

Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education

Preliminary Final Report (April 2009; Grant ends September 2009)

Project Description

Educating the K-Gray engineering community in today's digital world requires straightforward yet flexible access to high-quality educational resources. The goal of this project is to create and steward the *K-Gray Engineering Pathway (EP)*, a premier portal to comprehensive engineering and computing education resources within the greater National Science Digital Library (NSDL), by combining *NEEDS' (National Engineering Education Digital-library System's)* expertise in higher education and lifelong learning with *TE's (TeachEngineering's)* expertise and experience in K-12 engineering education.

The *K-Gray Engineering Pathway* is the engineering "wing" of the NSDL, serving resource providers and users from a broad spectrum of constituencies: elementary, middle and high schools; two/four-year undergraduate programs; graduate and professional schools; and lifelong learners. Key stewardship goals of the *K-Gray Engineering Pathway* are to merge *NEEDS* and *TE* into a unified *K-Gray Engineering Pathway*, significantly and sustainably grow the *K-Gray Engineering Pathway*, align *EP's* curricula with appropriate undergraduate or K-12 educational standards, increase the number of *EP* content providers and users, develop and implement interoperable quality control and review protocols for all *EP* content, and create a nonprofit strategy and partnership for sustaining the *K-Gray Engineering Pathway*.

Project Goals, Findings for Grant (October 2005-September 2009)

The *Engineering Pathway* site was launched in Year 2. One major finding was the difficulty in merging two established educational digital libraries, each with different target audiences. We worked together to find ways that the visual images, navigation and features would address both K-12 audiences as well as those in higher education. We adjusted our timeline to provide more time to develop the integrated website.

A major redesign of the *EP* website was initiated in Year 3, based on the Year 2 evaluation feedback and preliminary results from the National Academy of Engineering (NAE) study titled *Changing the Conversation: Messages for Improving Public Understanding of Engineering*. As a member of NAE's Committee on Public Understanding of Engineering Messages and co-author of the report, Jackie Sullivan worked with the *EP* team to develop a redesigned website to more effectively communicate the role, importance, and career potential of engineering to a variety of audiences, including engineering and computing faculty and students, as well as school children and their parents, teachers, and counselors. It was originally hoped that the thumbnail images used in the *EP* catalog records could be used as part of this redesign effort. One major finding was that most of the engineering images used in *EP*, and the related resources, were of technology and not people, whereas the NAE study emphasized the importance of displaying diverse people engaged in exciting engineering activities. To increase the pool of engaging images and related resources, a six-month competition for compelling messages and images was launched and advertised at professional society meetings with engineering education audiences. Voting was conducted on the *EP* blog launched in Year 3 as well. The final photographic images were selected to capture the excitement and diversity of engineering and computing education and practice. Taglines were selected for the different audiences within *EP*. The homepage and

general tagline is: *Turn Ideas into Reality – Learn, Connect and Create*. The K-12 pages communicate aspirations for the future: *Shape the Future – Dream. Design. Do*. The Broadening Participation tagline motivates professional development and personal goals: *Make a World of Difference – Dream Big. Love What You Do*.



Fig. 1. Screen image of the EP redesign.

Another major finding from our earlier evaluation studies was that users had trouble finding the resources they wanted based on a simple keyword search and very few users took advantage of the Advanced Search features. We subsequently redesigned the website to expand the simple search on every page to include grade/audience level. The search on all main pages also includes learning resource type. We tailored many of our features for K-12 versus higher education users. We also added disciplinary and interdisciplinary pages to tailor the search and resources for different communities.

These evaluation studies show that our strength is a consistent interface with strong usability features. We are valued for our quality content that is well defined in terms of engineering and computing education. Our users value “precision” in a search over “recall.” This justifies our emphasis on evaluation criteria and our review processes. We worked hard to

develop evaluation criteria, prune current resources and add to our quality content. These in-depth evaluations were used to improve the overall Engineering Pathway site, as well as our Higher Education, Diversity and K-12 resources. The results were also beneficial in upgrading the Teach Engineering K-12 digital library.

EP substantially grew its user base during the grant period in both content and functionality. We have over 6,000 registered users. We had over 1.4 million hits in March 2009 and are leveling off to approximately 300,000 page views per month (Fig. 7). Our disciplinary pages are typically in the top 10 for all major ABET disciplines under both Google and Yahoo searches. As detailed in this report, the number of catalog records increased by over five-fold from 2,408 engineering-relevant resources in October 2009 to 14,112 as of March 31, 2009 (Table 1). As of March 31, 2009, the cumulative number of views and downloads for our catalog records were 2,231,931 and 236,405, respectively (Table 2, Fig. 8, Fig. 9). A “view” is defined as viewing the catalog record; a “download” is defined as linking to the actual resource or downloading the document, file or executable. In recent years, approximately 10% of the views lead to a download. The average number of views and downloads has leveled off to over 1 million views and approximately 90,000-100,000 downloads. In addition, the number of comments and reviews has increased dramatically during the award period, starting with approximately 1,000 on Oct. 1 2005 reaching 10,000 on March 31, 2009 and projected to reach 12,000 at the end of the year (Fig. 3).

Our users studies of collection owners and faculty revealed that understanding the relationship between resources would be a value-added service of the aggregate collection. For example, they wanted to relate different pieces of a resource to one another or relate an interactive resource to an educational research paper that assessed the benefits of using the resource. The relations we support are: ‘part of’, ‘references’, ‘based on’, ‘formats’ and ‘requires’, with most using the first two. We currently have 3,527 relations between resources as of March 31, 2009.

The K-12-Higher Education integration and the redesign took more time than expected and some of the tasks involving our public relations efforts and sustainability goals were delayed. Other tasks involving site functions were accomplished earlier, however, and we believe we have strengthened our position for future years. We now have more in-depth community resources and services that are designed to appeal to different professional societies, publishers, industry and other funding sources.

Our original business strategy focused on sponsorship from professional society sponsorship. Our marketing research revealed that the services that would provide them the most value included customization for the discipline and remote search from their own website. Developing these new services caused a delay in our timeline and we are only now able to aggressively go after professional society sponsorship. One advantage is that these services appear to be useful in funding for new collections and industry sponsorship. The computing and engineering community sites greatly increased our community building efforts and user traffic. Negotiations are under way for industry sponsorship of some of our community sites. The American Society of Mechanical Engineers (ASME) has agreed to sponsor the Mechanical Engineering community site and the American Society of Computing Machinery has sponsored the ACM-Women collection.

To date, our most promising source of funding is from our collection services. We charge

\$20K for the basic collection set-up and \$5K for each year afterwards. The current collections in this category are: *ACM-Women and Engineers and Business for Sustainability (EBS)*. For advanced set-up, we charge \$50K and \$10K per year afterwards. Collections hosted in this category include: *Broadening Participation in Computing (BPC)*, *National Center for Information Technology in the Interest of Society (NCWIT)*, *Peer Reviewed Research Offering Validation of Effective and Innovative Teaching (PR2OVE-IT)*, and *Community Assessment of Renewable Energy and Sustainability (CARES)*. Both annual charges are limited to periods where the collection owner has a revenue stream. For projects funded by government or foundation grants, this typically means until the grant ends. As a service we continue to host the collection, but cannot provide any additional services or personalization.

Another promising revenue stream is associated with our Annotated Textbooks project. John Wiley & Sons worked with us on a prototype and are considering funding at a larger level. Currently, there are two annotated textbook demos at: <http://www.k-grayengineeringeducation.com/textbooks/>.

Details are summarized below by major project goals for each of our major goals.

Project Goals, Activities

Goal 1: Merge NEEDS and TeachEngineering to form the unified K-Gray Engineering Pathway

Merged advanced services; performed user testing to refine services to all engineering-related NSDL grantees.

- ◆ Registered the [engineeringpathway.org](http://www.engineeringpathway.org) (and .net and .com) domains and developed an *EP* prototype portal site at: <http://www.engineeringpathway.org>
- ◆ Registered www.k-grayengineeringeducation.com (and .net and .org) for the “Today in History” blog.
- ◆ Developed a survey to solicit feedback on digital library services on the *EP* prototype portal. Survey results guided the design of services of the first launch of the *K-Gray Engineering Pathway*.
- ◆ Launched *Engineering Pathway* website for the November 2006 NSDL meeting. Completed search functionality: simple search, advanced search (general, K-12, higher education), browse, login, registration, and workspace functionality. Modified *EP* metadata schema to accommodate TE/NEEDS merge. For example, agreed to permit only two categories for what *EP* resources cost (either “free” or “not free”) and added an additional field for K-12 standards.
- ◆ Added K-Gray “broadening participation” pages for engineering recruitment, diversity and professional societies.
- ◆ Added new functionality to the cataloging pages throughout the grant, based on user studies, needs of new collections, NSDL Pathways metadata recommendations and evolving multimedia technologies. New features include: pedagogical interventions, special topics for minorities and disabilities, media type and specific technical details as an option, such as download size, operating system, plug-ins, etc. We also added the ability for a resource to have secondary ownership in multiple collections. Only the primary owner can edit the basic fields. This reduced the number of duplicative records and consolidated comments and links.
- ◆ Added the ability to add relations to resources. Relations supported are: “parts,” “formats,”

“references,” “based on” and “required.” 3,527 total resources are now related (~25% of all resources) as of March 31, 2009.

