INTEGRATING STUDY, RESEARCH AND INTERNSHIPS IN A YEAR-LONG INTERNATIONAL ENGINEERING PROGRAM ABROAD

Dr. Sigrid – Berka, University of Rhode Island

Dr. Sigrid Berka is the Executive Director of the International Engineering Program (IEP) at the University of Rhode Island, and also the Director of the German IEP and the Chinese IEP, responsible for building academic programs with exchange partners abroad, internship placements for IEP's dual degree students, corporate relations, and fundraising for the IEP. Bi-annually the IEP organizes the Colloquium on International Engineering Education. Under Sigrid's leadership, the IEP received NAFSA's Senator Paul Simon Spotlight award for innovative campus internationalization (2011), and the Andrew Heiskell Award for study abroad (2012) by the Institute for International Education. Sigrid serves on the Provost's Global Education Steering Committee. In her previous appointment as Managing Director of the MIT Germany program, she built up an innovative program providing experiential learning opportunities such as internships and workshops for MIT students in German companies and research institutes, as well as MIT access for corporate partners in the MIT International Science & Technology Initiatives (MISTI).

From 2007-2009, Sigrid served as MIT Delegate for the Global Excellence Initiative (GEI-GEIP), a consortium of the best engineering schools world-wide with the mission to educate the global engineer, sponsored by Continental AG; consortium members included: MIT, GeorgiaTech, University of Darmstadt, RWTH Aachen, Shanghai Jiaotong, Tsinghua, Polytechnico de Sao Paulo, ETH Zurich, Monterrey Tech. Responsible for recruiting new universities, companies, and designing an academic curriculum.

Sigrid Berka is a native of Germany and has a Staatsexamen in German Literature, Philosophy, and Education from RWTH Aachen (1986), and a PhD in German Studies from the University of California, Santa Barbara (1990). As Assistant Professor of German Studies she taught 19th and 20th century literature and culture courses at Barnard College and Columbia University (1990-1996). Her book Mythos-Theorie und Allegorik bei Botho Strauss came out in 1991. She also co-authored an intermediate textbook for German language, Spiralen, and has written many articles on German and Austrian writers of the 19th and 20th centuries. As Associate Professor of German at the University of Rhode Island, her publications shifted to the field of international engineering education.

Walter von Reinhart

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Abstract:

The efficient design and implementation of study-abroad experiences for engineering students is crucial for the success rate and scalability of such a program. In this paper the authors describe how semester-long research experiences can be integrated into the study-abroad experience of engineering students during the fourth year of the five-year dual degree International Engineering Program (IEP) at the University of Rhode Island. While the IEP has for years been a model for integrating engineering with the languages, it has in recent years added the opportunity for students to do hands-on, experiential research before they start their internship in a company.

This research experience, if it is carefully matched with the students' engineering discipline, and also integrated into the curriculum they follow abroad, can be an excellent preparation for their internship in a company abroad, which follows the semester of study and research.

The paper will discuss

- How the IEP and its students go about finding the right match between their major and the appropriate institute at the partner university
- What the nature of these research projects is, what students have to submit to get credit and how credit transfer for this experience is being administered
- How the "Advanced Technical German" course they take at the partner university helps students integrate into their institute and make the most out of their technical and linguistic development
- Why this crucial research experience is an excellent preparation for placing students into competitive internships in companies and also for further graduate studies
- How applying both technical and linguistic skills in an applied real-world context prepares students for 21st century skills
- How graduates of the program and current IEP students who completed a year abroad assess learning outcomes and skill/proficiency gains

Introduction

The International Engineering Program at the University of Rhode Island was conceived in 1987. The program was originally designed as a dual degree program for German and Engineering majors; students received bachelor's degrees in the language as well as in their engineering discipline. Key components of the program from the beginning were specialized language courses that included instruction in technical German and a six-month professional internship with an engineering company in one of the German-speaking countries.[1] In 1995 an optional semester of study at URI's partner university, the *Technische Universität Braunschweig*, was added. The German undergraduate exchange was eventually expanded to include graduate programs in which students simultaneously earn advanced degrees in engineering from the University of Rhode Island and the *Technische Universität Braunschweig* at either the master's or the doctoral level.[2] Inspired by the immediate success of the German program, the University added similar dual degree programs in Engineering with Spanish, French, Chinese, and most recently Italian,[3] which also proved successful.

