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ABSTRACT
Engineering programs must prepare students for a global engineering profession. In global markets, processes as well as products can be outsourced. Highly technical engineering work may be completed by large and diverse collaborations. Engineering students need to have foundational work in languages, cultural differences, and strategies for working with diverse colleagues. Historically only about 3% to 4% of engineering students pursue study abroad opportunities. Clearly, new and innovative programs must be devised to build "global competency" in undergraduate engineers. In working toward that end, the authors suggest that interdisciplinary collaborations between departments of foreign language and schools of engineering can be highly productive. To illustrate the benefits of such collaborations and to share the results of recent program assessments, this case study presents a conceptual model useful in program design and describes the evolution of a particularly intensive and effective program in "global competency" for undergraduate engineers.

Introduction

Importance of Global Engineering Competency

Global competency is essential for U.S. engineers who now compete in an international market for engineering know-how. No longer is cultural sensitivity needed only for product design destined for diverse markets. Increasingly, successful entry into the engineering profession requires significant intercultural skills in order to join efficient and productive collaborations with diverse engineering colleagues. Those colleagues may be encountered "virtually" at a distance, in person at an international site, or next door in the office of a multinational corporation. Outsourcing is increasing, not only for products but also for processes, including highly technical engineering work. Projects are distributed across sites and effective collaboration requires professionals who can work productively with colleagues who are very different from themselves.

Concern about the impact of globalization on U.S. engineers is reflected in the recent report of the National Academy of Engineering, "Educating the engineer of 2020: Adapting Engineering Education to the New Century," which includes predictions that U.S. engineers will have to be fluent in more than one language, will have to adjust to being "minority culture," and will need to "appreciate the impact of these changes on the social and economic landscape in the U.S. and elsewhere" [1]. Potential employers of new engineering graduates underscore these concerns. Paul Camuti, CEO of Corporate Research for Siemens Corporation, lists both cross-cultural sensitivity and the ability to work in teams as skills the 21st Century engineer will need to succeed [2].

Global Program Design Constraints.

Clearly, innovative programs are needed to enable engineering students to acquire global competency as part of their undergraduate engineering curricula. New programs must offer *much more* than what has been available as traditional "study abroad" courses, which have rarely included engineering coursework. Also, *more* engineering students—perhaps *all* engineering students—need to complete relevant and substantive programs if they are to achieve real gains in global competency.

To understand the low participation rates of engineering students in "study abroad" (about 3% to 4% participation over the last decade, and for last reported year of 2005, [3]), the authors asked Purdue Mechanical Engineering students in each of the past

several semesters to state their own reasons for not pursuing international programs. Consistently, students mention three reasons: 1) Time—students do not want to extend *time* to graduation, 2) Cost—students are concerned about added *costs*, 3) Dislocation—students are concerned about separation from friends, family, and work opportunities. The loss of *technical employment opportunities* during summers impacts both professional development and student finances. All these concerns constitute important practical constraints on program design.

A further pressure on students and on curriculum design is the tight integration of engineering coursework. Engineering program change is always complicated by the course sequencing needed for science and math courses that necessarily cumulate across specific courses: Mechanics I must be completed before enrolling in Mechanics II. Given all those factors, it is almost surprising that undergraduate engineering programs have a remarkable history of accommodating the changes demanded by evolving technologies. One important avenue for such change is that of interdisciplinary collaboration. Such cooperative efforts allow the evolving technologies to be infused with the resources of more than one historically separate knowledge domain. The successes of those collaborations suggest that interdisciplinary collaborations could be important for building programs for global competency.

Foreign Language Collaborations as Key

While the new "cultural" challenges of global competency may seem similar to those of emerging technical areas, important differences should be identified. When new areas in engineering require collaborative and interdisciplinary work, such efforts are often sustained by overlapping academic areas and shared research methodologies. But what if there were no shared boundaries? Global competency for engineers necessarily involves knowledge domains at a far reach from the physical sciences and mathematics that constitute the core of technical knowledge. What often happens is that engineering students are asked to knit together the disparate parts—they complete two separate degrees (e.g., University of Rhode Island) or they relocate to an international site while going forward with their engineering coursework (e.g., Georgia Tech's "International Plan").

Recent innovations in providing international programs specifically for engineering students are now employing a range of *interdisciplinary* approaches to narrow the "gap" between domains. For example, programs at Virginia Tech and at the Colorado School of Mines use diverse case studies of engineering problem definition to bring considerations of culture into the *engineering* classroom. These interdisciplinary courses integrate the disciplines of cultural anthropology and of engineering design methodology [4].

At Purdue, an interdisciplinary collaboration between engineering and foreign language faculty has been developed to provide cohesion and depth for programs preparing students for intensive international experiences, especially those available through the undergraduate GEARE program (Global Engineering Alliance for Research and Education). Students participating in GEARE have on-going interactions with foreign language faculty to prepare them for global team design work, academic study at an international (partner) university, and an engineering internship at that foreign site. Teamwork among engineering and foreign language faculty has made it possible to develop appropriate materials for each program stage, including recruitment through student participation in on-site (Germany) courses of one or two weeks duration as well as with pre-departure orientation programs.

Additionally, the cultural diversity of the engineering faculty at Purdue has made it possible to find engineering faculty to serve as on-site mentors at the partner universities, drawing upon their own native backgrounds on site. A further source of program integration is the symmetry of the U.S./Germany partnerships so that all three elements, academic study, industry internship, and design team projects, occur both at "home" and "host" sites for all participants (e.g., Karlsruhe University students complete an internship in the U.S. and continue with the global design team while studying at Purdue for one semester.

