
AC 2012-4555: EDUCATING THE GLOBAL ENGINEER: IT TAKES A VILLAGE!

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Educating the Global Engineer – It takes a Village

Graduates of engineering programs are increasingly called upon to take on international assignments, thus becoming global engineers. As a result, engineering education is progressively focusing on preparing graduates to become global citizens who will find and implement innovative solutions for the complex issues facing our global society. Being able to successfully work as an engineer in a foreign country requires in addition to high professional competency, that one speaks the official language and be familiar with the cultural, ethical, business and technical practices and expectations of that country. In response to the increased emphasis on educating engineers for global citizenship, the engineering curriculum is changing to address the increased internationalization of engineering education. In this context, engineering libraries are also called upon to assess their role in supporting academic programs with global reach and to find new ways of becoming active partners in educating the Global Engineer. This paper highlights collaborative work and actions taken by one library to increase its role in assisting engineering students in their endeavor to prepare for a global professional experience.

The extent of the library's involvement with international aspects of engineering education is typically limited to ensuring seamless access to library resources and reference support for students studying abroad. Libraries may also be involved in initiatives such as the "Semester at Sea" offered at University of Pittsburgh, where a librarian was part of the academic team which led the 65 day summer trip and provided support to students engaged in the program "Following the Global Supply Chain"¹. Educating global engineers however, requires much more than what libraries have typically been asked or offered to provide. It takes a proactive attitude on behalf of engineering libraries to raise awareness of the full range of services and resources that the library can draw upon to assist in the process of educating the global engineer.

Defining Global Competence

From reviewing the literature, it appears that while Global Competence is increasingly used to describe attributes and skills desirable for all engineering graduates, the term is still considered to be an "elusive concept"². Parkinson identifies 13 attributes of global competence; to rank the top five attributes of global competence, the author surveyed the attendees to the NSF Summit on the Globalization held at the University of Rhode Island, Nov 5-6, 2008³. The respondents of the survey identified the top 5 attributes of global competence as follows:

1. Can appreciate other cultures.
2. Are proficient working in or directing a team of ethnic and cultural diversity.
3. Are able to communicate across cultures.
4. Have had a chance to practice engineering in a global context, whether through an international internship, a service-learning opportunity, a virtual global engineering project or some other form of experience.
5. Can effectively deal with ethical issues arising from cultural or national differences.

Grandin & Hedderich summarize all the nuances of describing global competence in their chapter "Global Competence for Engineers" as follows: "In sum, an interculturally competent person understands that all individuals' views of the world have been unknowingly shaped by one's own culture. This person also has sufficient knowledge of the target culture, including

history, geography, customs and so on, to put observations into a meaningful perspective. He or she also understands the importance of clear communication. Also, given the fact that culturally important and unique words often do not have a direct equivalent in the English language, the culturally competent person understands the limitations presented by a lack of proficiency in the other culture's language"². In a nutshell, to gain global competence as an engineer, along with the pre-requisite solid technical knowledge, one must also be proficient in the language of the land, and must understand the culture to the extent that all experiences can be interpreted through the lens of that particular culture.

So, how can this lofty task be accomplished? Mazumder points out that US academic institutions have the educational foundation necessary to combine technology and culture in the engineering curriculum. The current educational models in practice can take the form of international concentrations and minors, cultural courses and cultural components in dual degree and simultaneous degree programs, global simulation projects, international internships and team projects, study abroad and global courses. Her comprehensive overview of the educational models concludes with recommending a Global Skill Tool Box to prepare engineers for global competence⁴. The set of skills, which can prepare students for international assignments, according to Mazumder, consists of:

1. Foreign language capability and insight into communication style.
2. Knowledge of culture, customs, social behavioral and group thinking pattern of a region (e.g., differences and commonality, verbal-non-verbal communication, differences in negotiation styles).
3. Knowledge of global technology, foreign education system, and business practice.
4. Capacity to accept, adapt and integrate with other cultures; ability to bridge the differences.
5. Awareness of the phenomenon of cross-cultural refraction as an essential result of crossing cultures.
6. Self knowledge and knowledge of technology and culture of your own country.
7. Knowing that it is alright to seek a "cultural oasis" in a foreign country where you rest upon your own culture.
8. Learning the art of diplomacy in intercultural communication.
9. Ability to work on projects with multicultural teams face-to-face and through distance.
10. Ability to use all the computer and state of the art technology that makes this world an interconnected world.
11. Seeing oneself as a part of this diverse universe, a world person.

The literature offers a number of examples of successful courses focusing on developing global competency skills and awareness of cultural differences, such as "Engineering Cultures" offered at Virginia Tech and Colorado School of Mines⁵. Other courses, such as "Technology, Globalization and Culture" offered at Iowa State, focus on preparing students for leadership roles by examining the impact of globalization. The course offered in Fall 2007 has received corporate sponsorship and was led by faculty in the departments of Mechanical Engineering and World Languages and Cultures. Lectures, including an array of prominent speakers, are available online (<http://www3.me.iastate.edu/me484>).

While we may not have a set definition for Global Competence, there is wide agreement that global competency skills can only be developed through a combination of international

experience and classroom teaching. Also, as highlighted by all authors of the works referenced above, in order to educate the global engineer, partnerships are crucial; no single department or school can provide the breadth and depth or resources necessary to accomplish this goal. Partnerships are needed to create and teach courses with an international and global essence, to establish and manage international exchanges and programs and to bring forth those elements of the student's academic experience that would foster and develop the attributes needed to become a global engineer.

Educating the Global Engineer at Princeton University

With a university motto which states that we are “in the nation's **service** and in the **service** of **all nations**”, it is only natural that in the last decade, the School of Engineering and Applied Science (SEAS) has brought forth a renewed focus on educating engineering students to become global citizens. To reach this goal, the School uses a two-fold approach: 1) enrich the academic curriculum to bring global perspectives to technological applications and 2) encourage engineering students to study abroad or participate in international internships to use their work to advance societal change in areas of need.

To enrich the academic curriculum and offer students courses that build global competence and skills, partnerships and interdisciplinary connections are crucial. At Princeton, B.S.E. students must complete a minimum of seven courses in the humanities and social sciences (foreign language courses at the 107/108 level or above are included in this requirement). New courses offered by the Keller Center for Innovation in Engineering Education were developed by bringing together faculty from History, Philosophy and Sociology departments with Engineering faculty. By bringing together faculty from across the academic spectrum, courses such as “Radical Innovations in Global Markets”, where students explore how areas such as satellite imaging, global positioning, internet search engines, and pandemic vaccines have a profound impact on foreign policy are now part of the School's curriculum. Courses with a global character are added every semester. For example, “Global Environmental Issues” and “Global Technology” examine the potential role of global technology in the development of rural and urban areas within the developing world (the course is taught at the Mpala Center as part of the Tropical Biology Program in Kenya). Other courses take on a closer look at various regions of the world, such as “Oil, Energy, and the Middle East”, which explores the issues surrounding global energy supplies, oil's unique economic properties, and its role in shaping the political economy of the Middle East and U.S. strategic interests in the region. These courses bring more depth and variety to the already rich offerings at the university, giving more opportunities to engineering students to prepare for global careers while meeting the humanities and social sciences requirements.

With increased focus on educating engineers for the global economy, SEAS is continuously expanding the reach of its education programs through international collaborations and exchanges such as the newly established REACH International Exchange Program (participating institutions include Ruhr University Bochum, University of Duisburg-Essen and TU Dortmund and The Hong Kong University of Science and Technology and ASTRI, a Hong Kong government sponsored research center). The mission of the REACH program is “to offer students on both sides an eight-week, hands-on research internship in an international context.