- ◆ Added statistics pages for rankings on learning resource downloads, views and comments. Users can view these access statistics by authors and grades from the usage statistics page at <http://www.engineeringpathway.com/ep/util/Statistics/>.
- ◆ Launched monthly themes within the “In the Spotlight” section of the *EP* home page. The monthly themes highlight topical *EP* resources. For example, July's theme was on “entrepreneurship, innovation and creativity” in honor of the first U.S. patent filed in July 1790. Past monthly features can be found at our archive at: <http://www.engineeringpathway.com/ep/about/archives.jhtml>
- ◆ Implemented a framed-in search page on the *EP* prototype portal that allows users to search over metadata from multiple engineering collections that *EP* harvested using the *NEEDS* metadata subset of IEEE LOM.
- ◆ Implemented a news page and an events page to announce news, events and conferences in the engineering education community. Developed a web submission form to solicit engineering related events from our users. New submissions undergo a review process before being officially posted.
- ◆ Based on user studies, we completed a substantial redesign of *EP* in Year 3. The new “swoop” logo represents the many paths of engineering in a colorful, dynamic, flowing pattern. The photographic images were selected through a six-month competition to capture the excitement and diversity of engineering and computing education and practice. Taglines were selected for the different audiences within *EP*. The homepage and general tagline is: *Turn Ideas into Reality – Learn, Connect and Create*. The K-12 pages communicate aspirations for the future: *Shape the Future – Dream. Design. Do*. The Broadening Participation tagline motivates professional development and personal goals: *Make a World of Difference – Dream Big. Love What You Do*.
- ◆ Improved usability features were added to *EP* based on evaluation studies. For example, all main pages highlight a simple search that includes keyword, grade/audience and learning resource type. All other pages have grade/audience and keywords in the upper banner. A *First Time Users* page with FAQs was added.
- ◆ Translated all new functions developed in Years 1-3 into new redesign, including search, browse, monthly themes, statistics, search, login and interoperability with NSDL. *EP* continues to be the only Pathway and NSDL grantee to have a working single sign-in with the NSDL.
- ◆ Highlighted resources were added under the left navigation menu: Editor's Choice, 100 Most Popular, Premier Award Winners, 100 Most Commented, Recent Submissions and a general search page on user statistics.
- ◆ Created and released a revised catalog website for *Engineering Pathway* K-12 resources. We limited cataloging to a subset of the learning resource type (LRT) options available to higher education catalogers, chosen because they were more useful to K-12 educators. The resulting search page also reduced the number of optional categories available for new catalog records in order to simplify the cataloging process for users. Users are also provided with an online LRT glossary and review requirements document.
- ◆ Created and released a revised catalog website for partner collections. Some are private;

others can be cataloged by any registered user (e.g., *EP*, *International Journal of Engineering Education* and *Advances in Engineering Education*).

- ◆ Updated K-12 *EP* web pages to be more current and more robust: *K-12 Resources*, *Research Findings*, *Professional Development*, *Publish Your Curriculum*, and *Broadening Participation*. To the *Curricular Resources* page added information about JETS and their monthly newsletter, under “Our Favorite K-12 Engineering Collections.”
- ◆ Updated higher education *EP* web pages to include more recent events, Gordon Prize winners, disciplinary communities, engineering students and engineering competitions.
- ◆ Added two new dynamic *EP* K-12 features, a “Most Popular” and “What’s New” listing of catalogued *EP* K-12 engineering resources.
- ◆ Implemented Google and Yahoo hit-rate improvement strategies, resulting in *TE* appearing higher in the search results rankings for a variety of pertinent search strings. All of the major *EP* educational disciplinary pages show in a top 10 hit on both search engines.
- ◆ Provided the capability to search *EP* whenever a *TE* search is requested.
- ◆ *TE/EP* upgraded IEEE_LOM metadata format to include a representative image for each resource.

Goal 1: K-12 Activities

- ◆ Harvest *TE* resources regularly into *EP*; ingest *TE* K-12 standard information, when available. Show these standards on the K-12 search results page, as well as in catalog record.
- ◆ Created new K-12 engineering pages and content for the merged *Engineering Pathway* portal. Added pages for finding curriculum, research findings, educational standards, publishing curriculum and professional development, incorporating results of the NAE PUE study, especially to improve website imagery.
- ◆ Agreed upon 13 *EP* K-12 learning resource types — a subset of the types available in *EP* as a whole. The learning resource types were limited to those that provide useful resources for K-12 teachers. In addition, some of the learning resource types were grouped into categories on the K-12 search page to limit the number of choices on the K-12 search page to eight learning resource types, further simplifying the search process for teachers.
- ◆ Designed a K-12 catalog record form.
- ◆ Cleaned up the 1,000+ K-12 resources from *NEEDS*, individually evaluating them for quality, engineering connections and grade band appropriateness. Chose to retain only those resources with a clear engineering connection, reducing the resources teachers must sort through to find appropriate K-12 engineering content.
- ◆ Reworked the learning resource type reporting by *TeachEngineering*’s OAI metadata server to comply with the taxonomy developed by *TE* and *EP* staff. *TeachEngineering* now supports two types of metadata: *NSDL_DC* and *EP_LOM*.
- ◆ *TeachEngineering* searches now also hit *NSDL*, *NEEDS* and *EP*, and report the results as “search results from partner collections.”

Goal 1: Higher Education Activities

- ◆ Created new higher education engineering pages and content for the merged *Engineering Pathway* portal, incorporating pages for course preparation, research and scholarship, accreditation & curricula, research & scholarship and engineering students.

- ◆ Developed 30 Disciplinary Community pages for all ABET accredited disciplines in engineering and computing.
- ◆ Developed Interdisciplinary Community pages based on user feedback. To date, our 17 interdisciplinary communities are: Community-based Service Learning, Computing Diversity Design, Engineering Diversity, Engineering Education Research, Engineering Ethics, Engineering Graphics and Visualization, Entrepreneurship and Innovation, Green Design and Sustainable Engineering, International Engineering Education, Industrial Design, MEMS/NEMS, Mechatronics, Mobile Learning, Nanotechnology, Tablet PCs and Teamwork.
- ◆ Extended services to new engineering-related grantees, created and marketed search appliance and news services tools as a la carte items, and as components of larger membership packages (available to both educational and commercial entities).
- ◆ Developed Today in History Blog that links current technology to its technological roots. Hyperlinks provide a search over related resources in *EP*, which serves as example of interactive component we offer in the higher-level membership. See: <http://www.k-grayengineeringeducation.com/blog/>.

Goal 2: Stewardship and Growth of the K-Gray Engineering Pathway

Harvested or catalogued resources from targeted projects (e.g., NSF GK-12 awards, ERCs) and resources related to cutting-edge gaps (NSF priorities, NAE Engineer 2020 reports). Created an ABET Accreditation Series. Leverage engineering content and services within other NSDL collections. Infused resources on inclusion and diversity in engineering education.

Goal 2: Integrated K-Gray Activities

- ◆ *EP* has gone well above its goals in the growth of resources. A summary of the *EP* resources, by collection, is provided below. (Note: only resources in engineering-related collections managed by *EP* are included). Approximately 10% are K-12 resources and 90% are for Higher Education audiences.

Table 1. Number of EP resource records from Oct. 2005 to March 2009.			
EP Collection	Oct-05	Mar-09	% Increase
ACM Women in Computing	410	927	126
Advances in Engineering Education (AEE)	0	22	NA
Broadening Participation in Computing (BPC)	5	343	6,760
Community Assessment of Renewable Energy and Sustainability (CARES)	3	83	2,667
Center for Sustainable Engineering Electronic Library (CSEE)	4	28	600
Engineers and Business for Sustainability (EBS)	0	19	NA
International Journal of Engineering Education	0	177	NA
NEEDS – National Engineering Education Digital-library System	1,771	10,276	480
Pr2ove-it	0	556	NA
TeachEngineering	213	795	273
Tomorrow's Professor	0	893	NA
VaNTH Bioengineering, Biomedical ERC	2	55	2,650

Total	2,408	14,174	489
--------------	-------	--------	-----

- ◆ In addition, *EP* has grown the number of special topics associated with the Engineer 2020 project, integrated research and education centers, and GK-12 initiatives. See these special topics in our browse page at: <http://www.engineeringpathway.com/ep/browse/series/>

Goal 2: K-12 Activities

- ◆ Performed a Massachusetts-based K-12 gap analysis to assess content coverage in relation to the state technology/engineering curriculum standards. Undergraduate students developed initial ideas to address the areas with gaps; still looking for teachers willing to test the developed material.
- ◆ Goals for publishing new lessons and activities — the real “meat” of the *TeachEngineering* collection — will be exceeded: *TE*’s Year 4 goal is to have 49 units, 271 lessons and 490 K-12 activities published. Results at the 3.5 year mark are: 43 units, 271 lessons and 477 activities published. A sample of topics: biomedical engineering, bridges, weather and atmosphere, designing shoes, designing Viking ships, product development, energy-efficient housing, rivers, spectroscopy, etc.
- ◆ K-12 curricula were added to the *TE* collection by new external contributors, including Oregon State University’s NSF-funded Rural Science Education Program, the University of Colorado at Boulder’s Laboratory for Atmospheric and Space Physics (a NASA-funded program), University of Virginia’s Biomedical Engineering, Drexel University’s GK-12 Program and Vanderbilt University’s RET Program. In addition, we have indications from 12 other higher education institutions intending to publish their K-12 engineering curricula in *TE* in the next year or so (see below).
- ◆ Conducted a *TE Publishing Workshop* for NSF GK-12 engineering graduate student Fellows at Drexel University as they prepare their K-12 engineering curricula for publishing in *TeachEngineering*. Their feedback led to improvement of online instructions and tools provided for external contributors via the *Submit Curriculum* website page.
- ◆ Completed the *Wind Energy Living Lab* framework. Integrated three years of wind data (speed, direction, temperature, pressure, etc.) from hundreds of US sites (from every state) into a GUI that combined Google maps with interactive links to access specific durations and types of data. Access to this US data is now middle and high school student friendly. The data are static (using purchased 2000-03 archived data) and reside in a database. *Water Living Lab* development focused on real-time data harvesting from the USGS information website. Initial efforts to mine the entire website and keep a database of all their information (with a regularized mining schedule) proved too challenging due to too much data. Switching to an “on demand” search of USGS data per user request via the *Water Living Lab* is working well, and we are 60% complete with this task.
- ◆ Created a graphical program that mines USGS data on a state-by-state basis and displays the data for middle school students in either month-by-month or day-by-date format for the *Engineering Our Water Living Lab*.
- ◆ Formed a collaborative relationship and signed legal agreements to permit netTrekker to ingest *TE* metadata for exposure of *TE* collection to teachers at <http://netTrekker.com>.
- ◆ Established a relationship with Vanderbilt University’s Research Experiences for Teachers (RET) Program to publish curriculum written by teachers who are taught to use *The Legacy Cycle* instruction method for creating curricular units. Aided Vanderbilt in using the *TE*

templates to describe *The Legacy Cycle* when writing curricula. Their feedback led to an enhancement of the *TE* curricular unit template. During the 2007-08 academic year, all RET teachers used the *TE* lesson and activity templates when creating curricular units. As a result of this work, in January 2009 Vanderbilt published in *TE* a 10-lesson unit with four activities.