(Preparing for) The Semester Abroad

During their junior year, IEP students go through several pre-departure orientations which include: covering study-abroad paperwork and logistics; cross-cultural preparation and preparation of scholarship applications; selection of courses, research institutes and company hosts abroad, as well as preparation of resumes and cover letters in the language of the target country. In addition, some students also enroll for three or six weeks of the *Deutsche Sommerschule am Atlantik*, an intensive German Summer School Program to enhance their exposure to the target language. Participation in the German Summer School, where students can earn up to eight credits, is highly recommended, but optional. Upon arrival in Braunschweig all students take an additional Intensive German Summer course (4 credits) from mid September to mid October. During their semester of study abroad at *Technische Universität Braunschweig* they all enroll in "Advanced Technical German" which also counts as an engineering elective (3 credits), the "Intercultural Partnership Course" (IPP) which transfers back as 3 credits of their General Education Communication requirement, and a "Civilization and History" course which transfers back as 3 credits of their General Education Letters requirement. Students who still need help catching up with their language skills take an additional grammar or conversation

course (3 credits each), while more advanced students enroll in a "German in Natural Sciences & Technology" 3 credit course. Those courses count towards the B.A. in German. Students are also encouraged to enroll in an engineering lecture or a math course in German. If they pass, those courses can transfer back (according to a course equivalency sheet we developed for them) towards their B.S. in an engineering discipline; in the Spanish IEP it is mandatory to take an engineering subject in Spanish, which then transfers back as SPA 412 Engineering Elective.

Matching the Students with a Research Institute

The course load taken abroad is lighter than the regular course load dual degree IEP students take on their home campus. We therefore strongly encourage all students to also get involved for 10-12 hours per week in a research group at the partner university for one semester (120 hours work load total), and to actively browse through the lists of engineering research institutes to find one that is a good match for their major and academic interests. As students take their core courses together, having them conduct research at various institutes prevents them from clinging together as a group too much.

The value of experiential learning in engineering education has been pointed out before.[4] In fact, as the guest editors of the 100th volume of the *Journal for Engineering Education* summarize, "the most effective learning strategies require some account to be taken of the context in which the learning is useful, the need to relate ideas to previous experience."[5] The applied learning opportunity we set up for them is a special one for IEP students who have the language capacity and are enrolled at the University of Rhode Island; if other URI students in the STEM-disciplines are interested in summer research opportunities, we refer them to the Research Internships in Science & Engineering undergraduate (RISE) summer program offered by the German Academic Exchange Service[6], or to RWTH Aachen's undergraduate summer research program UROP International.[7]

In the spring or summer before departure, students then contact the heads of the research institutes, providing the background and dates of their study abroad program at the partner university, explaining why they are interested in a particular research field, and indicating what they can bring to the research group based on their prior course work, research experience on their home campus, or internship experience in a company. Some of those students may already

have begun doing undergraduate research in a lab on the home campus and wish to continue research along similar lines abroad. They attach their resume to the email and also copy the IEP director or a faculty member who might already have a connection to the institute due to prior faculty collaboration. This process is especially recommended for outstanding students who are applying for scholarship support, such as in the case of the German IEP, the DAAD (German Academic Exchange Service) undergraduate scholarships.[8] Once they are accepted by the institute abroad, the students request a letter of invitation from the head of the research group who admitted them to add to their portfolio for the DAAD grant application. The IEP usually supplies a template for the faculty member abroad to use for the letter of invitation. DAAD grant applications are highly competitive, and students who can demonstrate "contact to a research lab" by supplying an invitation letter, have more competitive applications, especially when they can show how their research abroad adds value to what they have done at home because the lab abroad has specialized equipment, or concentrates in an area that complements their work in the home lab, and thus bridges both research experiences.