Participating students will be immersed in a new culture while working on a research project in their field of study. The program aims to “broaden students' perspectives and enable them to become globally minded researchers and technologists”⁶. These programs, along with numerous other opportunities available through the University’s Office of International Programs, enable engineering students to work or study abroad for various periods of time, ranging from a few weeks to a full academic year. Within the university, the School of Engineering has the reputation of being the most proactive in encouraging students to study or work abroad; at every year’s engineering freshman orientation, there is one loud and clear message that the Associate Dean of Undergraduate Affairs passes on to all new students: “Welcome to Princeton, we are glad to have you here, but please go away.”

Through the combination of a globally relevant academic curriculum and international work and study programs, Princeton University engineering graduates gain both the academic and professional training and the international experience necessary to build a successful global career. Figure 1 illustrates all the elements of the educational process employed at the university to reach this goal.

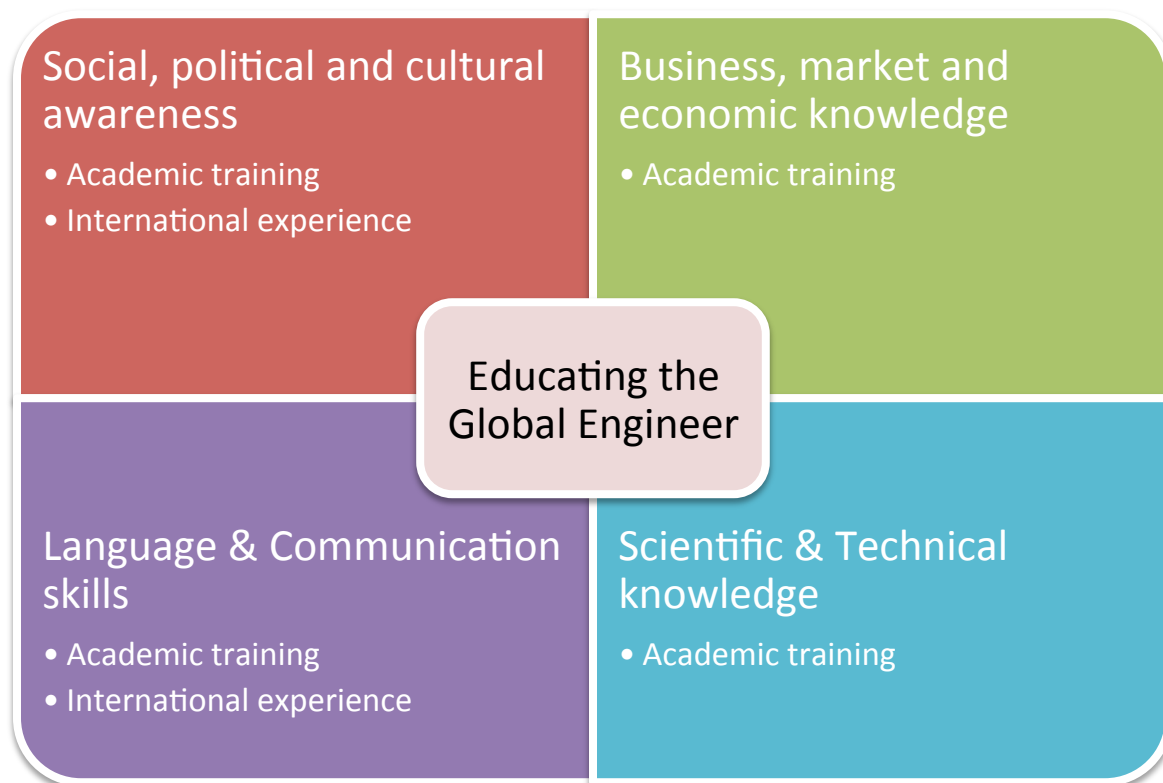


Figure 1. Elements of the global engineering educational process

How can the library help?