- ◆ In collaboration with NSF Engineering Education and Centers Division, hosted 1.5-day *NSF*-sponsored *Engineering GK-12 Workshop* in Boulder for 42 people from 25 institutions (22 GK-12 grants), plus three from NSF (Al Soyster, Mary Poats, Ping Ge). Results include commitment from 12 new engineering colleges to publish their K-12 engineering curricula in *TE* — a very high response rate (about 50%) — further growing the *TE* collection, and providing wide dissemination of the GK-12-generated engineering curricula. Institutions include: University of California-Berkeley, Vanderbilt, University of Cincinnati, Stevens Institute of Technology (NJ), South Florida, Washington State Univ., UCLA, Louisiana Tech, Johns Hopkins, Univ. of Virginia. Other results include updating of *TE* document templates and publishing help files, videotapes of the workshop sessions for website publication, and workshop assessment.

Goal 2: Higher Education Activities

- ◆ Increased higher education collection by almost 500% over the grant period.
- ◆ Ingested *PR2OVE-IT* collection from the National Academy of Engineering and developed a partnership to integrate the technical infrastructure. The *PR2OVE-IT* interventions were added to *EP* subject vocabularies.
- ◆ In partnership with the Center for Teaching and Learning from Stanford University, we developed a collection for the *Tomorrow's Professors* resources.
- ◆ Completed agreement with the *International Journal of Engineering Education* to catalog all new *IJEE* papers in *EP*. A specialized cataloging form was developed and *IJEE* assigned an editor for this addition.
- ◆ Cataloged 50 ABET self-studies. The draft criteria for exemplars is under review for using experts from ABET to identify and refine the criteria.
- ◆ Added new collection in partnership with ASEE (American Society for Engineering Education): *Advances in Engineering Education* (AEE). This new collection highlights significant advances in instruction, pedagogy, technology and assessment that substantially improve learning in the broadest sense.
- ◆ Added new collection: *Center for Sustainable Engineering Electronic Library* (CSEE). CSEE is a partnership of Carnegie Mellon University, the University of Texas at Austin, and Arizona State University established the Center for Sustainable Engineering in 2005, supported by the National Science Foundation and the Environmental Protection Agency.
- ◆ Expanded the *PR2OVE-IT* collection with the National Academy of Engineering to include intervention factors, outcomes assessment, evaluation, and study characteristics. *EP* now hosts the *PR2OVE-IT* collection both from within *EP* and as a standalone collection.
- ◆ Developed the following funded collections in Years 3 and 4: *Engineers and Business for Sustainability* (EBS), *Broadening Participation in Computing* (BPC), and *Community Assessment of Renewable Energy and Sustainability* (CARES).
- ◆ In addition, *EP* has grown the number of special topics associated with the Engineer 2020 project, integrated research and education centers and other targeted topics. See these special topics in our browse page at: <http://www.engineeringpathway.com/ep/browse/series/>

- ◆ Increased number of cataloged ABET Self-Studies to 50. Ensured that the items collected as ABET self-study examples are indeed exemplars through the use of an informal rating process that requires a certain minimum set of ABET report items be included in the candidate self-study. The process and the minimal set of items will be formalized once reviewed by our ABET partners.
- ◆ Experimented with and observed steps performed by users who are requested to seek out ABET related materials in order to help refine the ABET related metadata fields and the way in which the metadata is associated with resources.

Goal 3: Align Curricular Materials with Appropriate ABET or K-12 Standards

Aligned *TE* curricula with K-12 STEM educational standards, including emerging technology standards. Used ABET accreditation criteria for indexing, evaluating, selecting and reusing undergraduate engineering content. Created ABET accreditation series of exemplars.

Goal 3: K-12 Activities

- ◆ Added standards alignment information to the *TE* metadata.
- ◆ Further solidified our partnership with JES & Co.'s Achievement Standards Network (ASN). *TE* now receives regular updates of the ASN standards database and in return, makes available to JES & Co. (and NSDL) — as part of its metadata — its curriculum-standards alignment data.
- ◆ *TE*'s entire curriculum is periodically aligned with educational standards using the Center for Natural Language Processing's (CNLP) CAT (Curriculum Alignment Tool) and SAT (Standard Alignment Tool) services.
- ◆ On October 8, 2008, *TeachEngineering* released a new version of its K-12 engineering collection in which all 700+ existing and all future curricular items are aligned to the K-12 math and science educational standards of *all 50 states*. This multi-state alignment required more than a year of nightly “mining” of CNLP's CAT (Curriculum Alignment Tool) and SAT (Standard Alignment Tool), and JES & Co.'s ASN (Achievement Standards Network) data. Now, *TE* is able to support new content contributors, aligning their materials with the educational standards from any and all states. As a consequence, we anticipate rapid growth of the collection contents in the next few years.
- ◆ This all-state alignment — a project milestone — was an overarching *TeachEngineering* objective since inception of the collection five+ years ago; getting there was a bigger challenge than the five-institution partners ever imagined. Using CNLP's SAT and CAT web services, the “mining” approach involved periodically submitting all *TE* documents to CAT for alignment and aligning the science and math standards of all states to those of all other states (24 million alignments). During this process, *TE* provided a great amount of feedback to the CNLP people, helping them to stabilize and optimize their services.
- ◆ The user interface was modified with facilities to browse and search (full text search) the complete ASN, and software was written for automatic integration of new ASN issues into the *TE* system. Other user interface extensions cover searching the collection by educational standard. Conducted various internal university and external teacher evaluations to test and refine the new ASN-educational standards-based *TE* system version before implementation.
- ◆ We recognize the following organizations and people for their help in *TE* educational standards correlations: JES & Co. for working with us and making ASN available, and their willingness to fix errors and bugs (Bruce Walker and Diny Golder); and Center for Natural

Language Processing (CNLP) for all their SAT/CAT work and responsiveness to error reports, and generosity in permitting us to use their tools and results (Anne Diekema and Jennifer Bailey).

- ◆ During Years 3 and 4, the K-12 team conducted seven workshops in four states (OR, CO, NC, MA) with 53 K-12 and pre-service teachers. The sessions served both as “how to” *TeachEngineering* workshops and as testing of the new standards alignment scheme. Experimental data were collected and analyzed and are presented at several forums: paper presentations at the Joint Conference of Digital Libraries (JC DL) 2008 and 2009; at a January 26, 2009 NSF-sponsored workshop with 42 NSF GK-12 engineering curriculum authors and three NSF officers, and paper submitted to the Journal of Information Processing and Management (IPM). Among other things, the study provides a model of what teachers care about (what is relevant to them) when using a K-12 digital library such as *TeachEngineering* in search of standards-aligned curricula.
- ◆ The experimental sessions were designed in such a way that they also enabled us to assess the performance (precision and recall) of a significant number of CAT and SAT alignments. These data will be analyzed and made available in summer/fall 2009.

Goal 3: Higher Education Activities

- ◆ All of the higher education resources were aligned to general ABET disciplines and criteria ahead of schedule.
- ◆ All new resources are aligned to *PR2OVE-IT* interventions, where appropriate.
- ◆ Presented conference paper for ABET-alignment titled: “ABET Alignment of Learning Resources in the *Engineering Pathway* Digital Library.”

Goal 4: Grow Participation (Community Stewardship)

Formed partnerships with key disciplinary and women/minority-serving engineering professional societies. Hosted K-16 and engineering educator user and content provider workshops, including service learning. Created an enhanced user interface for content providers to easily submit their own curricula and participate in quality-controlled process. Developed marketing publications.

Goal 4: K-12 Activities

- ◆ Provided a text field option for EP K-12 catalogers to note K-12 educational standards addressed by their resource(s). This allows cataloguers who have created resources that meet specific standards to identify those standards; the text field provides limited search capability, and may allow for later enhanced standards alignment EP features.
- ◆ Conducted a 90-minute *TE Publishing Workshop* for ~10 Drexel University engineering graduate student Fellows in Philadelphia, preparing them to publish their extensive NSF GK-12 curricula in *TeachEngineering*.
- ◆ On January 26-27, 2009, the K-12 team conducted a 1.5-day NSF-sponsored *Engineering GK-12 Grantees Workshop* in Boulder for 42 people from 25 institutions, of which 22 were NSF engineering GK-12 projects. The workshop included instruction on how to use the *TE* resource, writing quality K-12 engineering curricula, the *TE* review process, the engineering message, and how-to publish curricula in *TE*, as well as exploring *TE* long-term ownership and sustainability issues. Twelve of these institutions intend to publish their original K-12 engineering curricula in *TE*.
- ◆ *TE* metadata are now being harvested by netTrekker (increased marketing/exposure to teachers), and many monthly referrals to *TE* are through *Lesson Planet*.

