring** – ComPADRE will provide an online mentoring interface for new and cross-over high school teachers in conjunction with PTEC-DL and the PTRAs. On the simplest level, discussion forums will provide advice to new teachers from experienced mentors. On a more personal level, private messaging between mentor and mentee is available. Mentors may provide content through their personal folders, where they can collect and annotate resources for specific needs. ComPADRE will provide the technology that will enable the experts from PTEC and the PTRAs to support new teachers.

- **Workshops for New Faculty in Physics and Astronomy** – The physics and astronomy professional societies conduct annual workshops to help new faculty in higher education adjust to their new roles²⁴. This includes help with their teaching, for which most of them have had little or no experience. However, too often workshop materials are not available afterwards. ComPADRE will integrate into its collections an interface for these workshops, host materials presented on education, and provide a discussion forum for new faculty after they leave the workshop. ComPADRE will support other education workshops and conferences by providing pre- and post-event access to resources and communication tools. ComPADRE will publish workshop results and new content created by the participants. ComPADRE staff and editors will develop simple materials that explain the use of and participation in ComPADRE for these workshops.

- **Physics Education Research and PER-CENTRAL** – ComPADRE has developed an online annotated bibliography and repository of PER results with the NSDL-supported PER-CENTRAL project, (<http://www.compadre.org/per>). This collection supports researchers and science faculty interested in improving teaching and learning by providing information and links to research results, research-based curricular materials, and news and events in this dynamic field.²⁵ The research bibliography is undergoing final testing. In the next few years, this collection will host PER dissertations, provide information pages about PER research groups, develop an events calendar, and host a series of PER monographs online. These resources are fundamental to the improvement of the educational culture of physics and astronomy and the professional development of physics teachers and faculty.

- **Joint membership with societies** – ComPADRE will create shared logins for the membership of interested professional societies. A society can then use ComPADRE to provide special services to their members, and increase the awareness of the efforts of both the society and ComPADRE. This service will be tested with the AAPT membership. ComPADRE has also agreed to provide this access to the members of the National Society of Black Physicists²⁶. This will enable the NSBP to extend the content it provides to its members through ComPADRE resources. To further extend these connections, we will work with the NSDL Core Integration Team to provide joint logins with the NSDL, thus increasing the membership and scope of the NSDL.

C. Resource Sharing

The ComPADRE Pathway will coordinate educational resources from a wide range of content creators and aggregators. We will work with developers of physics and astronomy educational content to help raise the awareness of their resources. Examples include Open Source Physics²⁷, Paradigms in Physics²⁸, Physics Pathways²⁹, and Visual Quantum Mechanics³⁰. The ComPADRE Pathway will link to these projects and, where possible and appropriate, to the

individual resources. The ComPADRE record cloning tool simplifies the process of creating records for materials from a single source. We also will collaborate with the NSDL Core Integration group in testing the Infomine/iVia system³¹ to streamline this process.

Many content creators and online repositories include detailed resource records. In linking users to these materials, ComPADRE will take advantage of available information where it exists. Two approaches will be taken to content sharing, OAI harvesting and delivery and Federated Search. ComPADRE will work with content creators to simplify the attachment of resource information to educational software. Finally, the ComPADRE repository will be used to store and deliver resources that will not otherwise be available or are recognized as being of particular importance to the collections.

▪ **Harvest and Recommendation of NSDL Content** – ComPADRE records are collected by the NSDL Metadata Repository (MR) through OAI harvesting. Currently, the ComPADRE Pathway project will expand this relationship by selective harvesting of the MR by ComPADRE and recommendation of materials returned to the MR. The MR contains records for resources in physics and astronomy that are appropriate for very specific audiences and not, generally, for education. ComPADRE will collect and process those items most appropriate for physics and astronomy education. ComPADRE will harvest records from collections most relevant to education, identify and catalog high quality items, then have records re-harvested back to the MR. This will add ComPADRE-related information regarding topic, grade level, and resource type to the NSDL records.

As an example, ComPADRE and the ENC Middle School Portal will use this process to provide more information about physics and astronomy resources for grades 6 – 8. Although this material is secondary in the pre-college collection, ComPADRE will provide grade information for these materials and evaluate the accuracy of their content. The ENC will then harvest these records and provide information about pedagogical context. This effort uses the MR to combine the pedagogical and discipline expertise of the two projects. We will work with ENC and the NSDL Core Integration Team on the development of the metadata vocabularies and processes necessary to make this occur.