The main focus of this paper is a discussion of what the authors, an interdisciplinary team of foreign language and engineering faculty, have observed with respect to students participating in the undergraduate GEARE program. While GEARE consists of five partner universities, this report concerns mainly students enrolled in the two founding partner universities, Purdue University and the University of Karlsruhe, looking at what students say about their experience and what they report having learned.

Focus on Learning Outcomes

A focus on outcomes is particularly strategic while programs are in early, formative stages. After the return of the very first Purdue cohort that completed GEARE in 2003, the authors realized that informal discussions were not sufficient. Thus, GEARE advisors committed to learning outcomes assessment in the hope of providing a basis for evidence-based program design. The work discussed in the following sections is from the second and third cohorts completing programs at the University of Karlsruhe in 2004 and 2005. For total participant numbers, see Table 1.

Table 1: Purdue-Karlsruhe Program Learning Outcomes Participants

Cohort	Home Country	Participants
Purdue Karlsruhe 2004—2006	U.S.	**12**
Karlsruhe Purdue 2004—2006	Germany	**16**
		28 total

Additionally, the authors are proposing a conceptual mapping of the domains of expertise at issue. One benefit of the following three-dimensional space defined by "technical," "professional," and "global" is that very different programs can be accommodated and an infinitely large number of "pathways" to the "surface" (distance from origin=level of competency) can be explored in a comparative context. A visualization of these dimensions cumulating to "global engineering competency" is presented in Figure 1.

The three axes acknowledge a shared context, with the "professional" axis for the curricular accommodation of teamwork skills and entrepreneurial know-how needed to meet an increased emphasis on design and product development, the "technical" axis for the continuing core of science and math needed for technical work, and the third dimension of "global" as the new challenge. The space defined by these three axes is the shared context for the professional work that engineers are actually called upon as they "apply science" in wider, world markets. The model, as it identifies three different dimensions of engineering competence, provides a conceptual map for both global engineering program design and program assessment.

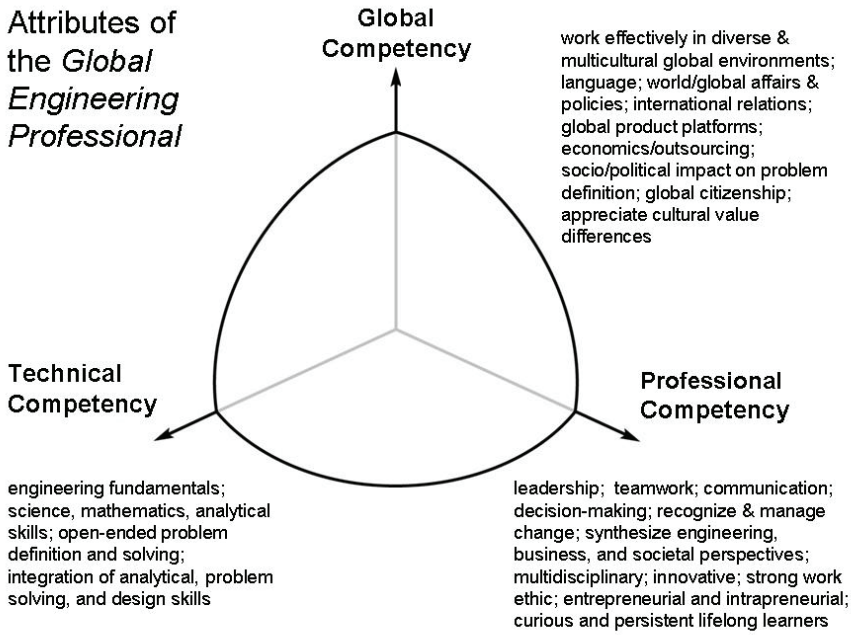

Figure 1: Attributes of the global engineering professional are conceptualized in a three dimensional space consisting of "technical," "professional," and "global" domains.

Designing Programs for Global Competency

Over the past five years, the authors have worked as an interdisciplinary team across several different projects. The purpose has been to provide a range of experiences appropriate for engineering students early in their programs. In particular, the authors wanted to encourage undergraduate engineering students to pursue intensive and varied opportunities. The team was also committed to identifying and providing program components to support student success. In the GEARE program, students would be working on a "global design team" with their international engineering peers, working one semester at one partner institution (U.S.) and also completing a second semester of engineering coursework at the other institution (Germany). The four distinct components of the Purdue-Karlsruhe Program are listed in Table 2. The "duration" column does not include pre-departure orientations and a minimum of two years university-level German language coursework.

Table 2: Purdue-Karlsruhe Program Components

Component	Location	Duration
Domestic Internship	U.S.	3 months
International Internship	Germany	3 months
Academic courses/team design	Karlsruhe	1 semester
Academic courses/team design	Purdue	1 semester

Early Commitment to Assessment. Without systematic data about program outcomes, development is problematic. Such feedback is especially important when the programs in question are innovative and experimental as well as interdisciplinary. The need for interdisciplinary collaboration extends to this assessment planning as well—which can also be expected to be more difficult to implement than where a shared knowledge core is already defined.

In the following discussion the authors will describe an interdisciplinary collaboration between the German section of Purdue's foreign language program and the Mechanical Engineering program at Purdue. The collaboration is currently providing intercultural team design experience, academic exchange between two partner universities, and industrial internships on site in each the two countries (U.S.A.--Purdue/ Germany--Karlsruhe). While this program continues to grow and evolve, the discussion presented here will concentrate on the very early phases (cohorts 2 and 3) as it is believed that these phases are most illustrative of the rewards and challenges of such efforts.