Some students may be open to doing research but need help with the selection or placement. In that case the IEP director writes on the students' behalf to contacts who have hosted students previously or solicits the help of the instructor of the "Advanced Technical German" course. Such a research project will allow URI students to get a first hand impression of typical German university life in the institutes and thus contributes to their intercultural learning. They learn about different approaches to problem solving which may be caused by the host country's research tradition and environment, policy issues and university culture, and they experience different leadership styles and teamwork in multi-cultural teams.[9]

Sample Project Topics and Credit Transfer

Not all degree-granting departments within URI's College of Engineering award transfer credits for those research projects, but the majority of departments do. Students are typically able to earn three credits for a special problems course in Chemical, Electrical, Biomedical, Computer, Civil and Ocean Engineering; in Mechanical Engineering the department's curricular affairs committee however, has decided not to award transfer credit. Credit transfer requires the general "special project" credits are pre-approved by their engineering advisor on the prior approval form; that students conduct their research project during the winter semester, supervised by an

assistant or faculty member in the institute; that they finalize their project by the beginning of February; write a ten- page report about their work and give fifteen-minute oral presentations in German to the research group and also in their "Advanced Technical German" course. They then receive a grade for their efforts which the supervising faculty member transmits to the International Office so that it appears on the students' final transcript. The supervisor also summarizes the nature of the project in a one-page memo in English. The students need to bring this memo home to their engineering advisor on the home campus, who then transfers credit towards the student's engineering major. In case students request transfer credit for a particular elective, they need to translate the ten-page report into English in order to receive the appropriate credit.

Following the recommendations for best practices in research abroad,[10] clear guidelines for the students, defining essential requirements, time frame, evaluation criteria and credit transfer as well as a point-person who serves as research mentor are clearly articulated ahead of time. The following examples may illustrate how a well-designed research experience can be set up.

Case I – Three Credit Research Project in Chemical Engineering at the **ICTV (Institute for Chemical and Thermal Processing Technology[11])**
Topic: ***Surface Roughness Effects on Surface Energy***

In many processes in the chemical, petrochemical, food and pharmaceutical industry wetting of solid surfaces plays a prominent role. Typically the desired wetting behavior can range from an almost complete wetting of the surface to a complete repulsion of the liquid from the surface. Therefore corresponding contact angles vary from 0° to 180°. The Institute for Chemical and Thermal Process Engineering at the *Technische Universität Braunschweig* investigates fouling of heat transfer surfaces resulting from the crystallisation of salts. The surface energy, which is determined by the contact angle, is used as a primary parameter to characterize the deposition tendency of crystals.

Surface roughness exerts a major influence on the interaction between substrate and liquid. Different interaction conditions occur for wetting and de-wetting as the liquid has wetted the

flanks of the surface roughness after a first full contact. This results in a hysteresis effect depending on the direction of the process.

For two different substrates, stainless steel and copper, surface roughness should be changed through mechanical treatment. The influence of surface roughness on surface energy can be determined. Also two different types of coatings on stainless steel, Sol Gel and DLC (Diamond like Carbon), should be characterised with respect to surface energy and roughness. A Profilometer and an Atomic Force Microscope (AFM) are available to determine surface roughness. As these techniques cover different surface areas, some cm^2 with the Profilometer vs. 100 µm x 100 µm for the AFM, results will not be identical. A Drop Shape Analyser (DSA) may be used to measure the contact angle and from this calculate surface energy.

Evaluation: Content and main results of the project will be presented in an approximately ten-page written report and in an oral presentation, both in German.

Workload: Project scheduled for 12 weeks/ approximately ten hours per week.

Research Assistant: Contact information for a Research Assistant is provided.

The IEP encourages students to pursue a research project even if no credits can be transferred for their work. Students still benefit from the experience in many ways, from improving their technical skills to increasing their technical vocabulary, from gaining valuable cross-cultural and team work skills, to enhancing their resumes.

Case II – Research Project in Mechanical Engineering – No credits transferred
Topic: "Experimental investigations of free-kinematical forming processes for the manufacturing of hybrid structures" at the **IWF (Institute for Tool Machines and Industrial Production[12])**

Introduction and motivation

Hybrid structures are a promising approach towards economic lightweight design in highly cost-driven automotive industries. During the manufacturing process, fiber-reinforced plastics (FRP) and metals are combined to form an intrinsic hybrid compound. Therefore, hybrid parts can be specifically designed to meet the requirements which are expected during their use phase (e.g. peak loads and load paths).