▪ **Federated Search** – ComPADRE is working with the MERLOT project to employ a Federated Search infrastructure³² for record sharing between collections. In this approach, the libraries are responsible for rich information on resources in their collections. Users search all participating libraries, or some subset, using an interface built on web services. Thus, users find the most complete and up-to-date records for resources. The Federated Search interface between ComPADRE and MERLOT is operating, and a similar interface with the Physlets Database³³ at Erskine College is in testing. The ComPADRE Pathway will work with other digital collections on a similar interface, including the Advanced Placement Digital Library and the Space Science Education Resource Directory.

▪ **Repository and Online Publishing** – The ComPADRE Pathway must provide reliable access to resources to fulfill its stewardship role. The ComPADRE staff has created a digital repository to hold materials and provide a web-publishing service from the library. The current repository content includes workshop manuals for high school physics, texts in development, physics simulations, and will soon include a monograph series on Physics Education Research results and curricula.

ComPADRE editors and librarians, with the agreement of content authors, decide what resources to include in the repository, who will have access, and who is responsible for maintaining the resources. Editors and Librarians recommend resources for the repository

and deaccession materials as needed. ComPADRE will use a three-tier policy for resource maintenance: resources that are mirrored on ComPADRE and are the responsibility of authors to maintain, resources hosted solely on ComPADRE and are the responsibility of authors to maintain, and vital hosted resources that are the responsibility of ComPADRE to maintain. The repository records all changes to materials and maintains old versions of resources so that a history of content development is available. In the future, ComPADRE staff will simplify the hosting of multiple-part resources in the repository, such as web pages with embedded applets. Unfortunately, ComPADRE can not host web sites with an active, database-driven structure without significant additional effort and expense.

III. Collaborations and Collaborators

Table 1 provides a list of the collaborators with which ComPADRE will be working on content development, professional development services, and library functions. A very brief description of the collaborations and responsibilities is included.

Project	Collaboration with ComPADRE
AIP Center for History of Physics	The History Center is a world leader in science history and is interested in the role of history in physics and astronomy curricula. The History Center will help editors select quality resources to enhance the collections. ComPADRE and the History Center will create examples to help faculty include historical information in their courses.
PTRA	The PTRA is a 20 year project developing mentors for high school physics teachers. ComPADRE will host PTRA resources. The projects will support e-mentoring using discussions, chat, and ComPADRE content.
PTEC	PTEC is a multi-institution effort to enhance teacher education in physics and physical sciences. PTEC will support the development of a digital library built on the ComPADRE infrastructure and participate in e-mentoring efforts.
Open Source Physics	OSP is an NSF-funded effort to develop advanced computer simulations for use in upper-division physics courses. ComPADRE and OSP will develop methods to reliably generate metadata for simulations and learning objects. ComPADRE will serve as a dissemination point for these resources using this metadata.
Physlet Database	The Physlet Database is an NSF funded repository for Physlet-based learning materials. ComPADRE aided in creating the vocabulary for this database. The projects will create a federated search interface to allow ComPADRE users to search the Physlet repository.
MERLOT	MERLOT is an international, interdisciplinary digital library of multimedia learning objects. MERLOT and ComPADRE will enhance the Federated Search interface to more closely align these libraries. Tools will be built to provide more immediate access to annotations and reviews by users of either library.
National Society of Black Physicists	The NSBP supports the development of African-American physicists. The NSBP and ComPADRE will create shared user accounts for transparent logins from the NSBP site to the digital library. ComPADRE will expand