"Global Competency" Program Components

The Beginning: What can be contributed by foreign language programs? From the start, it was evident that already established regular classes in the Department of Foreign Languages and Literatures simply did not meet all the needs of students undertaking the U.S.A./Germany exchange program. In considering an optimal integration of foreign language, a number of specific questions emerge:

1. First, how much foreign language instruction is appropriate for engineering students and what levels of proficiency should be expected?

   The interdisciplinary program team decided that a foreign language competence of the fifth semester language course (GER 301 at Purdue University) would be desirable for all global engineering program students. Taking regular courses on campus here or elsewhere, testing out by placement exams, or requesting equivalent credit via transfer, considering also study abroad, these options were all *modus vivendi*. Some students had no problem taking "regular" courses. Others found that classes were large, that many course participants were simply not as motivated as they were, that some classes did not fit into their already packed schedules, and that they did not have the expected focus on engineering vocabulary. This made us think.

2. If engineering students are principally focused on their discipline-specific engineering coursework, can they also do well in regular language courses?

   The answer is yes: these highly motivated engineering students typically excel in "regular" language courses. However, the additional question could be raised. What is the best course format for these program students who are setting new standards of interest and motivation? Apparently, "regular classes" are sometimes slow paced, leading to the issue of whether more specialized courses might be appropriate for

highly motivated GEARE program participants and to other students with similar interests.

3. Should there be investment in individualized foreign language instruction?

   The German section faculty has tried to offer group-individualized foreign language instruction that could be administered outside the usual minimum enrollment figures expected by the upper administration. A series of courses in "German for Scientists and Engineers" (Purdue courses GER 223, 323) has been developed meanwhile and offered with success. That series is parallel to a series offered for "Business German" students (Purdue courses GER 224, 324, etc) with enrollment from German language students especially interested in management and business. Students can now achieve "diplomas" for both "technical" and "business" German language tracks once they have taken a total of 15 credit hours in German with at least two such specialized language courses included. They have the option to continue further in order to complete also the internationally acclaimed ZDFB ("Zertifikat Deutsch für den Beruf" or "Certificate German for the Profession"), as co-administered by the Goethe Institute in Chicago together with certified examiners here at Purdue.

   Beginning this semester, students will no longer be required to fund their own testing if they pass successfully, as their costs are reimbursed by Purdue's Krannert School via a Center for International Business Education and Research (CIBER) grant. Six such ZDfB Certificates have been granted to Purdue students this semester. With strong German enrollment figures (700 students for fall 2006) even more such certificates can be predicted. The opportunity to earn the ZDfB Certificate is of particular interest to German language students who already have a good proficiency and who would be able to use this further distinction to prepare for international careers. Diploma completion draws recognition and facilitates job searches for global engineering students in particular.

4. Should a tailored course sequence be developed for engineering students offering particular time tables and targeted to specific international opportunities?

   The German Section has been open to experimenting with and designing German language courses specifically for science and engineering students and German for technical purposes during the last five years. A proposal that was presented last semester to the curriculum committee to offer a minor in German specifically designed for engineering and science students has, however, just recently been rejected. Among the reasons given was a lack of available tenure track faculty who would be trained especially in these interdisciplinary fields of expertise and who could regularly offer these course sequences. So far, the German Section often had to rely on visiting assistant professors who were trained specifically for this but could only be hired for a maximum of two years, or the Section had to rely on advanced teaching assistants and instructors who were competent enough in the various disciplines, for example in German and in Engineering both. What is needed is continuity and committed support. One can only hope that this need will continue to be recognized by the university administration and that positions with such interdisciplinary skills will receive the funding and support they deserve, also in the long run.

These specialized program resources were certainly not a ready-made answer for the needs of Purdue students participating in the exchange with Karlsruhe. For those students, all with at least minimum competency, and having only a small window available for additional language study, special sessions were held, conducted jointly by engineering and foreign languages personnel and emphasizing particular communications tasks. One sample assignment asked students to prepare a professional introduction of their engineering interests and present that material (completed in German) to everyone in the class. One concern that emerged from that particular session was the lack of technical vocabulary in the standard German language course sequences, evidenced in almost all of those presentations. Additionally, both foreign language and engineering personnel met individually with these "first cohort" students to address their concerns and to prepare them individually for the study and work experiences ahead in Germany.

Even in the early phase of mostly "informal" consultation, the Department of Foreign Languages and Literatures Faculty who worked with the engineering (GEARE program) faculty met opposition from colleagues holding quite different views about the suitability of the program participants. The issue was whether on-site international experience should

occur prior to participants attaining an advanced level of language proficiency and whether allowing these young engineering students to go abroad so soon would mean lowering the usual standards for foreign language proficiency as normally expected from all study abroad participants. Much convincing had to be done. Now it is documented that these highly motivated global engineering program students were well worth an exception to the long established rule and that they deserve all the support for their early study abroad experience. As a practical matter, such an approach would have completely depopulated the first cohort in question, but the concerns could not be answered satisfactorily on that basis. The authors had to convince critical colleagues that even at a beginners' stage, students can learn global awareness by going abroad.

