

# BRIDGING BARRIERS: USING TECHNOLOGY TO ATTRACT, RETAIN, AND MENTOR THE ENGINEERING WORKFORCE OF TOMORROW

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**Abstract** — Today's technology-based global economy places a high premium on STEM (science, technology, engineering, and mathematics) education. Educators committed to increasing the interest and achievement of females in engineering struggle to find appropriate resources. The Gender and Science Digital Library (GSDL) from Education Development Center, Inc., (EDC) is a unique on-line collection of exemplary resources aimed at encouraging girls and women to pursue science and engineering education and careers. Participants will receive an on-line tour of the GSDL and a hands-on look at exemplary engineering and science resources. An outgrowth of the GSDL, the Effective Access project, is studying how high-school level STEM educators use digital resources and how developers create resources to meet the needs of educators. Project outcomes will be used to refine and enhance the GSDL and other digital resources. Participants will learn more about these two exciting EDC projects, and their contribution towards achieving 50/50 by 2020!

**Index Terms** — digital libraries, digital resources, gender-equity, STEM

## INTRODUCTION

The Gender & Science Digital Library (GSDL) is a digital library developed by the Gender and Diversities Institute at Education Development Center, Inc (EDC). The GSDL is a highly interactive, on-line resource that has identified a vast array of exemplary science, technology, engineering, and mathematics (STEM) resources aimed at encouraging girls and women to pursue engineering education. It also provides educators at all levels with valuable resources necessary to help prepare these students, who represent a largely untapped labor source, for careers in engineering and science. Resources provided included targeted lesson plans and courseware; analysis of national and international retention strategies for women in engineering and science; on-line mentoring opportunities for students and educators to connect with each other and engineering professionals in the field; scholarship, fellowship, internship and special program information for women in engineering, and much more. The Gender & Diversities Institute's work focuses on humanizing technology, and using the lens of gender and its intersections with race, ethnicity, economic status, disability, and sexual orientation to deepen our understanding of

critical social problems and to create effective solutions through technology. The GSDL is one such unique solution to the complexity of effectively using on-line information resources.

Searching for Web-based educational resources using search engines can be a time consuming and frustrating endeavor. The overwhelming volume of resources available on-line can make finding high-quality content nearly impossible. Most digital collections and search mechanisms present a number of challenges for educators in both formal and informal settings including: the overwhelming variety and scope of the collections; the fragmentary nature of materials; search engines not designed for average users; teachers' lack of experience in using non-textual resources; and the on-going struggle between in-depth inquiry and curriculum breadth [1]. Teachers often cite inappropriate materials and the lack of knowledge about using the Internet effectively as further obstacles to using the Internet to find digital resources [2].

Digital libraries, such as the GSDL, offer a way to bring scattered digital resources together in a coherent and accessible framework. A digital library is a highly organized collection of electronic resources that makes searching the Internet for a particular topic much more efficient and productive. While search engines cover a wide range of subject areas, digital libraries are more narrowly focused around one or a specific group of disciplines. Digital libraries attach content-specific and highly descriptive metadata (descriptors/keywords) to describe each item in the collection. When a user conducts a search in the digital library, it is this metadata that is searched. Search engines, on the other hand, search "blindly" on an item's content and the results obtained may only indicate that a particular search term appears somewhere in the item, and not whether the overall content of the item is relevant to the search. Unlike some web-based resource databases which direct users to the abstracts of books or articles the GSDL provides instant access to the full, digital version of resources (PDF files, web sites, applets, audio/video segments, etc). In addition to producing more useful results, digital libraries can also offer other content specific resources and services, such as newsletters, which search engines cannot provide.

In addition to information availability, STEM educators also need digital resources and search mechanisms that serve their needs in context to how they find and use information in their classrooms. Digital library developers need to better

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understand and incorporate educators' mental models for retrieval and integration of digital information into the digital library design process. In addition, the voices, perspectives, and interests of women, people of color, and other under-represented groups are not often reflected in the design and development of Web-based educational resources since they are not well-represented in that workforce. Finding resources that reflect and support inclusive and equitable education with high expectations for all students continues to be a critical component in teaching and learning. To this end, the Effective Access project is exploring:

- How STEM educators use, and would like to use, digital resources for lesson preparation, instruction, and professional development.
- How developers of digital resources understand the unique needs of high school STEM educators.
- How educators find Web-based resources.
- Types of technical and educational supports educators want and need in digital libraries.
- Design features of digital libraries that meet the needs of STEM educators.
- Relationship of gender/race/ethnicity to educators' perceptions and use of digital resources.