	the educational content provided to NSBP members.
SERC	SERC provides support to improve the teaching skills of science faculty. SERC and ComPADRE will collaborate in applying the SERC pedagogic methods resource database to physics and astronomy, and hold a workshop to generate physics and astronomy examples. The results will be linked in both libraries.
Nuclear Pathways, ALSOS	Nuclear Pathways is a collaboration of digital libraries focused on nuclear science, energy, and policy, including the ALSOS NSDL Collection. These collections will be highlighted on ComPADRE and editors will connect records to references from the Nuclear Pathways project where appropriate.
Advanced Placement Digital Library	APDL is an extensive collection of annotated teaching resources for high school and advanced placement science classes. APDL and ComPADRE will develop tools to share resources between collections.
ENC	ENC is responsible for the middle school science portal for the NSDL. The ENC and ComPADRE will collaborate on identifying quality middle school physical science resources, ComPADRE providing the content expertise and ENC providing pedagogy and educational context information.
SSERD	The SSERD is a collection of primarily NASA funded educational materials in astronomy for K-12. ComPADRE will collaborate with SSERD to provide federated searches from SSERD to and from Astronomy Center and The Physics Front.
Physics Pathway (Kansas State University)	The Physics Pathway is a project delivering video resources for physics teachers and students with full text searching of the content. Physics Pathway will be a featured partner on ComPADRE. Methods for sharing of resource searches employed.
Workshops for New Faculty in Physics and Astronomy	The AAS, APS, and AAPT support teaching workshops at their meetings, as well as at the annual New Faculty Workshop. ComPADRE will integrate NFW workshop materials into collections and provide a “chat room” for workshop participants to share their experiences
Chairs and Directors Conference	Physics and Astronomy department chairs meet bi-annually at the American Center for Physics. ComPADRE will provide a web interface for the collection of materials shared at these meetings
Physics Education Research	Members of the Physics Education Research community are collaborating with ComPADRE to make available results from PER. The PER-CENTRAL site will be a comprehensive collection of research results, dissertations, and research-based curricula. Dissertations and monographs will be hosted on ComPADRE.
Nanotechnology	ComPADRE will collaborate with researchers in nano-science and technology and nanotechnology education at Kansas State University, the University of Arkansas and the University of Oklahoma to create a resource collection in this growing field.
PIRA	The Physics Instructional Resource Association (PIRA) consists of experts in physics lecture demonstrations and laboratories. PIRA members host databases of educational demonstrations. PIRA and

	ComPADRE will work on the sharing of these resources.
European Physical Society	ComPADRE and MERLOT are working with a group from the EPS on identification of high quality multimedia educational materials in physics. Topics studied include classical mechanics, quantum mechanics, thermodynamics, and optics.

IV. Previous Results, Existing Infrastructure, and New Developments

In its more than two years of operation, ComPADRE has developed prototype collections, services, and infrastructure to support physics and astronomy education. Highlights of the infrastructure are outlined below, along with ways in which they will be expanded in the ComPADRE Pathway.

A. Highlights of ComPADRE Developments

- Teams are operating in various roles to create and support collections.
- The general database interface, the PSRC, and the five prototype community collections are operational and growing. A sixth collection for Physics Education Research has just been launched and a collection to support teacher education is starting development.
- Over 3,200 members have registered with ComPADRE since the fall of 2003, even though access to resources does not require registration.
- ComPADRE averages 30,000 visits each month with nearly 90,000 total page views.
- More than 2,000 items have been or are being processed through the editorial workflow.
- User tools, including content recommendation, personal filing cabinets, discussion forums, and online chat are being developed and improved.
- Content display and collection organization have been re-designed based on user feedback.
- Outreach is underway highlighting ComPADRE and the NSDL.
- Collaborations with other digital libraries and educational resource projects in physics and astronomy are underway.

B. Tools and Technology for ComPADRE

The ComPADRE technical team has created a flexible infrastructure designed for multiple community collections. ComPADRE runs on a Cold Fusion application server and an SQL database as part of the AAPT technical infrastructure for compatibility with web standards. Important goals for development are providing effective user and editorial tools and quick and simple collection creation. These are required for fulfilling the stewardship duties of a Pathway.

The ComPADRE technical tools can be divided into four main groups:

User Tools – Search and Advanced Search allow for keyword searches; Browse allows selection of multiple metadata areas; Personal Filing Cabinets provide a place to store, annotate, and share records of interest; Personal Preferences and Profiles individualize the user’s view; and a Bibliography Generation Service generates human-usable citations from metadata standards. The ComPADRE Pathway will include full text search of hosted materials and more accurate search and browse as the library expands.

Communication Tools – Discussion boards are available for threaded, asynchronous communication; Chat rooms are used for multi-user synchronous communication; Individual Messaging allows private communication, particularly important for mentoring; and Item Comments can be created and added to any item record. The ComPADRE Pathway will include quantitative user reviews of items as an option to rank resources.

Editorial Tools – New Item Recommendation is available to registered users; a Content Filter allows new items to be checked, avoiding duplications and unsuitable content; the Librarian Interface streamlines the assignment and approval of full metadata creation; a Tagging Interface simplifies the accurate formation of records; the Editor Interface provides tools to specialize records, add relations and annotations, and approve collection items; a Review Tool manages the review process and contains a flexible rubric creation system. Table 2 shows the workflow process. The ComPADRE Pathway will provide a more powerful Flash interface to these tools.