Now that the program is established, much of the content of these intercultural orientations can actually be provided by interactions with their peers from Germany, who are coming to Purdue for an "exchange in kind" of global experience. Students, engineering faculty, and internship providers have learned to coordinate their efforts to provide needed program resources without unbalancing the complexly interrelated components of the various engineering degree programs. The goal remains to expand international engineering opportunities and also to ensure that engineering students can acquire the critical language skills needed for their new assignments.

Such investments by foreign language programs must also be sustainable in light of other strategic goals important for them. By focusing on shared teaching responsibilities, shared research projects, and shared (co-located) design teamwork, all academic partners, both foreign language faculty and engineering faculty, must benefit from program development. Foreign language student populations have been energized by these highly motivated engineering program participants. In addition, engineering faculty can gain new colleagues in distant institutions and increase their own range of potential collaborations.

Cultural Competency Components: What is "contained" in "culture"?

In considering program outcomes, cultural understanding and language skills are essential for building professional-level "global" competence. That competence is manifested in the success of engineering students who perform on global (diverse) design teams and who seek and are sought by global companies for international assignments post-graduation. But what are the precursors for that competency? For academic program design, a more nuanced understanding of what students gain from cultural orientations (including language instruction) is important.

Initially, program outcomes were classified in a three-part typology:

1) **Cultural awareness**, that is to gain the understanding of cultural differences and of the impact of culture on ways of thinking and patterns of behavior both with respect to others and with a self-reflective stance that allows to think critically of one's own cultural habits as perceived in the equally valid perspectives of others;

2) **Cultural skills** involving learning how to "fit in" and to be comfortable in a different and particular cultural context that is being comfortable with the role of being temporarily an outsider while continuing to communicate effectively.

3) **Engineering skills** must be strongly developed and connected with the skills that are usually pursued in the Liberal Arts, the Humanities, or Foreign Language and Literature Departments. Students learn how to link the on-the-job experience, the academic coursework included in the program and specific to engineering together with the foreign language instruction they have had and the international communication skills that will then prove vital for their future careers. To become globally educated depends on one's own life experience with foreign cultures and with being able to integrate the international and interdisciplinary academic study and practical work effectively, thus enhancing one's own discipline-specific professional expertise, as well as one's openness becoming a global citizen.

Such a model depends on the professional context for "global competency" and is necessarily conditional upon the profession in question. Since engineers have language competency needs that differ from those of liberal arts or other foreign language students, a new fourth and sixth semester language course was instituted in German and taught on the basis of teaching materials, often from various electronic and multi-media sources, specifically designed for engineers and scientists. As a result, more advanced language students can obtain more discipline-specific

vocabulary. These courses are also staffed by instructors mindful of engineering communications contexts. While not specifically required for the Purdue/Karlsruhe program, the growth of these technical German course offerings offer important resources for those participants with the prerequisite language proficiencies.

In addition, faculty in the program have become aware that class visits by and interaction among previous and current program participants is helpful and that foreign participants can be a great asset to those who are in the process of preparing for their internship and coursework abroad. The current concern is how these interactions could be more formally integrated into the program structure itself and how such interaction could go beyond the existing individual initiatives that have been so productive. A growing cohesion among pre-departure students and just-returned participants has just been formalized as an official student organization.

Short "pre-departure" orientation sessions do continue to be offered for students. Drawing on a canon of collected readings and also using practical exercises, small student groups meet with faculty facilitation. Students have the opportunity to comment and to explore these resources, as well as to become acquainted with one another on a personal basis. When possible, visitors from partner international universities, whether student or faculty, provide valuable help in addressing student concerns and helping students to anticipate what will be required for them to be productive in their international assignments. Not surprisingly, industry internship experiences vary greatly from one site to another and student commentary on what to expect is extremely helpful, particularly as students are individually assigned to their internships in contrast to the academic phase of the program where all are together and within the university community. Additionally, the industry internship may require adjustments to a specific organizational culture, beyond those encountered in everyday or academic life. Indeed, isolation was the most serious issue encountered "on the job." Strategies for supporting students in their endeavors to build global competency continue to evolve and a brief history is provided next.

Teaching Global Competency: Intercultural and Culture-Specific Awareness

A series of study modules have been developed, including the following: acceptability of multi-tasking, diverse understandings of time and space, expectations about joint decision making, and elements of effective communication. Students begin by comparing specific situations in Germany and the US. They comment on examples from personal experience (often supplied by instructors) and complete a number of short readings. They are asked to articulate exemplary intercultural observations which are then discussed as a group. The attempt is made to make the students aware of certain assumptions and expectations which they may have taken for granted but may well not be shared by others. Such differences have to be reflected upon and sometimes negotiated carefully. Concepts of personal and professional boundaries are questioned via drawing attention to culture-specific differences in using doors, windows, walls, topics that also have distinctive meanings, especially in Germany. They learn the basics of German history and the problems of post-unification. They raise questions about their cultural assumptions and the differences they might experience in processing work related issues in a non-US context.

The evolution of these sessions owes much to a concurrent effort to offer short-term experiences on site in Germany that afforded one academic credit for students participating. For both student and faculty, the time on-site provided important experience and material for pre-departure orientation meetings. On site, it was often evident where the "expectation gaps" were and what might be helpful. The short-term experiences abroad also brought home to instructors the motivating impact of everyday life on student interest and motivation. Even brief encounters with German culture (one or two weeks for the "short course" programs during Spring Break and post-semester) have contributed to student decisions to pursue admittance to the intensive 18 month GEARE program (Purdue/Karlsruhe). A typical agenda for one of the pre-departure orientation meetings is provided in Figure 2.

Figure 2: Typical agenda for a pre-departure orientation meeting.