### **NEED AND SIGNIFICANCE**

The need for resources and research such as the GSDL and Effective Access projects are strongly supported statistically. The majority of women who enroll in postsecondary engineering programs are likely to change their course of study. Women who are already working in engineering earn far less than their male counterparts. In 1997, male engineers who had received degrees 25-29 years ago earned approximately \$10,000 more than their female colleagues [3]. Many reasons for the lack of women in engineering have been speculated on, including the negative image women have of the field, the male-dominated classroom and workplace, and the lack of female role models. The National Science Foundation's 2000 report on Women, Minorities and Persons with Disabilities "both indicate that men and women differ little in labor force participation, but that women were more likely than men to be employed part time and to be unemployed; that women doctoral scientists and engineers employed in educational institutions were less likely than men to be tenured or have the rank of full professor; and that women scientists and engineers received lower salaries than men." [4] In 1996, women constituted 55% of all undergraduate students, but only 19.0% of undergraduate engineering students, and only 8.5% of all employed engineers [5,6,7]. Such discrepancies are indicative of the current climate for women in engineering.

Yet, despite recent economic downturns, demand for workers in engineering and other technology-related occupations continues. For example, with a national information technology (IT) workforce of 10.4 million,

employers anticipate that approximately 425,000 will go unfilled because of a lack of applicants with the required technical and non-technical skills. This increase is expected to remain steady with 18 million IT workers are projected by 2006 [9]. Women are an untapped labor source that could solve the shortage of highly skilled workers and provide insight into the development of new products and services to meet the needs of a diverse population.

The clear lack of diversity at all levels of engineering education and professional placement is of great concern. Valuable perspectives and experiences that could lead to varied interpretations of how STEM is created, taught, and applied are missing. The problem of recruiting and retaining girls and women in engineering has led to the creation of numerous organizations, studies, programs, and products over the past two decades. Efforts to create gender-equitable learning environments, to provide young women with the confidence and academic background to pursue high-level STEM courses and careers, are often individualized and lack the comprehensiveness to have a lasting impact.

As a repository of exemplary STEM work the GSDL makes individual efforts have more impact and effect towards lasting change. The GSDL is a member of the NSF-funded National STEM Digital Library (NSDL), a comprehensive STEM education portal for K-16+ learners and educators, aimed at becoming the largest heterogeneous collection of its' kind. As a member of this massive, international collection, the GSDL collaborates with other collection builders to fine tune the use of metadata, improve the libraries' search capabilities, and create user services. As the only collection in the NSDL with a gendered perspective, the GSDL aims to become the clearinghouse for gender-equitable STEM education materials and a repository of a vast majority of the research published in this area.

### **BUILDING THE COLLECTION**

Within the GSDL researchers, educators, and students can find high-quality digital resources and services to encourage the equitable integration of resources into the classroom, to facilitate community building, and provide guidance to young women interested in pursuing STEM education and employment. The collection includes selections of programs which encourage female students to pursue high-level STEM courses and engineering careers; research regarding the recruitment, orientation, and retention of students in higher education STEM programs; professional internship and placement opportunities, and other career development information. The GSDL is continually growing and evolving as new features and services are added to facilitate the dissemination of research and best practices in gender-equitable STEM teaching and learning.

Resources included in the GSDL are evaluated based on criteria for STEM accuracy and gender equitableness. The GSDL has drawn on the work of EDC projects such as the

Gender Equity in Mathematics and Science (GEMS) project and the Women's Educational Equity Act (WEEA) Resource Center, as well as projects such as Rutgers University's Douglas College Program for Women in Math, Science, and Engineering (GirlTech-<http://girlstech.douglass.rutgers.edu/>) to develop its equity criteria. Electronic resources which are likely to appeal to girls include components such as personal identification, contextuality, flexibility/ motility, social connectivity, and graphic/ multimedia concentration.