Library Tools – Library standards are used, including IMS-IEEE LOM, qualified Dublin Core, metadata vocabularies such as GEM, and OAI; Federated Search is available for inter-library sharing; Record Cloning simplifies the cataloging of multiple items from one source; Link Checking automates the search for broken links and changed

web sites; an Item Level Group Rights interface supports the assignment of access of permissions to individual on an item and service level; and the Repository provides reliable delivery of materials. The ComPADRE Pathway will expand the repository to handle a broader range of materials, will provide joint logins with associations and partner, and will provide a cross-walk to the Physics and Astronomy Classification Scheme used in research journals.

The flexibility and global nature of these tools mean about 70% of the technology for new collections exists, the remainder being specific customization. The upper-division course collections will be very uniform, simplifying their creation. More technical details are online.³⁴

C. Participant Roles

The people involved with the ComPADRE Pathway are essential for its success:

Leadership – The ComPADRE project is led by the principal investigator, Mason, and the co-PIs, Deustua, Hehn, Hein, and Hodapp who are leaders of educational and outreach efforts of the participating societies. Mason is responsible for project management and operations. He has experience as the developer of ComPADRE, as editor of MERLOT Physics, and in training and use of educational technology. The co-PIs are responsible for strategic planning, recruitment and evaluation of the ComPADRE editors, and connections to the professional organizations. They provide a broad view of professional societies to the NSDL. The PI and ComPADRE staff are also involved in NSDL standing committees and workshops.

Editors – ComPADRE editors are responsible for the organization and management of content in the community collections. They bring experience in content and teaching and community ties to the Pathway. They work with an editorial board on editorial decisions and community building, with authors on content, with the technical team on design, and with the library team on information organization and vocabularies. The PIs and community leaders will select editors for the new broad collections (introductory physics and PTEC) and two editors (on

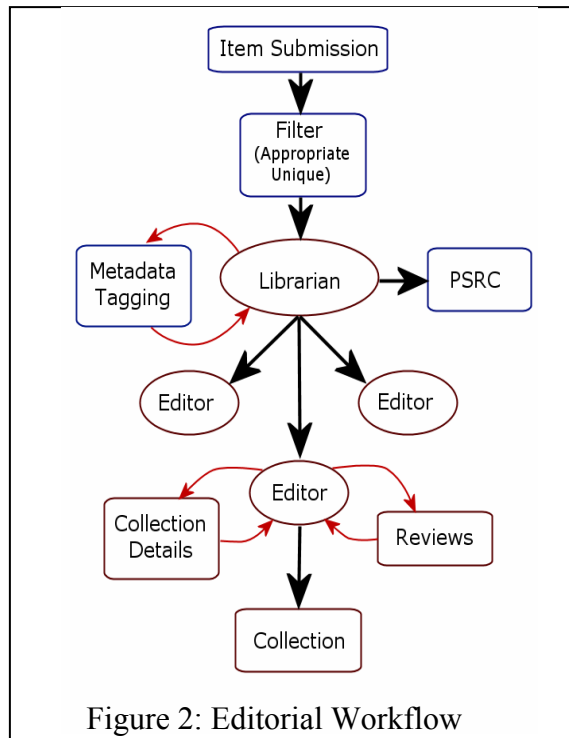


Figure 2: Editorial Workflow

each in physics and astronomy) to manage the upper-division courses. These editors help select sub-discipline editors and editorial boards. Editors are supported through the ComPADRE Pathway grant.

Advisory Groups – Each ComPADRE collection has an editorial board of community representatives working with the editor on content and usability issues. The editorial board members are volunteers, although they can receive support for travel to meetings or events related to ComPADRE. Current editorial boards have helped with development of communication tools, content review, and content for new teachers. The ComPADRE Pathway will have an advisory committee to match the project’s efforts with the needs of physics and astronomy education as a whole. These groups also provide informal evaluation of collections as they are developed.

Technical Staff – The ComPADRE Pathway technical staff has experience in web design and programming, education, and physics. They develop and support all technical aspects of the project, including database structure, web services, web site design, and tools. They are also responsible for maintenance and upgrades of the technology. The technical staff will consist of a web interface designer and technical lead, a database programmer, a web programmer, and a project coordinator to manage collaborations and address the needs of editors.