Also included in the pre-departure orientation meetings were examples from Ned Seelye's edited collection *Experiential Activities for Intercultural Learning,* especially Chapter 1 "Behind our Eyes" by Gary R. Smith and George G. Otero where "context" and "background" are perceived and described in diverse ways [5]. The instructors draw attention to the fact that all that is seen is usually already interpreted in culture-specific ways. Thus, the "same" situation can be seen differently by others from another culture. Such mental exercises as part of the pre-departure orientation meetings are complemented by Craig Storti's "Practical Guide," *Figuring Foreigners Out* to make the students aware of culturally engrained habits that come into question when the values of another culture contextualize things differently [6].

Short Course Synergy: A Convergence of Effort

While working with this first group of U.S. students participating in GEARE, another related program opportunity developed. The new program, a short on-site "study-tour," would allow many more students to participate in an international experience, but the entire program had to fit into the frame of one week. These "short courses" were available either during spring break in the middle of the semester or during a "Maymester" intensive period just after the close of the regular semester. These schedules have proven attractive, permitting students to complete the course and still have time available for summer commitments and employment. That schedule even allowed for the unexpected participation of one co-op student who was actually "excused" from the first week of his co-op assignment because of the value placed on the international "Maymester" opportunity by his co-op company (a major aircraft engine manufacturer). Students who participated in these short courses were assisted by discussion of relevant readings, orientation sessions, and to introductions to further opportunities offering more substantial international experience. While the syllabi for these short courses varied, all included visits to industrial sites and cultural centers, as well as sessions set aside for classroom work and interactions with partner university students. Classroom discussions were based on observations and readings concerning cultural differences, intercultural communications, and presentations on culturally specific matters, as well as foreign and local history. The automotive engineering heritage in Germany was an especially interesting and significant component for the mechanical engineering students who participated. Also, the ZKM "Zentrum für Kunst und Medientechnologie" (Center for Art and Media Technology) in Karlsruhe was of great interest to program students. Perhaps of most significance were the interactions with on-site intensive program participants who were working on design projects and eager to share their work in progress with the newcomers. Interactions were not just "on task" but included social occasions. The sessions are interwoven with excursions, including train rides and sightseeing tours, always including "factory floor" visits to partner companies, whether it is Siemens, Cummins, or John Deere. These factory visits were rated highly by practically all engineering students on their exit questionnaires.

The benefit for program development is that instructional materials once assembled and "field tested" for such "short course" can be re-purposed effectively for use in a range of additional venues, including the focus here, that of preparing U.S. students without international experience for a substantial period of work, study and team design in Germany. One particular benefit is the relatively small class size that is typical of these short courses, about 15 students with two instructors. That instructor-student ratio allowed for good exchange and feedback and the course really became a laboratory for exploring possibilities of what works for engineering students who are often encountering the broad issues of cultural diversity and global markets for the first time. These short courses proved to be an excellent recruitment tool for the long-term GEARE program with about 20% of these short course participants subsequently enrolling.

The Challenge of Limited Language Resources

In addressing the lack of second language skills in traditional engineering instruction, a couple of strategies have emerged: First, English-speaking industry personnel can provide case studies and sometimes personal experience that open the way for discussions about course materials. English speakers located on-site and often engaged in product development efforts in their organizations often experience the real complexities of cultural impact. Their awareness and involvement in such problems carries high credibility. A second strategy involves the staffing of the course—all of the short courses offered to date have been collaboratively taught, one instructor from the College of Engineering and one from College of Liberal Arts, Department of Foreign Languages and Literatures. So far, the language instructor has been a native speaker with first-hand knowledge of the cultural context and the engineering instructor has also had familiarity with global awareness issues. Contact with students who know the foreign language has proven to be a motivating factor for the participants to commit to further intensive language study.

With a collaborative approach to course design and instructional delivery and the on-site teamwork with university / industry partners, along with logistic help from the academic institution partnering with Purdue, short courses can indeed be rewarding for students and a practical solution for instructors. The longer the program has been established, the better the opportunities stand for students to have direct peer-to-peer interaction with foreign engineers. This has been fuelled by both the "local" Purdue cohort and the "global team" in residence. Student costs for the short course have thus been minimized by the infusion of "local know-how." Additionally, the history of such short courses is that they evolve as the availability of subsidies can be arranged. In the students' view any, even minor support counts as an affirmation of the importance of their international experience and gives it more weight. Such support has ranged so far from 15% to 30% of the actual cost to students. At the same time, international experience, even as a short course, is expensive relative to domestic alternatives and so costs remains a continuing concern. The growth of the program at each site means that increased on-site resources are needed. As more advanced students become involved in interacting with students before they go abroad or once they are there, as mentors for those back home, they have helped to reduce the demands on faculty for the sake of such "non-curricular" support.

Assessment: Student Perspectives

Program Background. The undergraduate GEARE program provides students many opportunities to build significant international experience in the second half of the four year global engineering program. Ideally, the student will seek and be selected for participation sometime during the first year of engineering study. At that point, a destination language can be identified and additional coursework completed in that language. During the second year of engineering study, a mutual choice is made between a global company and the student in question. After completing the second year, the student will be offered an initial "domestic" summer internship with that company, to be completed before progressing to an international assignment with the same company.

After completing the fifth semester of the engineering program, the student prepares to move to an international site, beginning with either enrollment in the partner university program or with the international internship. Ideally, the university experience is first since the faculty and the on-site design team participants (who will be returning to Purdue with the team to complete the second part of their project) provide important collective support for the transition. However, academic calendars vary so widely that the ideal sequence may not always be possible to maintain. In fact, some students' internship had to be segmented in order to accommodate academic terms of study.