- ◆ *Testimonial:* Susan Pruet, Program Director of the Mobile Area Education Foundation, is working with middle school math and science teachers to implement TE curricula in Mobile (AL) schools. She learned about *TeachEngineering* at the spring 2007 NCTM conference, is impressed with caliber of the materials, and has been accessing TE curriculum regularly since then. They conducted their own workshop to prepare teachers to implement several TE units. Susan said they are using TE curricula as “one strategy to engage K-12 students around engineering as a ‘hook’ to getting them into taking the math and science needed for our ever-growing technology-dependent jobs in the Mobile area.”
- ◆ *Testimonial:* Quote from Mary Beth Horton who was referred to the online *TeachEngineering* collection: “Thanks so much for making me aware of the ‘*TeachEngineering*’ collaborative effort. To say I was WOW’d by the depth and breadth of the curriculum effort is an understatement! This will be an exceptional resource both for our volunteer engineers as they prepare for their classroom visitations, as well as educators.” Mary Beth is deputy director of Business Education Compact (www.becpdx.org) in Beaverton, OR, an organization that connects the classroom and workplace with hands-on, innovative learning experiences for K-12 students and teachers. They arrange for hundreds of engineers to share their stores with kids and create excitement for the field.
- ◆ *Testimonial:* As the science specialist and magnet coordinator at Grantham Academy in Houston, TX, Deena Logan integrates four strands of engineering — civil, mechanical, biomedical and chemical — into core subject areas. She was led to *TeachEngineering* by an engineer at Texas A&M in Bryan, TX. She tells us, “The lessons are so well written and match many of our benchmark targets in our district and our national standards for math and science in Texas.” She plans to use several of the lessons at her middle school — and become a volunteer *TeachEngineering* reviewer of new curricula.
- ◆ *Testimonial:* Eugene Rutz from the University of Cincinnati partnered with an all-girls high school in Cincinnati to teach an engineering course; he regularly obtains about 25% of his teaching curricula from the *TeachEngineering* digital library. Eugene designed a junior and senior course that introduces several engineering disciplines through modular-based, project-centered pedagogy. Twelve of his 23 female students from one school went on to engineering college this year.
- ◆ *Testimonial:* “I would like to communicate my great appreciation for your resources. I taught science for Cincinnati Public Schools for quite a few years and often used these resources for my planning.” Mark Hannah, associate product manager of Thinkronize, Inc., the developer of netTrekker.com

Goal 4: Higher Education Activities

- ◆ Developed and deployed a new “Events in History” database to highlight important events in technology that could be linked to *EP* educational resources. An *EP* blog was developed and deployed to further expand community participation. Most of the blog authors focus on an event in history as the starting point for the discussion. Guest bloggers include representatives from professional societies and industry. For example, the July 22 blog is from the Microsoft archivist Amy Stevenson — *Engineering Education “Today in History”*: *Gates and Allen License Basic*. There are currently 350 blogs and 550 events in history.
- ◆ Developed database-driven website of engineering professional societies. The database is organized by age and audience (K-12, student, professional pages) as well as discipline.
- ◆ Advertised *EP* digital library at major engineering education meetings: Frontiers in

Education, American Society of Engineering Education as well as disciplinary meetings. Developed and distributed PR flyers of *EP* and NSDL. *EP* was also advertised as part of a full-page ad in the March and November issues of the *ASEE Prism* magazine every year.

- ◆ Developed Higher Education Disciplinary Communities with Associate Editors as well as interdisciplinary communities. See:
<http://www.engineeringpathway.com/ep/community/index.jhtml>
- ◆ Conducted four NSDL CI workshops: AAAS (2007, 2008), ASEE (2007), ABET (2007) as well as four webinars in Fall 2008. Another workshop is scheduled for June 2009 at the ASEE annual meeting.
- ◆ Held initial discussions with managers at HP, Autodesk, Kindle and Microsoft and others to determine how *EP* may cooperate in cataloging and disseminating educational materials currently on the Tablet PC web site and how this may support sustainability efforts.

Goal 5: Develop and Implement a Quality Control / Review Process

Enhanced and implemented integrated quality control and review protocols for all K-Gray *Engineering Pathway* content. Expand metadata and search filters to include enhanced quality/review criteria. Continued to offer the *Premier Award for Excellence in Courseware* and created a new K-12 version.

Goal 5: Integrated K-Gray Activities

- ◆ All new *EP* resources are reviewed for quality, using separate criteria for K-12 and Higher Education.
- ◆ All *EP* resources are checked for bad links twice a week. Those with questionable links are annotated with “Link to resource may not be available.” It turns out most of the links are only temporarily down. Some sites are down for maintenance on the weekends, for example. Those with consistent bad links over a month are either corrected or de-accessioned.
- ◆ We added the ability to search over comments for all resources. The “most commented” and “most downloaded” resources are accessible on the K-12, Higher Ed and disciplinary pages.

Goal 5: K-12 Activities

- ◆ Established a review process for incoming, newly catalogued EP K-12 resources, using existing grant partners and graduate students to evaluate based on the new criteria.
- ◆ Reviewed all *EP* K-12 catalog records submitted prior to June 2007 (most were originally from NEEDS) to ensure they met the revised requirements for quality, engineering connections and grade band appropriateness. We retained only those resources with a clear engineering connection, reducing the resources teachers must sort through to find K-12 engineering content. Of the 1,205 initial resources, 545 were removed for not meeting the K-12 criteria for an *EP* metadata record; many were resource types that were not utilized within the new K-12 framework; 427 of these continue to be searchable as an *EP* higher education resource as they were determined to be appropriate for a general public audience. An additional 118 were removed from the collection by making them “not searchable;” many of these were broken links or resources that were not engineering resources.
- ◆ To standardize the review of submitted *TeachEngineering* curricula, created three quality review rubrics — one for overall K-12 content, another for engineering content (based on the Engineering Habits of Mind), and a third for depth of engineering found in the hands-on activities.

- ◆ Solicited eight (to date) volunteer engineer and teacher curriculum reviewers for the inaugural National Board of *TE* Reviewers using an online website form. Each offered about five hours of their time per month. Initial assignments were to review hands-on activities in preparation for publishing in the *TE* digital library, as a pilot of our new review process. Their reviews aided in a revision of the evaluation rubrics from we evaluate the curricula's quality, completeness and engineering content. They also served as curricular award judges.
- ◆ Defined a new categorization of *TE* curricula by their approach to integrating engineering as a way to help users understand what is available to them in the digital library. These “engineering categories” are not rankings of the quality or value of the activities in any other sense. They include: relating science or math concept to engineering, providing engineering analysis or partial design, and engineering design. Currently, we are exploring the best way to integrate this feature into our tagging, search and user interface systems.
- ◆ Developed criteria and solicited submissions for the inaugural *Premier Curriculum Award for K-12 Engineering*. See details at the Engineering Pathway submission portal web page at: <http://www.engineeringpathway.com/ep/k12/award/>. Marketing and promotion included announcements in February at the 2008 International Technology Education Association (ITEA) conference in Salt Lake City, and in June at the 2008 ASEE conference in Pittsburgh, as well as ASEE K-12 Workshop registration packet flyers, session flyers, K-12 Division business meeting announcement, postcard mailings, a *Prism* ad, numerous e-mailings, e-newsletters and website pages. From 17 quality submissions, a winner was selected and notified. The winning and finalist curricula will become part of the Engineering Pathway and *TE* digital libraries. The prize includes a \$1,000 cash award. The winner will be announced at the June 2009 ASEE Conference in Austin.

Goal 5: Higher Ed Activities

- ◆ The Premier Award Jury met every year of the grant and the Premier Award(s) were announced and presented at the Frontiers in Education conference. The Premier Award reviews for the winner, finalists as well as the non-winner nominations were added to *EP*. <http://www.engineeringpathway.com/ep/premier/2009/index.jhtm>



Fig. 2. 2008 Premier Award Winner.

- ◆ All new higher education resources are reviewed through our RSS feed of new resources using established ingestion criteria.
- ◆ Disciplinary Associate Editors created “Editor's Choice” reviews of their picks for top resources.
- ◆ Dramatically increased the number of comments and reviews. We started virtually no

comments/ reviews at the beginning of the grant and ended with close to 12,000. The chart below shows the statistics to date for the period of the grant.

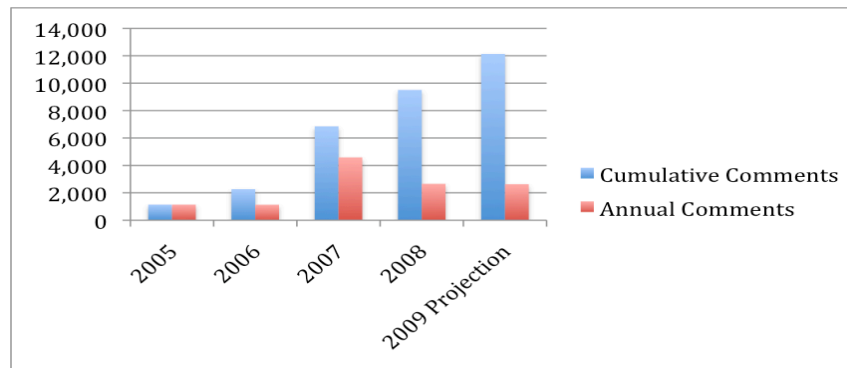


Fig. 3. Cumulative and Annual Number of Comments on EP Resources.

Goal 6: Create a Nonprofit Strategy and Partnership for Sustainability

Worked with professional societies, publishers, product vendors and collection developers to create a host of paid value-added educational digital library services. So far the hosted collection services have brought in the most revenue, but not enough to make EP self-supporting. We do believe the gradient looks good and self-sufficiency will be achieved with an extension of the EP grant. For services, see: <http://www.engineeringpathway.com/ep/about/services.jhtml>

Goal 6 K-12 Activities

- ◆ Discussed partnership opportunities with Curriki, but became disillusioned when their goal was merely to “scrape” *TE* and not invest in future development.
- ◆ At the well-attended January 2009 GK-12 Engineering Grantees Workshop, solidified about a dozen new partnerships with past and current GK-12 institutions, and began to explore a potential partnership with the Engineering Education and Centers Division of NSF for *TE* and *EP* to play a more prominent role as dissemination avenues for division-wide grants.

Goal 6 Higher Ed Activities

- ◆ Met with the EP Advisory Board in August 2006. The meeting provided a number of suggestions of avenues for sustainability. Interim feedback through email and webinars. Another in-person meeting is scheduled for ASEE in June 2009. Met with collection advisory boards, including those for the National Center for *Women in Information Technology (NCWIT)* and the *Broadening Participation in Computing (BPC)* collection.
- ◆ Took over the *PR2OVE-IT* collection for the National Academy of Engineering and received a \$50,000 grant to cover the costs. This fits into the business model of a fee for initiating new collections and became a model for others under development.
- ◆ Working with NSF-CCLI to develop a CCLI collection. To initiate the process a CCLI special topic has been formed. One funding model is to provide host services for NSF educational program areas. *EP* participated in the CCLI workshop on August 14-15, 2008 in Washington, DC.
- ◆ Developed a value-added model for publishers of engineering and computing textbooks. See: <http://www.k-grayengineeringeducation.com/textbooks/>. Prototyped developed, deployed and tested in spring 2008 with the John Wiley text: *Engineering Design: A Project-Based*

Introduction. Feedback from this deployment and evaluation led to more features for faculty and students in regards to learning resource types. These new features can be found in the spring 2009 version of the text at: <http://www.k-grayengineeringeducation.com/textbooks/?p=409>. Both Wiley and other publishers are interested in this model and we are currently exploring a financial arrangement as a business model. Additional publisher services were developed for author annotation, publisher collections, as well as the annotated textbooks. See: <http://www.engineeringpathway.com/ep/about/services.jhtml#textbook>

- ◆ MS report on *EP* business model completed. Conclusion that the publisher value-added model, along with service collection fees were the most promising directions.
- ◆ The following collections contracted with us for full collection services: *Peer Reviewed Research Offering Validation of Effective and Innovative Teaching (PR2OVE-IT)*, *Broadening Participation in Computing (BPC)* and *Community Assessment of Renewable Energy and Sustainability (CARES)*. Other collections funded us for a lower level of service, such as entry-level collections: *ACM-Women* and *Engineering and Business for Sustainability (EBS)*.
- ◆ Sponsorship of an entire community – disciplinary or interdisciplinary – is another service offered.
- ◆ Developed draft sponsorship pages that we are testing for professional society and corporate sponsorship.