Library Services Staff – Library services are provided by Brown, Mason and co-workers at the University of Oklahoma. These services include data entry and evaluation, quality control, and maintenance of the records. Full record creation is performed by physics and astronomy students trained to meet ComPADRE standards. All records are reviewed by librarians before being approved for collection editors. Brown and graduate students from the School of Library Science will evaluate the usability, information structure, and impact of the collections. They will use evaluation results to help improve the ComPADRE infrastructure. An external evaluator will provide independent feedback on the evaluation of the ComPADRE pathway.

D. Dissemination

The ComPADRE Pathway outreach efforts to the physics and astronomy communities are a crucial aspect of its stewardship. Editors, PIs, and technical staff will be involved in these efforts. We will use the traditional communication channels of the professional societies, including newsletters, journals, websites, and conferences. ComPADRE editors and staff will solicit users to test the collections and determine user needs. Editors and authors will create instructions for the use of resources, available both online and in print. ComPADRE editors and staff will develop instructions for participation in collections and use of ComPADRE for more effective teaching and learning. These materials will be available for both ComPADRE-sponsored workshops and faculty development efforts of ComPADRE collaborators. Where appropriate, results of workshops will be added back into the collections.

E. Operational Agreements

The collaboration between organizations participating in the Pathway will be managed through collaborative agreements as in the current ComPADRE operation. Memoranda of Understanding (MoU) between the AAPT and the AAS, AIP, and APS specify the goals, responsibilities, and funding of individual collections. Similarly, collaborations with other organizations involved in new ComPADRE collections will be managed through MoU with clear responsibilities, goals, costs, and timelines. These groups will partner with one of the four

primary societies in managing a collection. The efforts and costs of promoting collections and integrating organizational resources will be shared between ComPADRE and the participants.

V. Sustaining the ComPADRE Pathway

Sustaining a digital library requires the development of a symbiotic relationship between the library and its community, as well as finding funds to support its operations. The organizations collaborating in the ComPADRE Pathway promote this relationship by integrating the library into educational efforts in these broad STEM disciplines. The ComPADRE PI has been named the AAPT Online Publication Editor and a member of the AAPT Publications Committee. The ComPADRE Astronomy 101 collection is a key addition to the educational services of the AAS that would have been impossible without this collaboration. Susana Deustua is a strong advocate for the use of ComPADRE for fulfilling the society's needs. The SPS is integrating the ComPADRE student collection into their outreach efforts and the library will play an important role in an AIP effort to explore and enhance the undergraduate research experience in physics, astronomy, and other science disciplines. ComPADRE is providing another way for users to access APS outreach materials and is working with the APS Forum on Education and Committee on Education. ComPADRE will also provide the services and infrastructure for the PTEC effort to enhance physical science teacher education.

As the ComPADRE goals are achieved, the professional societies will play a key role in determining which aspects of the project that must be sustained and determining the optimal ways of supporting the ComPADRE Pathway. Several options are under consideration including fee-for-service, subscriptions, and sponsorships. Charges will apply for ComPADRE development services for external projects and workshops. These will include development and sustaining costs and depend on the extent to which new development is necessary. Although we intend to maintain a significant portion of ComPADRE free and open to the public, restricting certain resources or services to paying members will be explored. These may include repository content and specific discussion forums. The ComPADRE group rights structure provides item-level user permissions to the content in the database. Any for-fee structure will be established on the advice of the professional societies, perhaps as a membership benefit or as a subscription service. The societies bring over 60,000 members as potential participants in the Pathway. ComPADRE will also work with the professional societies to establish commercial sponsorships to help maintain the collections. The organizations have established relationships with companies that have expressed interest web services such as the ComPADRE Pathway. We will also explore the possibility of self-supporting workshops based on ComPADRE resources and best practices identified in the project.

VI. Evaluation and Community Feedback

The ComPADRE Pathway will evaluate³⁵ the products and gather feedback from the community to fulfill the stewardship role of supporting user needs. The ComPADRE evaluation efforts explore issues of web site usability, information seeking by users, and collection impact.³⁶ Three different evaluation instruments are being used or planned: task-based usability interviews, online surveys and web metrics, and user activity logs. Each instrument addresses all three issues, each with a different focus and strengths.

The formative evaluation of ComPADRE through task-based interviews and surveys addresses issues of usability, navigation, and the information needs of users. The library services team performs task-based usability evaluations³⁷ of each collection. Both new users and those

experienced with the site participate in usability interviews where their progress completing specific tasks is monitored. This testing takes place at OU and society conferences. This testing has already led to several changes in organization of links, content details, and instructions for users. Online surveys are used to gather broader user feedback on content and information architecture.³⁸ These surveys solicit simple demographic and usage information, such as user role, purposes for using the collection, successes or failures during use, and content breadth, depth, and descriptions. This data is combined with web log analysis to study use and potential problems. Brown and library science graduate students design and analyze the results of these surveys. In the future, the surveys will be refined to address specific issues, and the survey tool will be updated to provide greater data-mining capabilities.