Within the academic program, standard engineering coursework is completed and applied toward the bachelor degree. The key international experience, however, is that of participation in a "global team" design project where the same group of team members works together across the two phases, planning and prototyping, first at one partner institution, and then manufacturing and testing at the other institution. Ideally, the project phases can be adjusted so that access to the different strengths of the two institutions is optimized. For example, an institution with extensive "build" capability (machine shop access for example) would host the "prototype" phase of the design project. In any case, two different institutional homes provide sequential international experience for all members of the culturally diverse "global team." Whether a team is successful in designing a product such as a carousel, a vehicle with specific features, etc, is decided by an outside panel of judges and is usually accompanied by School-wide exhibit and celebration, contributing to additional recruiting for the international program. The

enthusiasm of the participants is obvious and the professional achievement is remarkable.

As is evident, the undergraduate GEARE program described here foregrounds engineering experience—in the workplace and on (diverse) global teams at the partner universities. Apart from the two year (or more) language coursework and the brief sessions mentioned, no additional coursework explicitly addressing global or cultural issues is provided as a part of GEARE. (While ABET requirements ensure a minimum competency in "world knowledge and cultural affairs," these courses are typically historical or focused on one aspect such as economics.) Just how much students gain from their "applied" experiences in intercultural contexts is the subject of the ongoing assessment discussed next.

As most available instructional materials are designed for multi-week academic coursework, or for use by re-located full-time employees and their families regardless of other courses in the given curriculum, the authors had to struggle to adapt relevant materials to the task at hand on their own. Hoping that others with similar challenges might relate to this issue, details about those materials follow, also in order to invite an exchange of ideas on how to best organize such courses and sessions, on how to design relevant new courses, and on how to effectively recruit more students for global studies.

Meeting "Human Subjects" Standards

While interviewing students and following up educational programs with surveys may not appear intrusive, that decision is not left to the individual researcher. All educational and research institutions must monitor the conduct of research that involves "human subjects." If researchers wish to disseminate findings (in contrast to "in house" use for course improvement for example), they must first secure a positive review from their Institutional Review Board. To do so, a detailed description of the planned session or sessions must be provided and minimum safeguards provided for participants, principally that participants must be free to participate or not. Further, they must be advised of their options not to participate and provided with contact information that could be used should they wish to object to any aspect of the experience. To submit a plan for review, researchers must first be made aware of the ethical issues at stake, including some history about the historical abuses that have contributed to the current investment in monitoring "human subjects" research. The findings summarized below were collated in sessions that met the approval of Purdue's Institutional Review Board, including the obtaining of approved consent forms from each participant.

The Program Assessment involved interviews with all participating students, written questionnaires, and openly shared discussions that helped to evaluate the various features of the program and to refine it further for the future. The certification process required by the "human subjects" review did raise awareness of the power structures involved in interviewing and in the publishing of questionnaire results. The authors also benefited from the wealth of historical information, and examples relating to according respect to interviewees. During the actual interview process, students participated and provided feed-back both on the written survey (appended) and in the interactive oral discussions which began with whole group discussions and then included "parallel" subgroup discussions, one for each native language group (English, German), led by native speakers (English, German). The purpose of the "focus group" approach was to add the benefit of group discussion to the responses provided individually in writing.

What Students Said

The primary focus of this assessment was to gauge the benefit of the program and its constituents to the students from their point of view and to have the opportunity to further develop the materials and strategies that have currently been identified as resources for pre-departure orientation sessions.

To elicit and record student feedback beginning with the second cohort of Purdue GEARE participants, a formal focus group methodology was employed, in conjunction with preliminary written survey responses provided by each student. The "focus group" methodology assures that "human subjects" institutional guidelines are met via both formal training for principal investigators and also Institutional Review Board (IRT) approval of a detailed session plan well in advance of the session proposed. That advance work also allowed for the use of student responses for research and publication purposes.

In addition to the meeting for the focus group session, student reports were given summarizing their experiences with the program. Surveys were completed by the students just prior to the session, and a video recording was made of the "debriefing

session" during which students discussed the individuals views presented on the written surveys (questions provided in Appendix). The potential benefit of the whole group discussion was that of drawing out commentary about each other's experiences and thus some sense of how similar these individuals' experiences were. Focus groups also have the distinctive feature of a discussion leader who can respond to comments and encourage staying on task (Morgan, 1995). In this discussion, students commented on the importance of all components of their global engineering education and confirmed the need to integrate foreign language learning and cultural awareness into their curriculum.

The written survey questions that were given to the program participants asked them to reflect upon their learning experience from a variety of perspectives. These questions are based on an on-going "exit" survey for engineering internships and co-operative education students that was initially developed to collate on-the-job experience for the purpose of ensuring that appropriate opportunities were made available to students in these assignments and, further, to assess whether students judged that their skills and academic preparations were indeed sufficient to meet industry expectations. It is interesting that whereas some students felt that their command of the German language was not drawn upon as much as they had expected and had prepared for, other students lamented their lack of better command of the foreign language, especially those who during their internship period were assigned a position with a firm not in one of the major urban centers. Experiences differed widely but confirmed the program and its features as very useful in general.