Following the example of the Engineering departments, where faculty develop and teach courses in partnership with colleagues outside Engineering departments or partner with institutions across borders, engineering librarians also need to seek opportunities to partner with colleagues outside the science and technology areas of specialization. It is crucial that we work closely with

colleagues whose library and information expertise covers political, cultural and social aspects of various regions of the world, to ensure a comprehensive level of service and assistance in educating global engineers. Figure 2 presents the broad information landscape (with selective examples) that libraries need to chart for the students training for global assignments.

Engineering librarians can guide students to the technical and specialized literature such as standards and technical specifications in use in various countries, but they must invite and join efforts with colleagues outside the science librarianship fold to successfully fill the picture beyond the scientific and technical information.

Global Engineer Information Needs

S&T	Foreign Languages	Social & geo-political	Cultural & ethnographic	Market, business & economic
<ul style="list-style-type: none"> •Curriculum support •Environmental issues •Standards •Technical specifications 	<ul style="list-style-type: none"> •Language learning tools •Dialects 	<ul style="list-style-type: none"> •Political governance •Laws •Demographic data •Displaced populations 	<ul style="list-style-type: none"> •Customs & traditions •Value systems •Religions •Philosophies 	<ul style="list-style-type: none"> •Global industry profiles •Key industry players •Supply chains and systems •Trade & commerce networks •Regulatory landscape •Professional ethics

Figure 2. Global engineer information needs

Despite shrinking budgets, libraries still collect materials to support engineering academic programs; so one thing to consider is if we are building collections to support the global engineering curriculum. Traditionally, we focused our collection development efforts on acquiring the materials that support the scientific and technical education of an engineer, but how many times do we think about buying books about the economical, political and societal change brought on by technological developments? How many books on globalization are engineering librarians with selection responsibilities actively collecting? And if responsibility for these areas is outside the scope of an engineering librarian, are we working closely with our colleagues from social sciences to ensure that our academic collections reflect and support the global aspects of the engineering curriculum?

Moving into action

In an attempt to answer these questions, the Engineering Library at Princeton University has embarked on an initiative of raising awareness with all university library departments about the global engineering education efforts and to partner and cooperate with library departments outside the Engineering Library to bring all relevant resources and services to the engineering students. By analyzing the elements of the existing educational process for engineering students, the library has identified new areas of involvement. While the Engineering Library already had in place services and processes to assist with the academic training in areas of scientific and technical education and business, market and economic education, the library had no involvement in the academic training or international experiences of students meant to raise

social, political and cultural awareness or to develop language and communication skills. In these two areas new partnerships and services have been explored and launched during the current academic year (see items marked with * in Figure 3).