Goal 7: Core Integration

Year 3 Combined Objectives: Expose metadata with educational extensions; update and implement revised MOU.

Goal 7: Integrated K-Gray Activities

- ◆ Participated in conference calls, reviews and meetings of the NSDL Pathways. Made recommendations for metadata and other documents. For example, modified age/audience level and learning resource type to conform to recommendations of the CI metadata task force.
- ◆ Developed single sign-in with the NSDL — the first Pathway to do so.
- ◆ Exposed metadata for OAI harvesting.
- ◆ Worked with NSDL on four in-person workshops and four webinars.
- ◆ Search results page, now interoperates with www.nsd.org to transfer keywords on EP to a related search on NSDL. In the example below, the “mechatronics” simple search showed 76 learning objects in EP. The user is told there are 356 objects in the NSDL and given the option to expand the search to the NSDL.

Search Results 1 - 10 of 76 for **mechatronics**
 Search results from National Science Digital Library: [NSDL \(356 results\)](#)
 Result page: 1 2 3 4 5 6 7 8 Next [Revise Search](#)

TITLE	RESOURCE TYPE	DISCIPLINE	SOURCE
Intelligent Mechatronics Lab at Boston University	Laboratory/Experiment/Field Activity (College Senior - Graduate)	Mechanical Engineering	NEEDS Catalog Record
Research laboratory at Boston University. Research areas include: medical robots, communicating mobile robots, contact sensing, structural dynamics, control of fluids, friction modeling, network control systems, tactile display... more			
Mechatronics Courses at RPI	Course (College Freshman - Graduate)	Mechanical Engineering	NEEDS Catalog Record
Courses include: Foundations of Engineering, Mechatronics, and Automotive Mechatronics.			
Mechatronics Tutorial Information	Tutorial (College Freshman - Graduate)	Mechanical Engineering	NEEDS Catalog Record
This site contains links to a wide spectrum of tutorials and references on key subjects in mechatronics.			

Fig. 4. Search Results for “mechatronics” that Interoperates with the NSDL NDR.

- ◆ *EP* added selected Events in History to the NSDL Expert Voices blog.
- ◆ Added three metadata formats to the *TE* OAI server (needs_lom, standard dc and *TE*_internal).
- ◆ NSDL and *EP* continued successful harvesting of the *TE* metadata. Several other groups and organizations, for example, OER Commons and JES & Co., routinely harvest *TE* and *EP* metadata from NSDL.
- ◆ Went live with Teachers’ Domain (TD) web search service. Now *TE* word searches automatically search the TD, *EP* and NSDL websites and provide links to these collections’ search results pages.
- ◆ *EP* added sets to its OAI server, along with co-branded logos for each of its collection. This added over 3,000 new high quality records to the NSDL NDR. These new collections are now available at NSDL.org through the Protocol for Metadata Harvesting (OAI-PMH) Version 2, development by the Open Archives Initiative. The new collections are co-branded with *EP* on the NSDL repository (NDR). See example search on the NDR below with co-branding with NEEDS, *PR2OVE-IT* and *EP*. For other new collections see: <http://nsdl.org/browse/?subject=New>





<p><u>Personalized, interactive, take-home examinations: For students studying experimental design</u></p> <p>Abstract: "Personalized, interactive, take-home examinations allow complex, thought-provoking and thorough examinations to be administered while minimizing..."</p> <p>Keywords: chemical Engineering, design</p> <p>http://www.engineeringpathway.com/view.jhtml?id=49DEDB05-010E-45CE-9AAA-5D2DA2009AFC</p> <p>View all related information</p>	 
<p><u>Effects of instructional intervention strategies on students at risk in engineering education</u></p> <p>Abstract: "The study was conducted on repeat students ...N ^ 139† from the second year Diploma in Mechatronics taking the Mechatronics Science..."</p> <p>Keywords: intervention, mechatronics, students-at-risk</p> <p>http://www.engineeringpathway.com/view.jhtml?id=0CFC1EFA-FE94-419A-90CC-43B7EF59E919</p>	 

Fig. 5. Examples of Search Results from the NSDL NDR with EP Co-Branding of Collections.

Goal 8: Dissemination

Conduct workshops, presentations, publications and public relations materials.

Goal 8: Integrated K-Gray Activities

- ◆ Poster session and updates at all NSDL Grantees meetings: 2005-2008.
- ◆ Participated in AAAS Workshops, ASEE workshops and webinars with NSDL.
- ◆ Provided *TE* and *EP* brochures for NSDL distribution at meetings and conferences.
- ◆ Conducted two engineer-led NSTA/NSDL web seminars for K-12 teachers:
 - “Engineering by Design!” with 42 participants, which used and promoted *EP* and *TE*. See summary, slides, participant comments and archive at <http://institute.nsta.org/NSDL/webseminar9.asp>. April 2007.
 - “Engineering: Because Dreams Need Doing” with 37 participants. See http://learningcenter.nsta.org/products/symposia_seminars/NSDL3/Webseminar6.aspx February 2009.
- ◆ A feature article on *TE and EP* was published in the ASEE *Prism* magazine, “Click. Build. Learn: A Digital K-12 Engineering Curriculum Expands with an Emphasis on Quality and Fun,” Teaching Toolbox, in September 2007.
- ◆ October 2007 presentation on the aspects of quality courseware development, illuminating the Premier Award quality criteria was given by Tront to the more than 400 participants at the Premier Award luncheon at the Frontiers in Education Conference.
- ◆ Conducted a 90-minute *TE Publishing Workshop* for ~10 Drexel University engineering graduate student Fellows in Philadelphia, preparing them to publish their curricula in *TE*. From their feedback, initiated changes to our templates and instructions for new contributors.
- ◆ Presented a *TE* poster at the K-12 Session of the yearly IBM University Day in Research Triangle Park, NC on October 30, 2007.
- ◆ At the November 2007 NSTA regional meeting in Denver, presented a Friday-evening exhibit booth and a Saturday-morning *EP K-12 / TE* workshop, “Using

TeachEngineering.org — A Free Teacher Resource,” for science teachers.

- ◆ Presented a 50-minute session on *TE* to an enthusiastic audience of teachers at the February 2008 International Technology Education Association (ITEA) in Salt Lake City. Also announced the inaugural Premier Curriculum Award.
- ◆ Conducted a 50-minute workshop, “Making Science Real with the Free *TE* Resource,” at the March 2008 annual NSTA Conference in Boston, and staffed the NSDL Pathways booth.
- ◆ Towards creating a partnership with the Boston Museum of Science to become the western US professional development providers, ran an inaugural Engineering is Elementary Workshop in Boulder. Several additional Engineering is Elementary Workshops were conducted by co-PI Martha Cyr in Worcester, MA, during summer 2008. All workshops were promoted on the EP professional development resources page.
- ◆ To promote *EP*, contributed brief articles highlighting EP K-12 resources for the monthly JETS’ (Junior Engineering Technical Society) *PreEngineering Times* online newsletter during the 2008-09 school year. Provided a *TE* activity write-up for the JETS E-Week poster.
- ◆ Provided numerous K-12 engineering activity curricula write-ups from *TE*, for ASEE’s revamped online *Go Engineering* monthly newsletter, which now provides K-12 engineering activities for teachers.
- ◆ Gave Eric Mann of the College of Education at Purdue University permission to include our *TeachEngineering* work in his K-12 engineering presentations for the November 2007 Gifted Education Research Institute (GERI) National Association for the Gifted Conference.
- ◆ Developed and hosted a joint *TE* and the Center for Natural Language Processing (CNLP) CAT/SAT poster for the NSDL Pathways annual meeting, highlighting our collaborative work on educational standards alignments.
- ◆ Distributed CDs containing the Premier Award winners, the finalist candidates, the Premier Award criteria and guidelines for developing quality courseware. Distributed 500 CDs at the Frontiers in Education conference each year; sent an additional 300 to each of the engineering deans on the ASEE Deans Mailing list; distributed 180 CDs at the ECE Department Heads Association meeting in April; distributed ~200 CDs at various other national and international conferences and workshops; sent 400+ CDs to faculty and students who requested them through the EP website.
- ◆ Conducted a 1.5-day *NSF Engineering GK-12 Workshop* in Boulder for 42 people representing the 22 NSF engineering GK-12 PIs. The workshop included instruction on how to publish curricula in *TE*. As a result, 12 higher education institutions expressed their intent to publish their K-12 engineering curricula in *TeachEngineering*, most in the upcoming year.
- ◆ Developed flyers and public relations literature that was handed out at national conferences and events.
- ◆ See attached list of journal and conference publications.

Goal 9: K-Gray Engineering Pathway Evaluation

- ◆ Participated in LibQUAL digital library evaluation project in Fall 2005.
- ◆ Participated in a survey on NSDL projects' evaluation practices.
- ◆ Offered annual awards for Premier Award for Excellence in Engineering Education.
- ◆ Initiated a K-12 Premier Curriculum Award that was awarded in Year 3
- ◆ Conducted in-depth evaluations of the Higher Education, K-12 and Diversity components of

the *Engineering Pathway*. The results of these efforts led to dramatic changes to the *Engineering Pathway* website, including revised navigation, style sheets, use of images, disciplinary communities and new services. The K-12 evaluation was also used to make improvements to the *TeachEngineering* digital library: a linked Table of Contents for each lesson and activity to aid in user navigation of the materials, ordering of the presentation of components, altered background colors for improved readability, hover-over pop-ups to provide explanation for technical and specific terms, a new menu system to reduce interface “flickering” when writing new pages, keyword search results in order of relevance weighting based on linguistic fit and page rank, a “more” option on search results listing, modifications of the word search algorithm to find partial beginnings of words, enabling of searches by educational standards to be re-sorted by users in various ways, option to set the number of desired educational standards to be returned (enabling power to shorten search and display time), re-organization of the admin pages, changes in the alphabetical listing on document browse pages to ignore leading articles (a, an, the), and the addition of an ASN interface to the Browse Educational Standards interface.

