Reaching Beyond Engineering to Achieve Best Practice in Global Learning

Dr. David DiBiasio, Worcester Polytechnic Institute

David DiBiasio is Associate Professor of Chemical Engineering and Department Head of ChE at WPI. He received his ChE degrees from Purdue University, worked for the DuPont Co, and has been at WPI since 1980. His current interests are in educational research: the process of student learning, international engineering education, and educational assessment. Collaboration with two colleagues resulted in being awarded the 2001 William Corcoran Award from Chemical Engineering Education. He served as 2004 chair of the ASEE ChE Division, has served as an ABET program evaluator and on the AIChE/ABET Education & Accreditation Committee. He has also served as Assessment Coordinator in WPI’s Interdisciplinary and Global Studies Division and as Director of WPI’s Washington DC Project Center. He was secretary/treasurer of the new Education Division of AIChE. In 2009 he was awarded the rank of Fellow in the ASEE, and in 2013 was awarded the rank of Fellow in AIChE.

Dr. Terri A. Camesano, Worcester Polytechnic Institute

Professor Camesano is Assistant Dean of Engineering and Professor of Chemical Engineering at Worcester Polytechnic Institute.

Ms. Natalie A Mello, The Forum on Education Abroad

Natalie A. Mello is Vice President for Member Services and Training at The Forum on Education Abroad. She oversees a range of initiatives that include programs to train members in the Standards of Good Practice though the expansion of workshops, Standards Institutes, Fireside Dialogues, and other programs. Natalie joined the Forum in 2011 after serving as Director of Global Operations in the Interdisciplinary and Global Studies Division at Worcester Polytechnic Institute (WPI). She also served as an onsite advisor for WPI students as they completed degree-required projects in Venice, Italy; San Jose, Costa Rica; and Washington, DC. She has been involved with national education abroad organizations for many years, particularly in the area of risk management, and is a recognized expert in responsible risk management for off-campus experiences. Natalie previously served as the Chair of the Advisory Council for The Forum on Education Abroad, and chaired the Forum’s 2008 Annual Conference as well as co-chaired its first stand-alone Standards of Good Practice Institute in 2011. She has published and presented in the areas of engineering education, education abroad and educational outcomes assessment.

Dr. Stephen James Kmiotek, Worcester Polytechnic Institute

Dr. Kmiotek has more than 30 years of experience in academics, the chemical industry, and consulting engineering, particularly in the fields of chemical process safety management and environmental engineering. He has worked and managed operations in manufacturing and in research and development and has designed environmental control systems for companies as diverse as pulp and paper mills, foundries, organic and inorganic chemical manufacturers, printing facilities, semiconductor manufacturers, mechanical assembly operations and dozens of others throughout North America. In his role as a Professor of Practice, he brings the lessons and practical examples from diverse background to the students at WPI.

Dr. David DiBiasio, Worcester Polytechnic Institute

David DiBiasio is Associate Professor of Chemical Engineering and Department Head of ChE at WPI. He received his ChE degrees from Purdue University, worked for the DuPont Co, and has been at WPI since 1980. His current interests are in educational research: the process of student learning, international engineering education, and educational assessment. Collaboration with two colleagues resulted in being awarded the 2001 William Corcoran Award from Chemical Engineering Education. He served as 2004 chair of the ASEE ChE Division, has served as an ABET program evaluator and on the AIChE/ABET Education & Accreditation Committee. He has also served as Assessment Coordinator in WPI’s Interdisciplinary and Global Studies Division and as Director of WPI’s Washington DC Project Center. He was secretary/treasurer of the new Education Division of AIChE. In 2009 he was awarded the rank of Fellow in the ASEE, and in 2013 was awarded the rank of Fellow in AIChE.
Reaching Beyond Engineering to Achieve Best Practice in Global Learning

Introduction

Certainly we all realize that our graduates need to function effectively in a global marketplace and will address complex engineering challenges that cannot be solved by technology alone. Our students must understand engineering practice in a global/societal context and know how to solve problems that involve political, social, cultural, and economic issues that are intimately connected to engineering issues and people affected by these engineering challenges. One of the most effective ways of providing our students these learning experiences is through education abroad opportunities. Yet less than 4% of US engineering students study abroad and there has been little growth in the past two years.

It is also well established that experiential, project/problem-based learning with an emphasis on acquiring new knowledge and applying and integrating previous knowledge can be very effective structures for enhancing student learning. These structures engage students in open-ended, ambiguous, authentic activities; and usually involve teams. It is learning that goes beyond what can be accomplished in the classroom.