That domestic exit survey was expanded to encompass several issues relevant to international work experience, including the brief descriptions of cultural adjustments that were required, how "habits" changed over time, whether there were shifts in basic cultural categories such as "time" and "space." Students were encouraged to write briefly about events that sharpened and then shaped their awareness of cultural differences, especially those that were addressed in orientation materials.

The function of the written survey design was to elicit feedback for use at the program level, locally as well as for international industry partners, as well as to encourage analytical processing on the part of all participants. The return rate of participation was excellent, more than 90%. The hope is that the assessment activities will help students summarize their experience at a conceptual level and thus increase the likelihood of that experience becoming useful and available for future challenges.

As a final activity, an attempt was made to elicit participant observations about how students' international experience integrated with other engineering experiences, including their academic program leading to the bachelor's degree. Students were asked about three different domains: First professional competency (technical knowledge and managerial skills), second an awareness of culture and cultural differences (abstract, conceptual understanding of trans-cultural issues), third the specific, experiential "know how" developed on particular sites. This led to intricate and stimulating discussions during an evening of shared experiences. Students talked about the Purdue/Karlsruhe GEARE program, which they obviously appreciated very much and they were unanimous in wanting the program to continue. It was encouraging to all participants to think about how to become even better prepared in the future for a globalizing and already very competitive world.

Letters were also sent to industry supervisors for all the international placements, with the intent of triangulating reports of how students became (or not) more culturally skilled over time, how language usage shifted during the course of the assignments, and how satisfactory was the student preparation and performance. This part of the assessment is still underway; supervisor responses, while encouraging, have so far neither been timely nor complete.

Lastly, the purpose of the written survey was to provide a common ground for the "focus group" discussions. While the overall purpose in the "focus group" was to move toward a collaborative understanding of how the international experience had fostered (or not) change in understandings and in capabilities, the conversation was grounded in the work leading up to the international assignment—the language coursework, the orientation sessions, the discussions about particular industry opportunities. Thus, the format of the focus group moved from the "common ground" of orientation issues (cultural issues such as "time" and "space") out to divergent and specific individual experience, and then (as much as possible) back to a shared estimate of what was gained or what was changed, across everyone's assignment.

A major theme in student comments concerned the positive and empowering effects of their international

work experiences. Overwhelmingly, students reported that their technical background and their cultural preparations were sufficient for the tasks at hand which were above all communicating across cultures to effectively complete their assigned tasks, for example, building a carousel or an autonomous vehicle. Students said they had estimated that these new international assignments would be easier for them because of their preparatory experience. Looking back, the general estimate was that they had more apprehension before this assignment than was actually warranted. Further, while the cultural orientation touched on basic elementary issues, the application of it was less than expected. That is, while awareness of cultural differences was helpful, they also reported that the differences, in actual practices, were more "idiosyncratic." Individuals differed from other individuals to a greater degree than expected. Becoming more "aware" often seemed to occur at the level of particular people (e.g., supervisors) than at the level of an "entire culture." Another general theme was the corollary that others (e.g., supervisors) were often quite capable in clearing a path for the newcomer so that the institutional placement actually smoothed the way considerably for their successes and (short-term) integration.

The authors had expected to find a certain consensus among various perspectives on the international experience but very divergent experiences suggest multiple issues for future consideration. In particular, the range of technical tasks was surprising. The usual "descriptors" for these assignments did not capture the range actually encountered, particularly so far as the following issues were concerned: "friendship" expectations of immediate supervisors, the expectations for social integration in non-work hours, and the interrelatedness with home industrial units. For some students, participation in the program already included the prospect of full-time regular employment for the future after their graduation. Others did not get any such long-term invitations by their internship employers. In one of the cohorts, differing experiences based on gender were reported. A female participant had difficulties with social integration at work during her internship with a firm in Germany. Very little interaction and social integration off-hours seemed possible and she felt isolated. It was added that an even better knowledge of the foreign language would have been a benefit in dealing with these problems she encountered at the workplace. Students confirmed that they observed differences in Germany when it comes to approaches to time. One tends to be more monochrome in Germany and more polychrome in the US (for definitions of these terms see either Hall, p.15 or Storti 54-55). Whereas in Germany one must respect the Motto "Eins nach dem Anderen" (one after the other), in the US things are dealt with simultaneously and multi-tasking can always be expected. The patterns that were introduced to the students as part of their pre-departure, cultural orientation meetings were often confirmed by the students' own experiences.

In sum, students felt that the pre-departure orientation meetings had been helpful and suggested that more interaction with the German students would be an additional asset even before departure. Some would have liked to interact more in German rather than in English, even in Germany, and commented how often people in Germany tried to speak English with them once they detected an accent. It will be important to give students more confidence to apply what they have learnt in the foreign language and to insist on their own learning opportunities. Other students commented that they would have much preferred to have more of a foreign language skill while living abroad as they realized that being part of another culture is much more than simply the effective functioning at the work place. It was interesting to note that the US students felt the need to be more self-reliant in Germany and to forget about the instant feed-back they are used to receive here.

Conclusion: Integrating Student Experience and Program Development

The assessment instruments and procedures discussed here provide ways to accumulate the less "tangible" outcomes, incorporating subjective judgments of all participants, while allowing for group consensus and variants thereof. There was a surprising range of student intern experiences, as well as a lack of real consensus among students as to the precise benefits of their experience working in a company abroad. This suggests a need for more additional feedback sources from industry, as well as more nuanced communications and the opening of new channels between the academic and industrial components of the program. A preliminary attempt to secure individual review forms from each industry supervisor was not successful yet since industry supervisors tend to be far removed from those in their companies who personally interact with the students and collaborate with university partners. Such a realization also leads to a possible explanation for the large range of student experiences on the job.