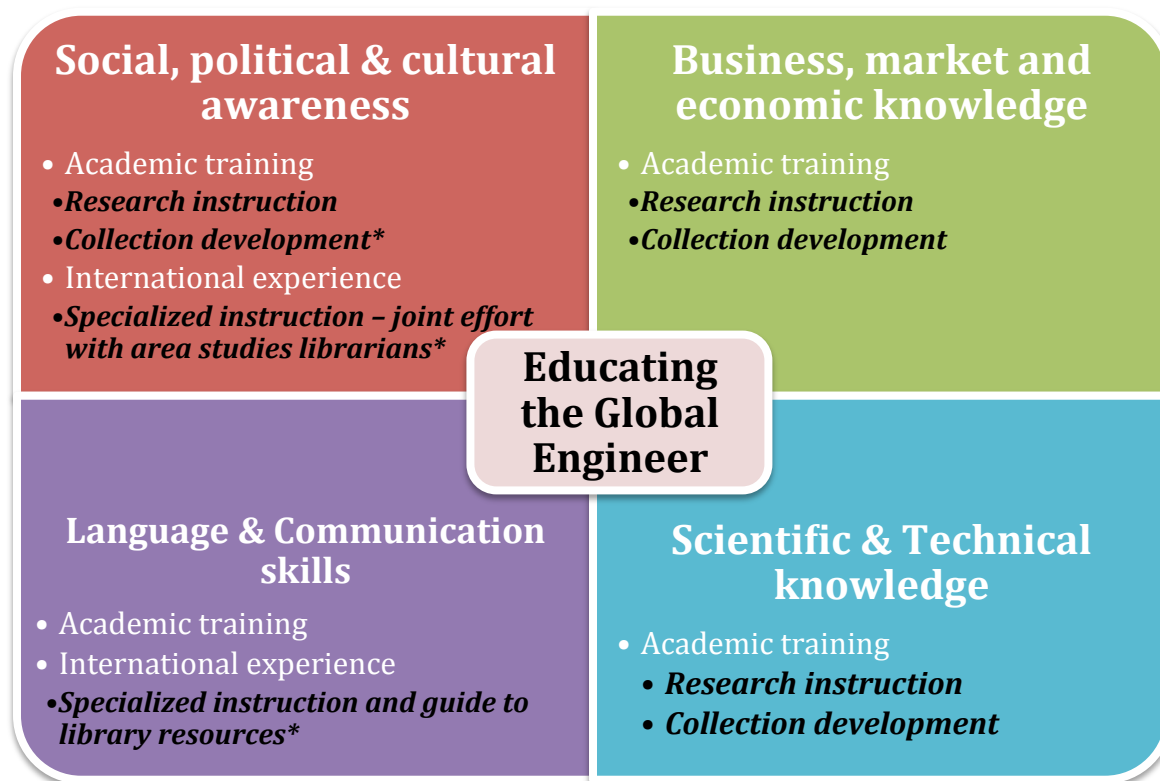


Figure 3. New library initiatives to support the global engineering curriculum

The first step undertaken by the Engineering Library was to assess if our own collection development efforts up to this point, have supported the new courses and areas of inquiry with a globalization aspect. To this end, an analysis of the book (print) acquisitions activity of the Engineering Library has been conducted (other emerging areas of inquiry such as nanotechnology, biotechnology and materials science have been included in the analysis). The results showed that the range of LC classes for books purchased for the Engineering Library has broadened up significantly, beyond the traditional QA72 and T classes. Despite the significant increase in e-book purchases over the past 5 years (which is not taken into consideration in this analysis), the numbers of print books purchased in subject areas relevant for the global engineering curriculum, such as economic, social, and political aspects of technology (identified by LC classification and interdisciplinary treatment by the approval vendor), has increased significantly in the past 5 years (Figure 4). This increase has been strictly in response to faculty requirements for course reserve materials for the new courses introduced by the Keller Center.