When experiential learning (we will use that term to include PBL) is combined with a properly designed education abroad experience, the results are better than either experience alone. The “experience” provides an authentic context where students work on “real” projects with “real” people; they include social/cultural issues and forces students to engage ambiguity, multiple constraints, and human issues connected to the specific engineering challenge. The benefits of authentic learning, and assessment, are well established in the educational scholarship literature.

The traditional assumption is that students must learn fundamentals before they can successfully attack significant open-ended problems. How can students solve difficult open-ended interdisciplinary problems before they've actually learned some of what they need to know in order to solve them? How can they do this in different culture when a significant language barrier exists? The answer lies in intentional program design—combining technical and general education electives in an experiential, interdisciplinary project. And, it also lies in proper preparation, project and team management, and in providing multidimensional assessments that support the academic enterprise.

In this paper we present the WPI international education model with some examples. We include some assessment results that demonstrate the superiority of international experiential learning over on-campus experiences and how some of the problematic ABET criteria can be addressed by global student projects. We also draw from the field of education abroad to illustrate the standards of good practice expected by experts outside of engineering. Those practices represent aspirational levels that, we argue, engineering disciplines should strive to achieve.

WPI Educational Goals
For 40 years, WPI’s educational goals have been “to lead students to develop an excellent grasp of fundamental concepts in their major; to lay a foundation for life-long renewal of knowledge; to gain a mature understanding of themselves; and, most importantly, to form a deep appreciation of the interrelationships among basic knowledge, technological advance, and human need”. Although classroom work is part of the major structure for achieving these goals, the curriculum includes an interdisciplinary (ID) project during the junior year and a senior year research project in the students’ major. In the past 15 years, students completing one or more of these projects abroad have made our program one of the largest in engineering education in the US. More than half complete their ID projects at one of our 30 project centers throughout the world as part of our Global Perspective Program (GPP). Most students complete their senior year project on campus, but global participation is growing. In chemical engineering about 20% participate in our senior global projects, but overall over 80% of chemical engineering majors complete at least one project experience off-campus.

The ID project requires student teams to “research, solve, and report on a problem examining how science or technology interacts with cultures, societal structures, and values. Project objectives include enabling students to understand, as citizens and as professionals, how their careers will affect the larger society of which they are a part.” The senior year project, in the major, “should demonstrate… skills, methods, and knowledge of the discipline to… solve a problem… representative of the type to be encountered in one’s career. Activities encompass research, development, and application, involve analysis or synthesis, are experimental or theoretical, emphasize a particular subarea of the major, or combine aspects of several subareas (p. 17: http://www.wpi.edu/Images/CMS/Pubs-Catalogs-Ugrad/UGCat14-15FinalWEB.pdf).”

Instructional Design and Project Structure/Logistics

As described elsewhere: “The GPP instructional design is based upon situated learning theory that includes authentic activities, contexts, and assessments. It provides collaborative knowledge construction and opportunities for explicit articulation of knowledge during the learning process… Authentic learning environments seek to place students in situations that mimic the way knowledge will be used in professional practice. Learners have access to both WPI and host country experts… Collaborative activities provide multiple roles, and multiple opportunities to engage material.”

In WPI’s global program, each project requires 4.5 credit hours of preparation and 9 credit hours for the project itself. So in an academic year the experience is a major part of a student’s academic load. Students prepare during the quarter before leaving campus, and then are on-site working full-time on the project for the following quarter (2 months). The global program is coordinated through our Interdisciplinary and Global Studies Division. Faculty and staff in that division provide academic instruction and additional preparation (cultural, language, health and safety) for the ID project. Academic preparation for the major project occurs within each engineering department while the global division again provides additional preparation similar to the ID project.

All projects are generated by our local in-country collaborators and are facilitated by WPI faculty who serve as project center coordinators. This insures that the projects are important and
relevant to the local sponsor, address a current local need, and also meet WPI’s academic goals. Some brief examples follow.

**Interdisciplinary Project Example (ChE, ME, MGMT, Bio students)**

*Sponsor: The City of Venice, Italy*

This interdisciplinary group of students helped develop a possible plan for recycling in the historic center of Venice. All garbage and recycling is collected by boat on a daily basis. The project involved a complex consideration of politics, economics, technology, logistics, and people issues. Garbage and recycling collection boats have different designs, and there exist a complex set of traffic patterns for collection, many of which were based on historical reasons rather than logic and most of which result in unnecessary boat trips. In addition to the engineering issues, recycling was not generally adhered to so addressing incentives and education was critical. The result was a plan that would allow for significant decreases in trash that needs processing while collecting much more recycling material without adding pollution from excessive boat trips. Implementation will result in significant environmental benefits.