Studies have also shown that girls and women prefer to work and learn in collaborative environments in which communication and problem solving plays a large role. While men tend to treat technology as an end in itself, women are turned off by the masculine focus on the power and speed of the machine [10]. Women are more likely to engage in a task in which they help someone or create a product someone can use than participate in a competitive task in which the goal is to beat ones opponent or a clock. Miller, Chaika, and Groppe found that women prefer electronic resources that allowed them to move freely from one section to another without having to "win" or "beat" the level as in most popular software games [11].

Further, research has shown that women learn more effectively when they can connect what they are learning to their own lives and real-world situations. Women have historically been drawn to subjects such as the arts and humanities in which skills such as story telling, communication, and real-world problem solving are essential. STEM has traditionally been taught in a linear, systematic, and abstract manner with which women have difficulty connecting. Teaching that demonstrates how STEM can be used to solve problems and produce useful products has been shown to be more appealing to young women. Current research also supports the notion that technology which is designed with these factors in mind (to engage women) will also engage men, although the opposite is not true.

Building upon such work, the GSDL has also developed criteria to evaluate the merit of resources' inclusiveness with respect to gender, ethnicity, and disability. With respect to gender, resources in the GSDL must be of high quality STEM content and should fulfill at least one of the following criteria:

- Use inclusive images of girls or women
- Target girls or women (research, camps, scholarships)
- Identify women role models or mentors in STEM
- Address concerns relating to gender-bias and/or discrimination
- Be written/developed by a woman
- Acknowledge women's contributions to STEM
- Involve teamwork and communication skills
- Involve hands-on activities that produce a tangible result or product

- Link STEM to other topics of interest such as arts and humanities
- Use STEM to solve real-world problems

## USING THE GSDL

In addition to a vast array of exemplary STEM educational resources, the GSDL collection also provides educators at all levels, in formal and informal settings, with resources necessary to help them get students interested and prepared for careers in STEM. Materials include:

- Lesson plans and courseware
- Retention and instructional strategies
- Information about camps, internships, fellowships, scholarships, and post-doctoral opportunities
- Organizations which support female STEM students and professionals
- Hands-on activities and projects
- On-line simulations and demonstrations
- Research on STEM and gender equity

Lesson plans have been developed to demonstrate how traditional topics can be taught in a more gender-equitable manner using resources found within the GSDL. For instance, one such lesson plan asks students to discuss why bridges are important, what occupations are associated with bridge construction, and to read about women who contributed to the design and development of bridges and other structures. Students are asked to design and build a bridge using commonly found materials. Another such lesson plan asks students to read about male and female aviators, to consider how gender affected their experiences, and to create a model airplane or glider.

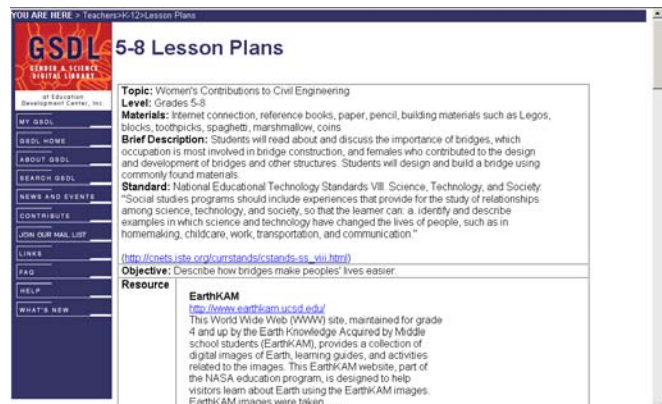


FIGURE 1  
LESSON PLAN FOR GRADES 5-8: WOMEN'S CONTRIBUTIONS TO CIVIL ENGINEERING.

Additional services and features included in the GSDL include links to Headline News and Current Events, Contribute, Links to other digital libraries, and My GSDL. Through the Contribute page, users can complete an

application to submit a resource to the GSDL, become a reviewer, or make suggestions to collaborate with the GSDL. Resources submitted in this manner are first reviewed by staff and are then reviewed by two experts to ensure the resource aligns with gender-equitable criteria and is accurate in content. Through My GSDL users can log-in to save resources in their own folder or “recipe box.” This feature will be of use to users who do not have time to complete a search in one sitting, who wish to develop their own collection of resources for future use, or who want to share searches and resources with others.