In automotive production, cycle times are an essential factor for economic feasibility. Low cycle times in the implementation of FRPs, however, can only be achieved by a high degree of automation as well as fast-curing matrix systems. Structural elements are to be reinforced with endless carbon fibers in order to provide an adequate rigidity and crash behavior of hybrid parts. The production of such structures can be realized best through forming processes and pressing, respectively. However, linear pressing processes are expected to cause an undesired flow of the liquid resin, thus resulting in a disadvantageous displacement of fibers. Therefore, an alternative forming concept is to be established which allows proper resin infiltration at a minimum of fiber displacement. Fiber displacement is expected to be minimized by an incremental free-kinematical forming process which allows an independent and discontinuous process conduct.

Your research assignment

During your stay at the IWF, it is your responsibility to conduct experimental investigations regarding fiber displacement during the forming process of CFRPs. Thereby, the hypothesis of fiber displacement mechanisms explained above is to be validated. You will be provided with materials as well as an introduction in machine operations regarding the tumbling press on which the experiments shall be conducted.

- Literature review of production technologies for hybrid structures, especially for endless-fiber-reinforced parts
- Familiarization with the tumbling press, especially programming and control (seek assistance from respective members of staff)
- Planning of practical experiments, experimental approach and materials
- Conduct experiments
- Documentation of fiber orientation by means of destructive and non-destructive testing
- Continuous documentation (images and video)
- Final written documentation (10 pages in German)
- Presentation (15 minutes in German)

Benefits for and beyond Student Gains

The right match between a student's major and the focus of the research institute can be especially valuable if the research project continues work begun at the home institution or complements that experience. This sequence of research at home and abroad has the additional effect of fostering or deepening collaboration between the student and home institution faculty, and between home faculty and on-site/ program faculty and experts.

A successful student exchange depends on keeping faculty collaboration in an exchange or dual master program alive and active, and thus new faculty on both sides need to be continually introduced to one another while continuing faculty have to make an effort to keep up with developments.[13] Such collaboration is often initiated by mutual visits to each other's campus or even by ensuing joint grant proposals; sending undergraduate researchers to the faculty member abroad whose research closely matches your own, keeps the collaboration going "by proxy" when both parties on either side of the Atlantic might not find the time for repeated visits.

Exchanging undergraduate researchers makes sure, on the one hand, that the undergraduate receives optimal mentoring; on the other hand it encourages the host institution to recommend excellent students of their own to participate in the exchange program; these students may decide to attend the *Technische Universität Braunschweig* as part of the dual masters program and complete their master theses with the collaborator.[14] This set-up has the additional advantage that the undergraduate researchers, upon their return to the home campus for the 5th year of study can continue their research in the home lab, bringing back the expertise developed in the lab abroad, and also work alongside a new dual master exchange student from the TU Braunschweig whom they may have encountered in the host professor's institute.

Institute Research as a Means to Addresses the Technical German Challenge

A secondary reason why the IEP suggested in more recent years that most, if not all, of our undergraduate exchange students should engage in research in a university institute is to address the significant problems alumni reported with mastering engineering and math classes in the target language. Walter von Reinhart conducted a comprehensive, longitudinal alumni survey

which assessed the study and work abroad experience of IEP students as a professional, cultural and personal experience.[15]

This survey of 226 students who had completed the German IEP showed high overall satisfaction of the graduates with the IEP program. Of 111 respondents, only one participant indicated that he would probably not want to repeat his internship experience; two participants stated that they would probably not want to repeat their study abroad, and two participants declared that they would definitely not repeat their study abroad experience (see table 1).