**Major Project Examples: (ChE Only)**

*Sponsor: École Nationale Supérieure des Industries Chimiques Nancy, France*

For several years, undergraduate chemical engineering students from WPI have conducted biochemical engineering and energy-related research in the labs at l’École Nationale Supérieure des Industries Chimiques in Nancy, France. For example, in 2014, two students studied the degradation of commercial hair dyes in a UV-oxidation reactor. The increased use of a number of azo-based hair dyes, some with unusual color properties, has resulted in impairment of water quality in France and in Europe and conventional treatment methods have not been fully effective. Students are comparing the initial impairment, and the effectiveness of the UV-oxidation, on a number of these commercial dyes, and natural dyes found through the developing and developed world (such as henna), using a combination UV visible spectroscopy and toxicity testing. WPI students work under the daily direction of ENSIC faculty and graduate students, who also constructed the reactor and developed the basic analytical techniques. WPI students, working in conjunction with WPI faculty and ENSIC personnel, then tailored the systems and analysis to the specific dyes. WPI faculty help direct and provide analysis through weekly video conferences and e-mail. Ultimately, the team anticipates that the work will lead to a solar-powered oxidation system, suitable for use in treating wastewater in both the developed and developing world.

*Sponsor: Shanghai Jiao Tong University Shanghai, China*

Currently it is estimated that a large percent of the world’s freshwater supplies are polluted to the point of being unsafe to drink. This is especially a problem in developing countries where environmental standards often lag behind those of more developed countries. People in these countries also often rely heavily on local water sources; the infrastructure to transport fresh water may be limited. With a growing world population, obtaining potable water is one of the great challenges of the 21st century. Therefore, there is a great need for technologies to ensure safe drinking water. These projects build on the educational background of chemical and environmental engineering students. Typical projects involve ultra-filtration or reactions to remove harmful contaminants.
The students of Shanghai project center at WPI are co-advised by WPI and SJTU (Shanghai Jiaotong University) faculty. Our SJTU collaborators develop the project scope and objectives. WPI faculty spend one quarter preparing students on background and preparation of a research proposal. During the second quarter, students travel to SJTU where they work full-time in the SJTU research lab. SJTU provides detailed technical supervision, access to labs, assistance with on-site logistics, and support for non-academic issues or problems that might develop. Some recent project topics illustrate the types of projects and the relation to the global/local challenge of engineering clean water.

- Removal of natural organic matter and heavy metal using charged ultrafiltration membranes.
- Adsorptive removal of inorganic pollutants from nuclear power plant wastewater using modified zeolite nanocomposites
- Optimization of membrane ultrafiltration for organic matter removal
- Removal of dye from textile processing effluents using charged ultrafiltration membranes

**Multilevel Assessment**

Details of the multilevel assessment can be found in reference 3 but it is appropriate to summarize some of that here. WPI has used student, faculty, alumni, and program level assessments to evaluate program success and student learning against educational goals. The data is used for continuous improvement. Without exception, the projects completed at global centers rank higher than those done on campus.

**Student Level:**

Senior exit surveys repeatedly demonstrate that students value their global experience and frequently cite it as their “best experience” at WPI. They also value the “internship-like” experience they get while satisfying a degree requirement. All projects generate a final report that is graded including a formal final presentation for the sponsor. Additionally, WPI sponsors Project Presentation Day (a day with no classes) and all project teams (global and on-campus) make presentations judged by external professionals. This day really sends the message that the project work is important. In chemical engineering typically one or more of the off-campus projects place in top 3 each year.

**Program Level Assessment**

We annually ask collaborators for their evaluation of student work. This assessment is somewhat anecdotal but the extremely high rate of returning collaborators is probably the strongest indication of local success of each global project.