- ◆ In an NAE “state of K-12 engineering in the US” report issued in spring 2009, *TeachEngineering* was referenced with a positive statement about *TE*.
- ◆ Conducted numerous internal university and external teacher evaluations towards refinement of the new ASN-educational standards-based *TeachEngineering* system version implemented in late Year 4.
- ◆ Secured Year 4 funding from the Agilent Technologies Foundation to conduct a web metrics analysis of *TeachEngineering* user logs— to delve deeper into *TE* user metrics to investigate how the collection is being used and how it can be tuned to improve the user experience. Work so far has concentrated on describing the hit frequency distributions, i.e., rather than relying on overall average, arrive at a better view of how hit frequencies are distributed over different users. Frequency distributions are also derived for each and every of the *TE* user pages; e.g., document and educational standards viewing, word searching, etc. During the period October 2006 – February 2009, *TeachEngineering* received an average of 32,513 hits per month. During this same period, on average, 21,038 IP addresses generated requests every month. These numbers reflect “clean” hits; that is, to the best of our knowledge these visits do not include any hits from the partnering institutions, test or experimental events, nor do they include any visits by harvesting and data mining robots, e.g., googlebot, msnbot, inktomi, NSDL metadata harvesting, *Engineering Pathway*, etc. Furthermore, these numbers include only “serviced” pages (e.g., searches, document renderings, etc.); they do not include any isolated requests for non-rendered documents or images nor do they include HTTP requests triggered by links embedded in pages. Graph 1 shows the frequency hit distributions for this period. Notice the sharp increase in the period October 2008 – February 2009. Although more research must be done, part of the increase in traffic can be explained by the growth of Google-based references (October 2008, 1037; November 2008, 4725; December 2008, 7724; January 2009, 18204; February 2009, 37596; March 2009, 51184).

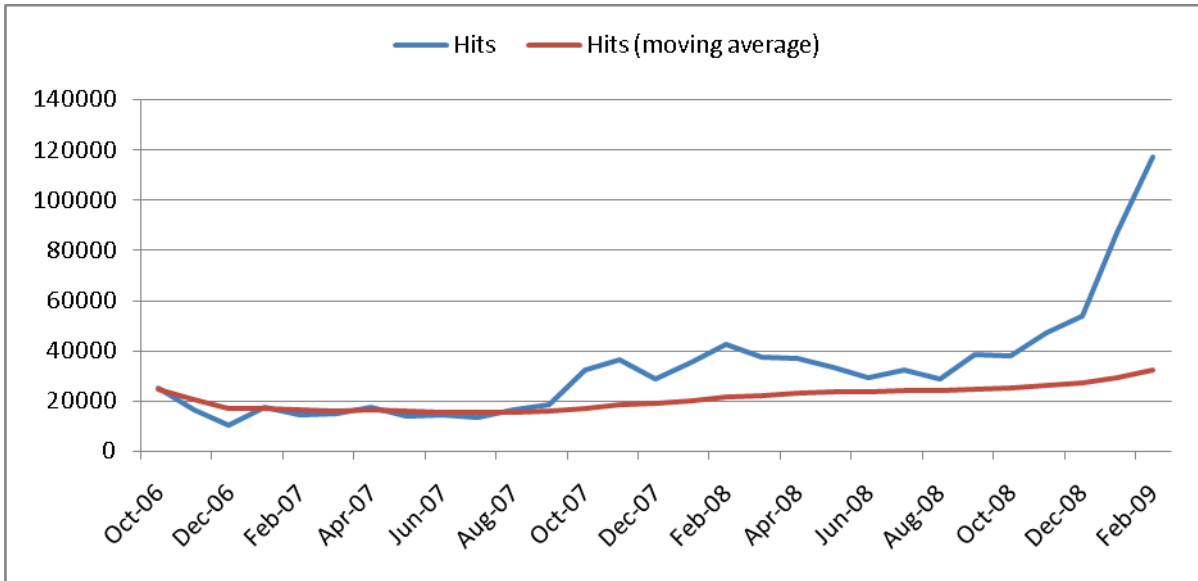


Fig. 6. History of TeachEngineering monthly hit rates.

- ◆ *EP* website continues to enjoy linear growth in its user base. *EP* received 1.4 million hits in March 2009 with approximately 300,000 page views per month (Fig. 7). Our disciplinary pages are typically in the top 10 for all major ABET disciplines under both Google and Yahoo searches. One-third of the visitors arrived at *EP* through these search engines.

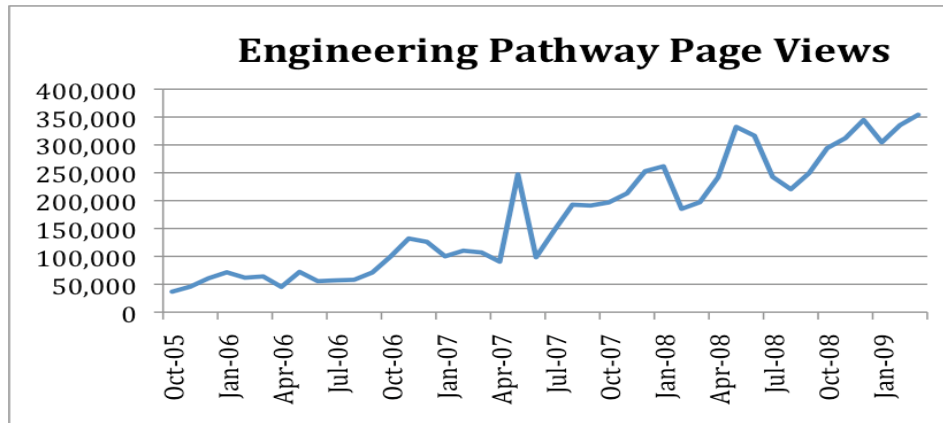


Fig. 7. *EP* page views from October 2005 to March 2009.

- ◆ A good measure of use of the digital library is to look at the record of views of individual resource records and then the download or link to the original resource it describes. The cumulative record is shown in Table 2.

Table 2: Cumulative views and downloads of EP records

Year	Cumulative Record Views	Cumulative Downloads of Resource
2005	57,091	6,958
2006	137,591	17,049
2007	582,138	107,449
2008	1,823,218	213,630
March 2009	2,231,931	236,405

- ◆ The cumulative and annual views for the collective *EP* resources are shown below. There appears to be a healthy annual growth.

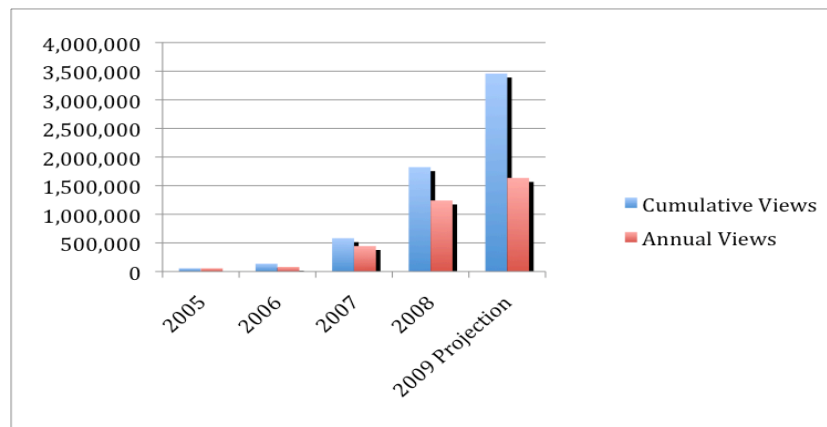


Fig. 8. *EP* record views from October 2005 to March 2009.

- ◆ The cumulative and annual downloads (approximately 11-12% of the records viewed are downloaded) for the collective *EP* resources are shown below. The number of downloads grew exponentially in the first few years, but appears to be leveling off.

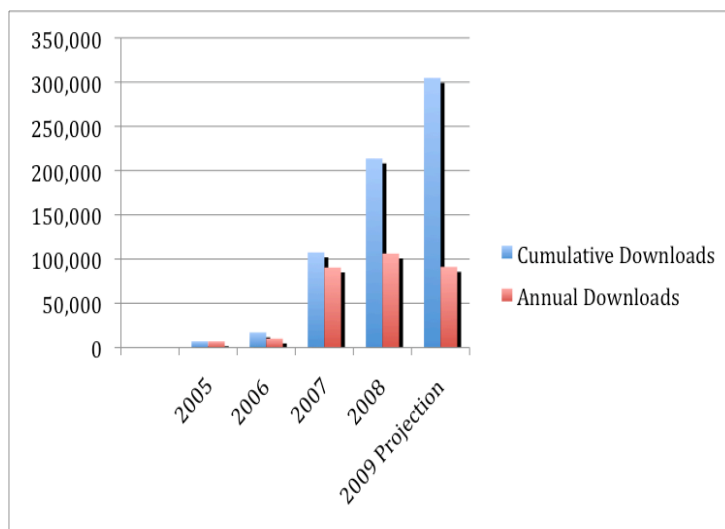


Fig. 9. EP record downloads from October 2005 to March 2009.

- ◆ Maintained and posted web statistics at: <http://stats.smete.org/full/>
- ◆ Participated in the NSDL Omniture webtracking program. Omniture has been useful to understand user behavior. Unique page views of selected pages shows a continuous upward trend, but clearly shows unique new views at the start of each semester or quarter with reduced use over the summer when fewer courses are offered.