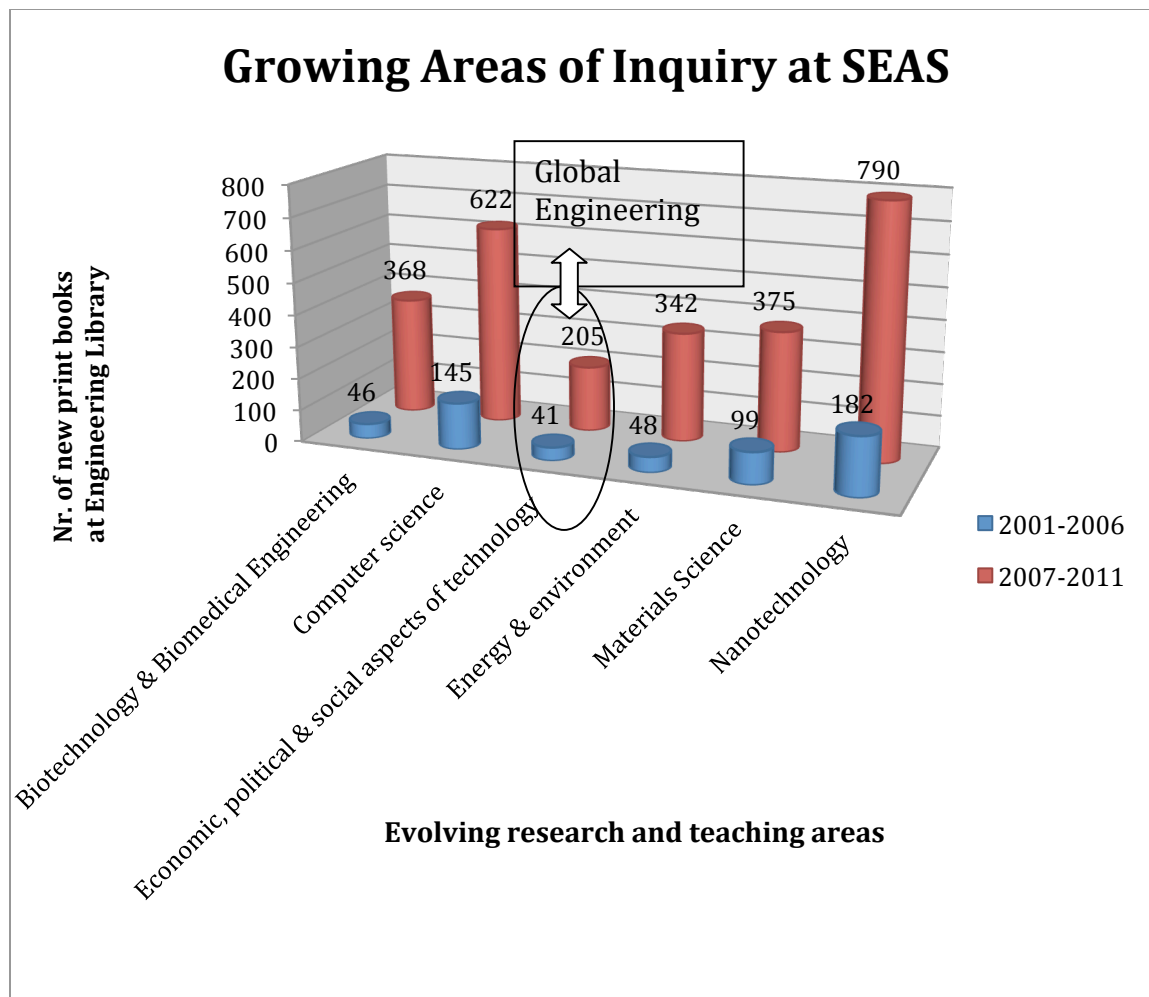


Figure 4. Growing areas of inquiry at SEAS

While the Engineering Library can sustain a certain level of collection development to address the political and social aspects of technological development in some areas of the world, it is definitely beyond the scope of the engineering collection to build comprehensive research collections in area studies. This should however not stop engineering librarians from pursuing collaborative efforts to ensure the institution's library builds the collection necessary to support the education of global engineers. Despite the fact that libraries have various organizational structures, which dictate different models for collection funding, opportunities to partner and seek funding support for collections beyond technical and engineering materials should be actively explored.

Following the engineering collection analysis, the Engineering Library has initiated a series of round table discussions with colleagues who have area studies collecting responsibilities, in an effort to ensure that the university library will continue to build a strong and vibrant "global engineering" research collection. It was apparent quite early in the discussions, that the level of collaboration and effort coordination between engineering selectors and area studies selectors could be significantly improved.

The round table discussions conducted explored the following issues:

1. Does the Engineering collection reflect the geographical trends in the output of scientific research? The increase in scientific output from Asia and other parts of the world is undeniable. While the quality of these publications may still be in question, according to SCImago Journal Rankings⁷, impact factors for engineering and science journals from these parts of the world have been on the rise in the past years.
2. Can we increase coordination of area studies and engineering collecting efforts to shape the engineering collection to reflect what is going on in the world?
3. How does the library promote its existing area studies resources to engineering students?
4. Is there a role for area studies collections in helping students develop contextual knowledge of society and cultures that they are called to transform? Can area studies librarians assist in preparing engineering students for global citizenship?