The primary program level assessment occurs in two ways. For ID projects a team of trained and calibrated faculty read all projects generated in a given year and rate them using an internally generated evaluation form, with rubrics and calibration. Included in that evaluation are the appropriate ABET criteria including the difficult criteria: global/societal impacts, communication skills, contemporary issues, and life-long learning. Global project results historically always achieve higher ratings than on-campus projects. A typical result is shown in Table 1 for the non-technical abilities that may be problematic to achieve in traditional coursework.
Table 1: Average Scores for On-Campus and Off-Campus Cohorts Relative to Some Accreditation Outcomes
(The rating scale is 1=poor, 3=acceptable, to 5=excellent)

<table>
<thead>
<tr>
<th>Desired Accreditation Outcome</th>
<th>On-Campus</th>
<th>Off-Campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary team and topic</td>
<td>2.91</td>
<td>4.14</td>
</tr>
<tr>
<td>Evidence of ability to engage in life-long learning</td>
<td>2.99</td>
<td>4.14</td>
</tr>
<tr>
<td>Understand impact of engineering on society</td>
<td>2.45</td>
<td>3.33</td>
</tr>
<tr>
<td>Knowledge of contemporary issues</td>
<td>3.06</td>
<td>3.68</td>
</tr>
<tr>
<td>Understanding of professional and ethical responsibility</td>
<td>2.17</td>
<td>2.79</td>
</tr>
</tbody>
</table>

Figure 1 illustrates that overall project quality for global projects significantly exceeds that for on-campus projects.

![Figure 1](image)

**Figure 1.** Comparison of global projects to on-campus for overall quality.

In chemical engineering, all of the senior projects are evaluated biannually by an external evaluator who rates them against department rubrics. Again, the consistent results are that off-campus projects equal or exceed on-campus.
Some additional program level assessment has been the awards the program has received from the education abroad community. Such recognition confirms that the educational structures and the international collaborations we’ve established result in improved student learning and educationally productive international experiences. These awards include:

- TIAA-CREF Hesburgh Award: Certificate of Excellence
- NAFSA: one of ten institutions honored for “exemplary internationalization”
- AACU: one of its sixteen Leadership Institutions, for “its vision and program as an exemplary way of infusing liberal and global studies into pre-professional education.”
- IIE’s Heiskell Award: for innovation in international education
- And, some student work has been recognized by the Smithsonian and featured by the National Geographic magazine and channel.

Alumni Level

Recently an extensive external survey of WPI alumni was conducted to understand the long-term impacts of the program and to probe some comparisons of off-campus project experiences to on-campus projects. Ten thousand alums were contacted and a 25% response rate was achieved. Pertinent to this presentation are the results comparing experiential learning on respondents’ world views. There were statistically significant positive differences for global projects compared to on-campus projects in all six items probed:

- Understanding people of other cultures
- Respect for cultures outside of own
- Understanding global issues
- Understanding people of other racial and ethnic backgrounds
- Awareness of how decisions affect and are affected by others
- Understanding of the connections between technology and society

Use of the Standards of Good Practice for Education Abroad

Founded in 2001, The Forum on Education Abroad is the only professional organization whose exclusive purpose is to serve the field of education abroad. It is located on the campus of Dickinson College in Carlisle, Pennsylvania and is recognized by the US Department of Justice and the Federal Trade Commission as the Standards Development Organization (SDO) for education abroad.

According to its mission statement, the Forum on Education Abroad develops comprehensive standards of good practice for the field of education abroad in higher education, as well as promoting best practices and excellence in curricular design, engaging in data collection and research, conducting program assessment and quality improvement. The Forum serves institutions and organizations that sponsor and support education abroad programs for students enrolled at U.S. colleges and universities, independent of discipline. In addition, the Forum collaborates with international member institutions and organizations to identify and facilitate best practices and standards for education abroad. Ultimately, its mission is to help to improve education abroad programs to benefit the students that participate in them. Presently,
membership in the Forum represented over 90% of the US students who participate in education abroad programs.

The governing Board of Directors of the Forum formally adopted the *Standards of Good Practice for Education Abroad* in July of 2007. Currently in its 4th edition, published in 2011, the *Standards* are being reviewed and updated to reflect changes in the field. In addition to these Standards, the Forum also published the *Standards of Good Practice for Short-Term Education Abroad Programs* in 2009 and a second edition of the *Code of Ethics for Education Abroad* in 2011. The Forum's “Standards of Good Practice are recognized as the definitive means by which the quality of education abroad programs may be judged.”

For the purposes of this paper we will limit discussion to 4th edition of the *Standards of Good Practice for Education Abroad*. The Forum *Standards* are designed and intended to be implemented on an ongoing basis to respond to the practical realities of developing, managing and evaluating education abroad programs. The *Standards* are composed of three interrelated elements intended to be used together in a comprehensive and rigorous process of assessment and improvement:

- The *statements* of the standards;
- *Queries* designed to be used for assessing how well the standards are being met;
- A *toolbox* of model approaches and best practices in meeting the standards.

The Forum intentionally chose a multi-tiered approach to the implementation of these standards to reach the broadest possible audience and include the diversity of programs that represent the field.