If you could, would you repeat …	**the IEP program overall**	**the internship experience**	**the study abroad experience**
definitely	80.9%	82%	71%
probably	14.9%	7%	15%
maybe	4.3%	10%	10%
probably not	0%	1%	2%
definitely not	0%	0%	2%

Nevertheless, the survey also demonstrated that considerable numbers of students experienced problems during their study abroad in Braunschweig, especially with their science and engineering classes. During their semester at Braunschweig, all students enrolled in language classes; 84% also enrolled in engineering courses; 39% in culture classes, 20% in computer courses, 11% in mathematics, and 9% in business courses. Unfortunately, reliable data for the completion and passing rates of these courses are not available.[16] In written comments, several students mentioned academic problems with their engineering courses, ranging from problems to "fully understand and take advantage of" technical courses taught in German to "taking exams … was difficult" and from "I did not complete any engineering classes. I did start them but never took the exams" to "Failing both my engineering exams." Despite their training in German for Science and Technology, the students' missing linguistic preparation appears to be the main reason for their academic problems: none of the participants felt very well prepared to discuss academic and technical topics with their professors and only 11 % felt well prepared; 19% on the

other hand, felt totally unprepared to do so and 32% felt very unprepared. Consequently, only 51.2% of the participants expressed satisfaction with their study-abroad experience as a preparation for their professional careers.

The research institute placements as described in the sections above and below were developed to address this issue and to increase student satisfaction with the Braunschweig exchange. At the time of the alumni survey development of the research component of the study abroad semester was in its beginning stages, so we only have limited student assessment data on this aspect. Initial feedback to the change of adding undergraduate research has been predominantly positive—13 out of 18 students would recommend it,—but the number of survey participants was still too small to be statistically significant.

Despite the academic problems they disclosed in science and engineering courses, students nevertheless reported significant gains in certain skill areas during their study-abroad experience. While only 51.2% of participants were satisfied with their professional preparation while studying abroad, 60.2% reported significant gains in their ability to solve complex technical problems. Even more astounding are the 71.5% of respondents who reported that they gained a significantly better understanding of engineering processes and the 84.1% of participants who acquired a considerably better understanding of professional expectations and conduct.

Brief Outlook into Assessing Linguistic/Technical Skills in the other IEP Programs

Broadening our view to other IEP programs beyond the German IEP, when we look at the study abroad and internship surveys we have conducted since the alumni survey, the trend we can observe is that taking engineering or math courses in French and Spanish is higher than in German. Of the 26 students who studied abroad in France, Germany, and Spain in 2012-13, 85% responded to the survey. Of the 22 students who responded, 64% had enrolled in engineering classes.

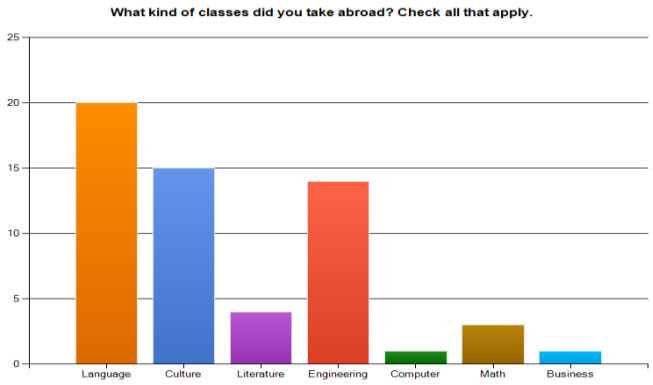

Chart 1 from IEP study and internship abroad survey 2012-13

A closer look at the language break-down reveals that 100% of the French IEPers (all 5) and 100% of the Spanish IEPers (all 5) had taken an engineering class, but only 50% of German IEPers (6/12). A reason might be that while taking an engineering or math class and transferring credits for it in the French, German, and Chinese IEP is highly recommended, it is actually mandatory for Spanish IEP students to take the Spanish 412/EGR Engineering Elective course. SIEP students get credit for this course if they pass an engineering class in their field taken in Spanish at the partner university, and they usually take several of those classes.

Evaluating the success rate we must caution that passing a technical subject in the target language entirely depends on the student's proficiency level when entering the foreign country and, of course, various factors through which students then manage to make significant gains. A few students in the Chinese IEP (and all in the Chinese Language Flagship Program[17] which aims at superior proficiency in Chinese) successfully took engineering classes; and while the majority of Spanish IEP students pass at least one of several technical classes they take, a few do not; in the French IEP the success rate is about 50%. An examination into the causes of the success and failure rate of proficiency gains and performing various language tasks in the target language would warrant another, more proficiency based paper. The chart below indicates that most students in the 2012-13 group rate their language gains in the social and informal settings higher than that in the academic and professional settings (research institutes and internships), but still believe to have made significant gains even in those more challenging applications of the foreign language.