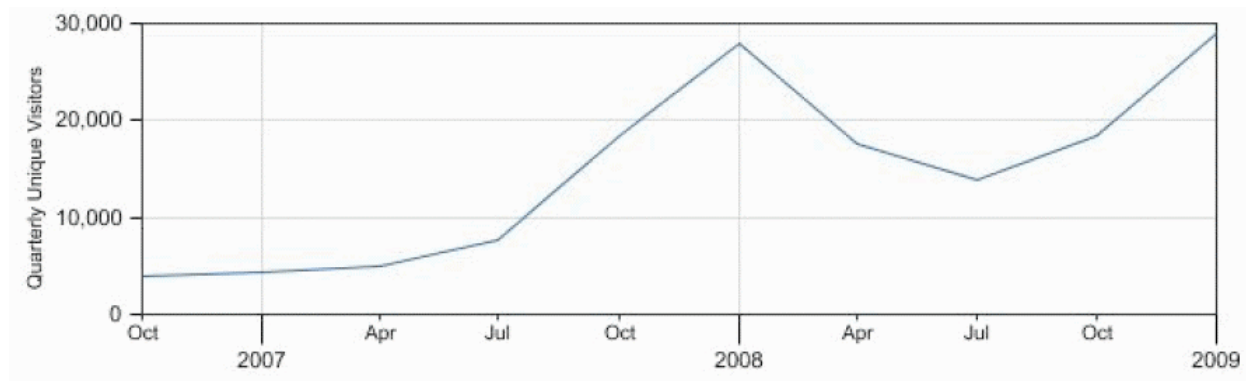


Fig. 10. Omniture trends for unique visitors for selected pages in EP.

- ◆ A team of graduate students in Nancy Van House's UC Berkeley information systems evaluation course conducted an evaluation of EP's higher education site in fall 2006 and the *TeachEngineering / Engineering Pathways* K-12 website in fall 2007. The evaluation included a user needs and usability analysis. Based on the feedback many user interface changes were made. During fall 2008 and spring 2009 the Broadening Participation on Computing community conducted another review through workshops and a user interface course taught at Auburn University.

Other Reporting Categories:

- ◆ **Training and Development.** EP training workshops were held at the AAAS Annual meetings in 2007 and 2008, at ASEE Workshops, webinars and at a number of other venues. More detail on additional training and development activities is provided in Goal 8 activities

and in the workshop list below.

- ◆ **Outreach Activities.** See Goal 8 activities and presentations and workshops list.
- ◆ **Contributions within Discipline.** Our project covers engineering, computer science and technology. Also see all activities and findings.
- ◆ **Contributions to Other Disciplines.** We also cover areas in applications of math and science, as well as education and technology literacy.
- ◆ **Contributions to Human Resource Development.** All of the work in the project tasks and goals are related to education or increasing the number and diversity of engineering students, faculty and professionals.
- ◆ **Contributions to Resources for Research and Education.** The portal provides links to scholarship in engineering education and related fields. We host several collections that focus on engineering education research, including the *PR2OVE-IT* collection and the International Journal of Engineering Education. Also see list of publications.
- ◆ **Contributions Beyond Science and Engineering.** This project provides a portal and workshops to support technology literacy and professional development in K-12.
- ◆ **Collaborators and Partners.** See:
<http://www.engineeringpathway.com/ep/about/contacts.jhtml>
- ◆ **Publications and Presentations.** See Goal 8 activities and list below.

Journals

1. Hey, J., C. Newman, J. Sandhu, C. Daniels, and J.-S. Hsu, and A.M. Agogino, "Designing Mobile Digital Library Services for Pre-Engineering and Technology Literacy," *International Journal of Engineering Education*, Special Issue on Mobile Technologies for Engineering Education, Vol. 23 (3), pp. 441-453, 2007.
2. Reitsma, R., Trubin, S., "Information Space Partitioning Using Adaptive Voronoi Diagrams," *Information Visualization*, May 17, 2007. <http://www.palgrave-journals.com/doi/10.1057/palgrave.ivs.9500152>.
3. Reitsma, R., Trubin, S., Mortenson, E. (2007) "Weight-proportional Space Partitioning Using Adaptive Voronoi Diagrams," *Geoinformatica*.
<http://www.springerlink.com/content/586276j71402v2h6/>
4. Reitsma, René F., Marshall, Byron, and Zarske, Malinda S. (2009) "Aspects of 'Relevance' in the Alignment of Curriculum with Educational Standards," *Information Processing and Management (IPM)*. (submitted)

Conference Proceedings, Press and Books

5. Agogino, Alice, L. Jamieson, G. Kalonji, D.F. Ollis, H.V. Poor, S.E. Powers, and C. Rodgers, "Integrating Education, Research, and Outreach: Exemplars from the NSF Distinguished Scholars Program," Extended Abstract in Proceedings of the Frontiers in Education Conference, ASEE/IEEE, Session T1A (October 19-22, 2005, Indianapolis, IN).
6. Agogino, A.M., T.E. Batchman, F. Bullen, L.H. Jamieson, W.C. Johnson and A.B. Western), "Invited Panel - Engineering and Computer Science Education in the Era of Globalization," Extended Abstract in Proceedings of the Frontiers in Education Conference 2005, ASEE/IEEE, Session F2B (October 19-22, 2005, Indianapolis, IN).
7. Agogino, Alice, "Engineering Education - Present and Future," panel, National Science Board Workshop on "Engineering Workforce Issues and Engineering Education: What are

- the Linkages,” M.I.T., October 20, 2005.
8. Agogino, Alice, “Women in Engineering in the Year 2020: Possible, Probable, and Preferable Scenarios,” Stanford University, March 9, 2006.
 9. Agogino, Alice, “Technology, Pedagogy and Design: Global Visions for the New Century,” June 1, 2006, University of Michigan.
 10. Agogino, Alice and Michael Smith, “Broadening Participation in Computing with the K-Gray Engineering Pathway Digital Library,” interactive poster session at the *Joint Conference on Digital Libraries*, Pittsburgh, PA, June 2008 PDF © ACM (2008).
 11. Datta, E., “Mobile Learning and Digital Libraries: Designing for Pre-Engineering Education at the Elementary School Level,” MS Project Report, 2007.
 12. Datta, E. and A.M. Agogino, “Mobile Learning and Digital Libraries: Designing for Diversity,” ASME Annual Congress, 2007 (ISBN 0-7918-3812-9).
 13. Hsu, J.-S., A.M. Agogino, C. Daniels, C.-E. Montgomery, P. Mackinney, and A. A. Gieringer, “Unblinking in Mobile Learning,” UnBlinking: New Perspectives on Visual Privacy in the 21st Century, A Cross-Disciplinary Symposium at UC Berkeley, 3-4 November 2006.
 14. Marshall, Byron, Reitsma, René and Cyr, Martha (2007) “Standards or Semantics for Curriculum Search?” Joint Conference on Digital Libraries, Vancouver, BC, June 2007. ACM/IEEE. pp. 181-182.
 15. Reitsma, René F., Marshall, Byron, Dalton, Michael and Cyr, Martha (2008) "Exploring Educational Standard Alignment: In Search of 'Relevance,'" *Joint Conference on Digital Libraries*. [PDF](#) © ACM (2008)
 16. Marshall, Byron, Reitsma, René F., and Zarske, Malinda S. (2009) "Differentiating Search and Evaluation Behavior in K-12 Digital Libraries," *Joint Conference on Digital Libraries (JCDL)*, Austin, TX, June 2009. (submitted)
 17. Mathias-Riegel, Barbara. “Click. Build. Learn: A Digital K-12 Engineering Curriculum Expands with an Emphasis on Quality and Fun,” Teaching Toolbox, American Society for Engineering Education *Prism*, Vol. 17, No. 1, September 2007, pp 44-47. See http://www.prism-magazine.org/sept07/tt_01.cfm
 18. Reitsma, R., Trubin, S., “Weight-proportional Information Space Partitioning Using Inverse Multiplicatively Weighted Voronoi Diagrams,” Proceedings of AMCIS, 2006.
Reitsma, René F., Byron Marshall, Michael Dalton, and Martha Cyr (2008) “Exploring Educational Standards Alignment: In Search of 'Relevance,’” *Joint Conference on Digital Libraries*, Pittsburgh, PA, June 2008 PDF © ACM (2008).
 19. Sullivan, J.F., (2006) “Broadening Engineering’s Participation — A Call for K-16 Engineering Education,” *The Bridge*. Washington, DC: National Academies Press, Vol. 36, No. 2. Summer 2006.
http://www.engineeringpathway.com/ep/learning_resource/summary/?id=ADE0DA15-DF65-4CEA-A863-C7EB7F495CF3.
 20. Sullivan, Jacquelyn F., “Last Word: Lessons from the Sandbox,” ASEE Prism, January 2007, p. 68.
 21. Teng, X., J.G. Tront, B. Muramatsu, and A.M. Agogino, “Best Practices in the Design, Development and Use of Courseware in Engineering Education,” *Proceedings of the*

- Frontiers in Education Conference*, ASEE/IEEE, (October 19-22, 2005, Indianapolis, IN).
22. Tront, Joseph, Reviewed and awarded 2005 Premier Award at the ASEE/IEEE Frontiers in Engineering Education Conference in November 2005-2008.
 23. Tront, J., "Technology for use in Distance Learning and Collaboration", Distributed Learning and Collaboration (DLAC) Symposium, on Theory, Research and Practice," sponsored by the NSF, hosted by Shanghai Jiao Tong University in collaboration with the US Air Force Academy and the University of Texas at Austin, Shanghai and Hangzhou, China, June 6-9, 2006.
 24. Tront, Joseph and Jane Prey, "Support for Mobile Learning Using Tablet PCs," International Conference on Mobile Learning, Amman, Jordan, April 14-16, 2008.
 25. Wu, J.-L., and A.M. Agogino, "ABET Alignment of Learning Resources in the Engineering Pathway Digital Library," ASME Annual Congress, 2007 (ISBN 0-7918-3812-9).
 26. Zarske, Malinda S., Yowell, Janet L., Sullivan, Jacquelyn F., Knight, Daniel W. and Wiant, Diana (2007) "The TEAMS Program: A Study of a Grades 3-12 Engineering Continuum," *Proceedings*, ASEE Annual Conference, Honolulu, HI, June 2007.