FIGURE. 2  
My GSDL.

Such features and services, as well as others to be added such as on-line chat forums and annotated resources, serve to create a vehicle for connecting parts of the educational and industrial sectors which have not been able to communicate in the past. For example, in an on-line forum, K-12 educators would be able to communicate with university faculty and STEM experts and vice versa; students would be able to access and communicate with educators at all levels. An annotations feature, in which users can comment on resources they have used, will serve to create new knowledge and facilitate the dissemination of research and best practices amongst educators.

Additional future endeavors for the GSDL include building a gender-fair, on-line career development system using the resources of the GSDL. The system would be designed for use by girls and adults who work with and influence female students in both formal and informal learning environments. An on-line career development system would address historical biases in career development theory and resources, as well as allow girls to ‘experience’ technology. Further, there is a great need for quick, efficient access to STEM career information in a manner that also provides a context for use. A comprehensive system offered through the GSDL would make finding and using the information much simpler and more appropriate to user needs. It could increase the use of the best teaching practices by providing the tools, training, and data needed to build equitable instruction, inquiry, and

discovery into all aspects of education and career development.

## EFFECTIVE ACCESS RESEARCH

Educators need to be supported in their efforts to effectively and efficiently locate digital resources that address the needs of their diverse learner populations and to incorporate these resources in their work with students. Without “effective access” to Web-based resources, teaching and learning with digital resources runs the risk of being adopted solely by a small group of technology enthusiasts, further widening the gap between male and female participation in STEM education and employment.

GSDL has made significant strides towards the development of a comprehensive, user friendly resource for a broad audience. These and other lessons about inclusive and equitable STEM education learned through projects at the Gender & Diversities Institute are informing Effective Access project’s research. These projects explore how male and female educators from different racial/ ethnic groups perceive and use digital resources and how they use diversity as a lens to align resources with their students’ needs. By examining these issues, we hope to stimulate the development of educational tools that meet the diverse needs, interests, and learning styles of our heterogeneous society.

The Effective Access project is furthering this work by paying particular attention to the self-perceived needs of high school level STEM educators who are struggling with the difficulties of selecting quality materials and tailoring those materials to meet the needs of their diverse student populations. The project has begun an examination of the cognitive frameworks used by teachers in order to understand how they search for digital resources and how they conceptualize the integration of digital resources into their teaching. Through a parallel study of the cognitive frameworks used by developers in the creation of digital resources, Effective Access hopes to inform the future of how digital materials are developed and distributed to educators.

We have begun a literature review of related evaluation and research, an analysis and evaluation of existing tools and search engines, and created and distributed surveys (on-line and paper versions) to high school level STEM educators and digital resource developers. We will be conducting focus groups with a select number of survey participants. Through our investigation of how teachers search for and use educational resources, we hope to create a bridge between the needs of teachers and the work of developers. We anticipate that some perceptions held by developers about teachers’ technological fluency and the use of Web-based resources will be very similar to what teachers express. Other ideas will be glaringly different.

By synthesizing the similarities and differences among teachers' and developers' responses, we will create a framework for developing effective digital resources. The framework will integrate the results of our surveys and focus groups with what is known about the roles of gender, culture, race/ethnicity, language, and disabilities in on-line teaching and learning. Such a framework is necessary because the number of digital library collections is rapidly growing and developers of these digital libraries have limited knowledge of educators' searching and integration needs. This framework will help developers create Web-based educational resources that better meet the needs of STEM teachers in high schools and informal educational settings, and further inform the development of the GSDL and the NSDL as a whole.

## CONCLUSION

Digital libraries and the effective use of technology in the classroom, can make the difference in whether or not students use technology resources to further their STEM education and career preparedness. Through the effective use of technology we can positively impact student achievement in order to encourage recruitment and retention into STEM degree programs, and ensure their successful transition into the engineering workforce. In order to help students, particularly girls and women, learn and achieve in preparation for the future, educators must have access to exemplary digital resources such as the GSDL, and learn how to effectively use such resources to engage their students. In these ways, we will be able to collectively achieve the goal of 50/50 by 2020!

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