There are nine Standards that cover the entire realm of developing and maintaining a quality, sustainable education abroad program, regardless of discipline. Standard 2 is this paper’s focus:

1. **Mission**: The organization, with respect to education abroad, has a formally-adopted mission statement for its overall operations and for its individual programs that is known to and accepted by its faculty and staff.

2. **Student learning and development**: The organization has stated educational objectives that foster student learning and development, has an established process for regularly collecting and analyzing data to assess the degree to which it is accomplishing each; and utilizes these findings to monitor, maintain, support, and continuously improve student success.

3. **Academic framework**: The organization maintains clearly stated and publicly available policies on academic matters related to education abroad; regularly reviews them for relevance and effectiveness; and implements appropriate changes as needed.

4. **Student preparation for the learning environment abroad and returning student support**: The organization has processes in place to assess student needs, provides advising and orientation support to address these needs that is consistent with the program’s mission, regularly assesses the quality of this support, and utilizes its findings to continuously monitor, maintain, support, and improve its advising, orientation, and re-entry processes.
Student selection and code of conduct: The organization maintains, and makes publicly accessible, its commitment to fair and appropriate policies regarding student selection and code of conduct.

5. **Student selection and code of conduct**: The organization maintains, and makes publicly available, its commitment to fair and appropriate policies regarding student selection and code of conduct.

6. **Policies and procedures**: The organization has in place policies and procedures that govern its education abroad program and practices.

7. **Organizational and program resources**: The organization provides adequate financial and personnel resources to support its programs.

8. **Health, safety, security and risk management**: The organization assures continuous attention to the health, safety, and security of its students, faculty, and staff, from program development stages through program implementation, by way of established policies, procedures, student orientation, and faculty and staff training.

9. **Ethics and integrity**: The organization educates its employees in and adheres to its own code of ethics and/or to the ethical principles of the Forum’s *Code of Ethics for Education Abroad*.

All of these standard statements have sub-statements to help tease out certain areas that deserve attention. And within these sub-statements are the queries (open-ended questions) designed to help one evaluate how well a program is meeting the standard. The Standard that we are concerned with for this discussion is Standard 2 that addresses student learning and development. There are four sub-statements to this Standard dealing with a) intercultural understanding, b) language and communication, c) academic growth and d) student development. It is important to note here that the second sub-statement that deals with language is not applicable to the WPI program being discussed. With the remaining 3, there are 24 corresponding queries.

Space does not permit a detailed presentation of each of the 24 queries and how the WPI program does or does not satisfy them. We present only a summary here. Copies of the complete set of standards and queries will be distributed at the presentation.

Standard 2a has 8 queries related to intercultural understanding. Our preparation requirements and international collaborations allow us to satisfy only 2 of those. The other 6 involve assessing student growth in cultural awareness in several areas and assessment of such skills and abilities. These remain a challenge to address. Hence this is a focus of continuous improvement.

Standard 2c has 10 queries related to academic growth. We fare much better here by satisfying 8 with two that are not applicable. These items all connect with the experiential
structure of our program, the curriculum design that prepares students in both technical and non-technical abilities, and the extensive assessment process we’ve implemented.

Standard 2d has 6 queries all related to student development. We likely satisfy 4 of these with one other not being applicable. The primary mechanisms justifying satisfaction are the assessment program, the faculty evaluation and grade for project work, and formal final presentation given by a project team.

Note that the eight additional standards, underlined above, present a challenging benchmark for any university to reach. However, they are critical in making the experience the best it can be for every student. As engineering departments grow international programs we must look to focusing on experiential, project/problem-based experiences wherever possible and to use the standards as a guide in constructing not just the academic parts but all the other equally important parts of a high quality education abroad program.

Summary
Despite having a long-standing, well-developed international program, WPI has significant opportunity for improvement. There is evidence that, together with our international collaborators, the program has evolved to become the major learning experience in our curriculum. And, it provides students opportunities to conduct research at many possible international sites, practice engineering, learn about themselves and others, and satisfy degree requirements. However, the next level has yet to be reached and Standards provide a high benchmark for which to strive. While engineering disciplines have ABET to measure themselves against, the broader field of education abroad has the Standards of Good Practice. Attention to the guiding principles provided by both of these bodies will ensure development of robust, quality programs. WPI needs to move beyond pride in our high participation rates, and must work to improve the experience, using standards developed by experts in the field that predates STEM efforts to send students out into the world. This is best for our students, their learning, their growth, and ultimately for the impact they will make addressing engineering challenges in areas like energy, clean water, health and environmental impacts while abroad.
References