Presentations and Workshops

27. Agogino, Alice, "Engineering Education - Present and Future," panel, National Science Board Workshop on "Engineering Workforce Issues and Engineering Education: What are the Linkages," MIT, October 20, 2005.
28. Agogino, Alice, "Women in Engineering in the Year 2020: Possible, Probable, and Preferable Scenarios," Stanford University, March 9, 2006.
29. Agogino, Alice, "Technology, Pedagogy and Design: Global Visions for the New Century," June 1, 2006, University of Michigan.
30. Agogino, Alice, Robert Payo, Joseph G. Tront, Jackie Sullivan, "The Power of Digital Libraries: Inquiry-Based and Experiential Learning and Teaching", AAAS Annual Meeting, February 15-19, 2007, San Francisco, CA.
31. Agogino, Alice, Robert Payo, Joseph G. Tront, "Collaborative Models of Digital Library Use and Utility," AAAS Annual Meeting, Feb. 15-19, 2007.
32. Agogino, Alice, "Women and Men in the Academy: Beyond Bias and Barriers," Yale University, April 12, 2007. (EP used as comment site)
33. Agogino, Alice, "Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering," Smith College, April 13, 2007. (EP used as comment site)
34. Agogino, Alice, "Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering," APS (American Physical Society), April 15, 2007. (EP used as comment site)
35. Agogino, Alice, "Educating the Engineer of 2020," College of Engineering Seminar, University of Oklahoma, April 20, 2007. (EP used as comment site)
36. Agogino, Alice, Invited talk at the APS (American Physical Society) workshop titled: "Gender Equity: Strengthening the Physics Enterprise in Universities and National Laboratories." Maryland, May 6, 2007. (EP used as comment site)
37. Agogino, Alice, "Engineer of 2020 and the Gathering Storm," Opening Panel, Mudd Design Workshop VI "Design and Engineering Education in a Flat World," May 23, 2007. (EP used as comment site).

38. Agogino, Alice, "Teaching Women Engineering," ASME Think Tank Summit, June 10, 2007. (EP used as comment site)
39. Agogino, Alice, "Engineering Pathway Education Digital Library," ABET Workshop, June 24, 2007.
40. Agogino, Alice, Joseph Tront and Brandon Muramatsu, Workshop: "Selecting and Evaluating Digital Learning Materials for Engineering and Pre-Engineering Education," ASEE 2007 Annual Conference and Exposition, Honolulu, HI, June 23, 2007.
41. Agogino, Alice, *EP* introduced as a resource for commenting on the NRC *Beyond Bias and Barriers* report during her talk on "Women and Men in the Globalizing University: Mapping Gender in University Data," International Alliance of Research Universities (IARU), Yale University, April 21, 2008.
42. Agogino, Alice, *EP* introduced as a resource in Presidential Talk at Northwestern University, "Educating Engineers for a Flat World: Implications across the Academy," April 22, 2008.
43. Agogino, Alice, *EP* introduced as a resource while giving a keynote talk on the Engineering 2020 project and a paper titled "Longitudinal Study of Project-Based Learning Course in New Product Development," Technion, Israel, July 6, 2008.
44. Agogino, Alice, two sessions on "Using the Engineering Pathway" at the Indo-US Engineering Faculty Leadership Institute in Mysore, India, July 2008.
45. Agogino worked with ASME to launch the Design Interdisciplinary Community at the August 2008 Design Engineering Technical Conference in New York.
46. Agogino, Alice and Michael Smith, "A Portal for BPC: What features will allow us to accommodate the needs of novice BPC and experienced BPC users?", PAIRS/ BPC Advisory Board Meeting, April 1, Richard Tapia - Celebration of Diversity in Computing Conference, Portland, Oregon.
47. *Engineering Pathway* Higher Ed, CCLI workshop on August 14-15 2008.
48. TE/EP Presentation at NSTA (National Science Teachers Association) in Connecticut.
49. TE/EP Poster session for the NSF National Science Board's winter meeting at the University of Colorado at Boulder.
50. TE/EP Presented a February 8, 2007, *TeachEngineering* poster session at the National Science Board visit to Oregon State University, Corvallis, OR.
51. TE/EP On April 10, 2007, presented a live *TeachEngineering* NSTA/NSDL webinar titled, "Engineering by Design!" to 42 attendees, which used and promoted EP and TE. See summary, slides, participant comments and archive at <http://institute.nsta.org/NSDL/webseminar9.asp>.
52. TE/EP On June 20, 2007, conducted two-hour Wind Engineering Living Lab activity with 40 physical science teachers attending a renewable energy workshop at Colorado School of Mines in Golden, CO.
53. TE/EP On June 24, 2007, conducted a 75-minute, hands-on TE workshop, "Using *TeachEngineering.org*: A Free K-12 Resource," at the 2007 ASEE in Hawaii with an audience of middle and high school teachers, as well as engineering educators. Workshop showed how engineering activities can bring real-world relevance to everyday classroom science topics.

54. TE/EP Conducted mid-September 2007 authoring/publishing workshops in two locations for potential new contributors.
55. TE/EP Conducted a 90-minute *TE Publishing Workshop* for ~10 Drexel University engineering graduate student Fellows in Philadelphia, on September 14, 2007, preparing them to publish their curricula in *TE*. From their feedback, initiated changes to our templates and instructions for new contributors.
56. TE/EP Poster at the K-12 Session of the yearly IBM University Day in Research Triangle Park, NC, on October 30, 2007.
57. TE/EP At the November 2007 NSTA regional meeting in Denver, presented a Friday-evening exhibit booth and a Saturday-morning *EP K-12 / TE* workshop, “Using *TeachEngineering.org* — A Free Teacher Resource,” for science teachers.
58. TE/EP Presented a 50-minute session on *TeachEngineering* to an enthusiastic audience of teachers at the February 2008 International Technology Education Association (ITEA) in Salt Lake City. Also announced the inaugural Premier Curriculum Award.
59. TE/EP Conducted a 50-minute workshop, “Making Science Real with the Free TeachEngineering Resource,” at the March 2008 annual NSTA Conference in Boston, and staffed the NSDL Pathways booth.
60. TE/EP Conducted a 1.5-day workshop in Boulder, CO on January 26-27, 2009 for 42 attendees, representing the 22 NSF engineering GK-12 projects. The conference included instruction on how to publish curricula in *TE*, and 12 participating institutions indicated their intent to publish in *TE*.
61. TE/EP From May 15, 2008 through February 23, 2009, the K-12 team conducted seven workshops in four states (OR, CO, NC, MA) with a total of 53 K-12 and pre-service teachers. These “how to” *TeachEngineering* sessions enabled us to internally test the new 50-state standards alignment schema (see Goal 3), and collect experimental statistics that were analyzed and disseminated nationally.
62. TE/EP On February 19, 2009, presented a live *TeachEngineering* NSTA/NSDL webinar titled, “Engineering: Because Dreams Need Doing” for K-12 teachers, with 37 participants. See http://learningcenter.nsta.org/products/symposia_seminars/NSDL3/Webseminar6.aspx
63. Sullivan, Jacquelyn F. “Changing the Engineering Conversation: Talking to Teens and the People That Influence Their Lives,” 2008 NAE Convocation of the Professional Engineering Societies and the AAES Board of Directors Meeting, Washington, DC, May 5, 2008.
64. Sullivan, Jacquelyn F., “Changing the Conversation—Engineering Messages That Resonate for All,” keynote address, 2008 WEPAN National Conference, St. Louis, MO, June 10, 2008. URL
65. Sullivan, Jacquelyn F., “Public Understanding of Engineering Messaging Workshop,” 2008 ASEE K-12 Workshop, Pittsburgh, PA, June 12, 2008.
66. Sullivan, Jacquelyn F. and Lawrence E. Carlson, “Engineering... Because Dreams Need Doing,” Gordon Prize Lecture, National Academy of Engineering Annual Meeting, Washington, DC, October 5, 2008.
67. Sullivan, Jacquelyn F., “Engineering... Because Dreams Need Doing,” keynote address, 2009 NSF ECE Grantees Conference, Washington, DC, February 3, 2009.
68. Tront, Joseph, presented the “2006 Premier Award for Excellence in Engineering Education,” at the Frontiers in Engineering Conference, ASEE/IEEE, October 31, 2006.

69. Tront, Joseph, presented session on *Using Educational Digital Libraries* at the Indo-US Engineering Faculty Leadership Institute in Mysore, India, June 2008.
70. Tront, Joseph, invited presentation, “Effective Use of Tablet PCs in Engineering Education,” Carnegie Mellon Qatar faculty, Doha, Qatar, 18 attendees, April 20, 2008.
71. Tront, Joseph, invited presentation, “Using Tablet PCs in Elementary Education – Teacher Certification Workshop,” Carnegie Mellon Qatar campus, Doha, Qatar, 30 attendees, April 20, 2008.
72. Tront, Joseph, invited presentation, “Effective Use of Tablet PCs in Engineering Education,” ECE Department Heads Association, San Diego, CA, March 18-21, 2008.
73. Tront, Joseph, invited workshop, “Using OneNote to Improve Notetaking and Foster Collaboration,” 2008 HP Teaching with Technology Conference, LaJolla, CA, February 18-19, 2008.
74. Tront, Joseph, invited workshops, “Tablet PCs in Engineering Education & Research,” Joseph Tront and Jane Prey, (two workshops – limited to 15 participants each), EDUCAUSE Learning Initiative Annual Meeting, San Antonio, TX, January 28-30, 2008.

Websites

75. NEEDS (National Engineering Education Digital-library System), <http://needs.org>
76. *TeachEngineering*, <http://TeachEngineering.org>
77. *Engineering Pathway*, <http://EngineeringPathway.org>
78. *Engineering Pathway’s Today in History Blog*, <http://www.k-grayengineeringeducation.com/>
79. *Peer Reviewed Research Offering Validation of Effective and Innovative Teaching*, <http://www.pr2ove-it.org> (EP hosted collection)
80. *National Center for Women in Information Technology (NCWIT)*, <http://ncwit.org/resources.library.html>, (EP hosted collection)
81. *Broadening Participation in Computing*, <http://www.bpcportal.org/> (EP hosted collection)
82. *Community Assessment of Renewable Energy and Sustainability (CARES)*, <http://planetcares.com/> (EP hosted collection)