User activity logs will explore the use and impact on teaching of the ComPADRE Pathway. In this new effort, volunteers will maintain records of their visits, their goals, their search processes, and their success or failure on ComPADRE. They will record how they use of the materials found and the impact on their classes. The evaluation team will interview the volunteers about their experiences to gather additional perception and impact data. These logs will provide longitudinal data as participation is tracked over two to three years. Together with surveys, this work will evaluate the success of the ComPADRE collections in meeting audience needs.

Table 2 shows relations between instruments and issues. In all cases, demographic information is collected (e.g., position and comfort/experience with the Web for teaching and learning). Flora McMartin, our external evaluator, will review and critique these efforts' results.

Issues Instruments	Site Usability: Web site design Navigation	Information-seeking: Information discovery Information description	User Impact: User goals Material use
task-based interviews (Underway and Ongoing)	<ul style="list-style-type: none"> Find material useful for your class. Create an account, and login. Submit materials and use Filing Cabinet 	<ul style="list-style-type: none"> Is the organization confusing? Useful? How useful are the descriptions and other information? 	<ul style="list-style-type: none"> What features are useful? What features are needed? Will you use the collection again?
online survey (piloted)	<ul style="list-style-type: none"> Which factors did you find helpful: content, resource types, grade levels, descriptions and other information, search/browse tools, layout and navigation? Which caused difficulties? 		<ul style="list-style-type: none"> How often do you use ComPADRE? Are goals met? Do you contribute?
activity logs and process-based interviews (to be done)	<ul style="list-style-type: none"> Describe your search path. Include search terms, buttons, and links. How long did this search take? What design features were helpful or frustrating? Did you find what you were looking for? Did you find something else? 		<ul style="list-style-type: none"> Did you use the content found? Describe its use in the classroom.

Table 2: ComPADRE Evaluation Activities

VII. Tasks and Timeline

Table 3 outlines the major tasks and timeline for the Pathway, and the responsible participants. This gives an overview of the project. (Editors – Ed., Librarians – Lib, Technical Staff – T.S., Advisory Group – Adv.)

10/2005 – 3/2006		
Existing Collections	Ed., Lib.	Enhance summer research database service (Student Collection)
New Collections	Co-PIs, Adv.	Select Intro Physics and Upper Division Editors. Develop & deliver PTEC collection.
Technical	T.S., MERLOT	Enhance Federated Search interface. Joint logins for society membership.
Collaborations	T. S., NSDL	Interface to harvest NSDL physics records
Outreach	Co-PIs, Ed.	Round table discussions at national meetings
4/2006 – 9/2006		
Existing Collections	Ed., Co-PIs	e-Mentoring (High School, PTEC, PTR A)
New Collections	Ed., T.S., Lib.	Develop Intro Physics Collection. Create uniform template for Upper Division. Create
Technical	T.S., Ed.	Calendaring tool, full text repository search
Collaborations	SERC, Ed., Lib.	SERC workshop. PTR A mentoring training
Outreach	Ed., Lib.	PTR A mentoring training
10/2006 – 3/2007		
Existing Collections	Ed.	Reach desired level of reviews in Astronomy Collection
New Collections	Ed., T.S.	Intro Physics beta testing and availability. 2 new Upper Division collections.
Technical	T.S., Lib.	Database streamlining. Enhanced search & browse interface.
Collaborations	T.S., MERLOT	Fed Search interface with APDL and SSERD
Outreach	Co-PIs, T.S.	New Faculty workshop online
3/2007 – 9/2007		
Existing Collections	Ed.	New teacher support through Pre-College collection. Student research interface.
New Collections	Ed.	Intro Physics completion. 2 new Upper Division collections.
Technical	T.S.	Enhanced repository for
10/2007 – 9/2009		
Existing Collections	Ed., Lib.	Content development and collaboration with content developers.
New Collections	Ed., T.S.	4 – 6 new upper division collections per year
Technical	T.S.	Evaluation-based enhancements of collections
Outreach	Co-PIs, Ed.	Conference proceedings and workshops on ComPADRE and NSDL