There is a need to optimize student knowledge and find ways to measure and evaluate the actual technical benefit this program has to various partner companies. Some students expressed a concern that their technical skills had been underutilized in internship assignments. Students who find themselves in such situations need to be able to communicate their impressions and concerns earlier, while on-site, rather than after the fact, at the end of their internship period. Since the student assessment is based on student commentaries, it is difficult to know if any lack of involvement or effectiveness in the workplace should be attributed to deficits in professional engineering preparation, or in cultural skills or sensitivities. The uncertainty on that score leads to the question of whether personal on-site visits to industrial workplaces may be required in order to improve the experiences of both program participants and industry supervisors. During the face-to-face reviews, informal exchanges may provide essential "tune-ups" to better match student capabilities to technical opportunities. Because the typical "apprenticeship" of technical students already established is both longer and much more structured than "U.S.-style" engineering internships, uncertainty about how to gauge this opportunity remains challenging. There is the problem of more and sustained funding and access to more committed industry partners, more course development in engineering, as well as in the foreign languages and together with wider support for short courses and orientation sessions, but also for the recruitment and assessment procedures.

A Steering Committee and an interdisciplinary Organizing Committee have been established at Purdue University in order to host the 10th Annual Colloquium on International Engineering Education to take place November 1-4, 2007 at Purdue University. This will be a tremendous opportunity for the community to address any related issues to Global Engineering Education and to share their own responses and insights to questions and concerns as presented in this case study.

Appendix

Survey Questions These questions were first answered by individuals in writing (30 minutes). The same questions were then discussed as a whole group with the intent of discerning whether a consensus would emerge or whether there would be distinct subgroups with differing responses (60 minutes). Finally, the group was divided into a native speaker of the target language group (English and German) to explore any differences that participants may not have fully expressed in the "whole group" setting (30 minutes). Each of these two discussion groups were led by native speakers of either English or German.

1. Based on your total international experience associated with GEARE in both home and host country, how would you describe the degree of "cultural difference" between those two cultures?

2. Thinking back to the time before your arrival for the sojourn in your host country, what prediction would you have made about the degree of "cultural difference" between your home and your host country?

3. Specifically regarding the cultural perception of time, what differences did you experience? Please think of a specific instance of difference that you noticed at the time it happened.

4. Specifically regarding the cultural perception of space, what differences did you experience? Please think of a specific instance of difference that you noticed when it happened.

5. On balance, how would you describe the importance of host country language skills on your international experience, including both academic and also informal interactions while abroad?

6. Based on your particular experience and background, how do you view the importance of host country history and host country literature for your international experience? Please comment briefly about your own background and views.

References

[1] Committee on Engineering Education, National Academy of Engineering, Educating the Engineer of 2020: Adapting Engineering Education to the New Century. 2005, Washington, D.C.: National Academies Press.

[2] P.A. Camuti, Engineering the Future: Staying Competitive in the Global Economy, *Online Journal for Global Engineering Education*, 2006.

[3] Institute of International Education, "Open Doors"database,

<http://opendoors.iienetwork.org/?p=89217>, visited 16 February 2007.

[4] Downey, G.L., Lucena, J.C., Moskal, B.M., Bigley, T., Hays, C., Jesiek, B., Kelly, L., Lehr, J., Miller, J., Nichols-Belo, A., Ruff, S., and Parkhurst, R., The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently. *Journal of Engineering Education*, in press.

[5] G. R. Smith and G. G. Otero, "Behind our Eyes," pp. 27—37, in H.N. Seelye, ed. *Experiential Activities for Intercultural Learning*. Vol 1. Yarmouth, Maine: Intercultural Press 1996.

[6] C. Storti, *Figuring Foreigners Out: A Practical Guide*. Yarmouth, Maine: Intercultural Press, 1999.

Further Reading

B. Allert, D. Atkinson "Work in Progress—Identifying Learning Outcomes of a Multi-Semester International Program in Mechanical Engineering, *Frontiers in Education, American Society of Engineering Education,* October 19—22, 2005.

D. Atkinson, B. Allert, E. D. Hirleman, and E. Groll, "International Short Courses and Domestic Orientation Sessions for Engineering Students." *Proceedings of the 9th International Conference on Engineering Education* July 23-28, 2006.

E. D. Hirleman, D. Atkinson, E. A.Groll, J. Matthews, L. Xu, B. Allert, W. Hong, A. Albers, S. L. K. Wittig, Z. Q. Lin, and L. F. Xi, GEARE: A Comprehensive Program for Globalizing Engineering Education, American Society for Engineering Education Annual Conference & Exposition, *ASEE Proceedings*, 2004.

A. Gardt, B. Hüppauf, eds. *Globalization and the Future of German*. Berlin, New York: De Gruyter, 2004.

D. L. Morgan, "Focus Groups." *Annual Review of Sociology*, v 22 pp. 129-52, 1996.

M. W. McCall, Jr, G. Hollenbeck, *Lessons of International Experience: Developing Global Cultures*. Boston: Harvard Business School Press, 2002.

H. Flippo, *The German Way: Aspects of Behavior, Attitudes, and Customs in the German-Speaking World*. Lincolnwood, Chicago: Passport Books, NTC Contemporary Publishing Group Inc., 1997.

E. T. Hall and M.R. Hall, *Understanding Cultural Differences*. Yarmouth, Maine: Intercultural Press, 1990.