As a result of the round table discussions, a number of actions and projects have been undertaken. First of all, a unified vision for a “global engineering” collection was established and a commitment was made that all parties will continue to work together to ensure its future development is cohesive. Librarians with selection responsibilities in area studies and the engineering librarians have agreed to collectively assess the strengths of the collection. Feedback from area studies specialists about new publishers and resources that should be pursued along with the gaps identified by the engineering librarians formed the foundation of a long term collecting strategy. On a broader scale, bringing the global aspects of engineering education into focus, led into further discussions on how the various library departments and units can work collectively to support discipline based collections with multiple interdisciplinary relations, such as engineering.

The other action taken was to update the profile for the engineering approval plan to broaden the coverage to specific geographic areas corresponding to places where the university offers internships and study abroad programs, as well as to extend the plan to include titles with interdisciplinary treatment. The collecting focus for the engineering library has actively shifted towards areas of the world with high output of STM research and scholarship, such as Asia and South America and selective collecting in other languages than English has been initiated. To this extent, specific subject areas have been identified (Engineering, Soil & Water Management, Computer Science, and Energy) and funding has been allocated to support a new area studies approval plan (LC-Delhi), which includes these subjects. Ongoing referrals for acquisitions are taking place between engineering librarians and Slavic and Eastern European and Latin America bibliographers.

To support the activities of the Keller Center for Innovation in Engineering Education, a resource guide (http://libguides.princeton.edu/global_engineering) has been created for Global Engineering Education to highlight all relevant library resources, which address the global competence attributes. As the Center’s programs grow and solidify in various regions of the world (India, China, France along with Germany and Hong Kong) more guides to resources specific to these regions are being developed. The guides have been adopted by the Keller Center as research tools and the engineering librarians have been invited to present at all orientation sessions for students traveling abroad.

Conclusion

Engineering librarians can make a difference and bring considerable contributions in the process of educating the global engineer, when the right partnerships and collaborations are forged within the larger library institution and outside. However, this requires a shift in our philosophy, as we tend to create in our profession solid “silos of excellence”, on strong foundations of technical and scientific knowledge. Our students are challenged to learn and explore new territories (literally and metaphorically) so we must also be bold enough to step out of our own silos and serve as catalysts to bring together all that the library institution has to offer (both human and educational resources), and pass it on to our students. It may take time and effort to reach the point where the “village” is truly brought together to raise the “global engineer”, but by reflecting and acting on the following ideas, the mission can be accomplished:

1. It is crucial that librarians be tuned in and aware of the global engineering education efforts going on in schools and departments.
2. Engineering librarianship is a truly interdisciplinary and global discipline. Familiarity with the scientific and technical research tools centered on English-language scientific output is no longer sufficient if we want to make significant differences in the students’ global educational experience.
3. Engineering librarians need to learn about resources and tools relevant to global engineering curriculum outside the STEM realm. This can only be achieved by collaborating and working with area studies colleagues to identify specific tools and resources that can help students understand cultural differences and help them improve inter-cultural communication skills.
4. A proactive stance is needed to ensure that students traveling and studying abroad are fully aware of the library services and resources available to them even though these resources may lie beyond the Engineering Library’s web portal.

It is hoped that these first small steps taken by the Engineering Library at Princeton University to actively get involved in the education of engineers for global assignments and citizenship, will lead to new opportunities for collaboration with the School of Engineering. As new initiatives in global engineering take form at the University, the library will actively pursue opportunities for further involvement. We have already forged strong collaboration and coordination within the library with area studies librarians to build relevant collections and to provide research instruction; this has been a valuable learning experience, as typically there have been few opportunities to build work relationships between area studies librarians and engineering librarians.

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