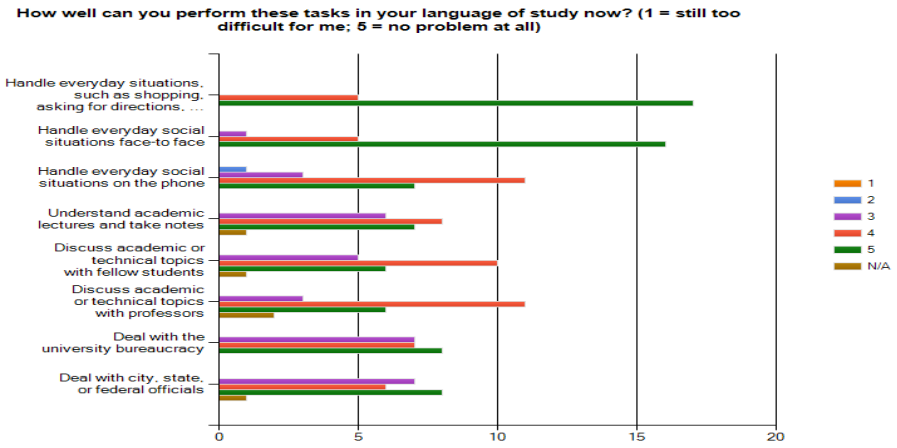

Chart 2 from IEP study and internship abroad survey 2012-13

45% of the students who responded did have a research experience while studying abroad, and of those most rated the gains in engineering skills, technical language skills and different ways of problem solving highly. Deeming the research experience valuable as a preparation for their internship is rated lower, but this can have to do with the fact that the nature of some students' internships was entirely different from their prior research experience.

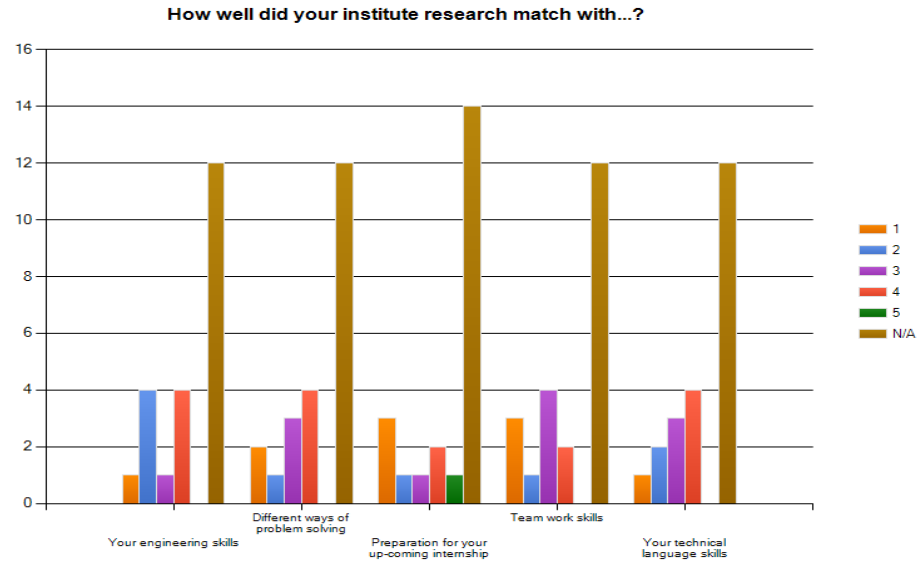

Chart 3 from IEP study and internship abroad survey 2012-13

Assessing the Work Abroad Experience

Looking back at the German IEP alumni survey, compared to their study abroad experience, participants rated their internships higher as a preparation for a professional career, but slightly lower as cultural and personal growth experience (see Table 5). Participants valued their internships less as an opportunity to gain technical hard skills (61.3%), but more as an opportunity to apply their technical skills (67.1%) and to make professional contacts (75.5%).

This assessment is partially supported by the gains participants reported in various skill sets. Ranking their skill gains on a scale from one to five, relatively few graduates reported impressive gains in hard skills, such as technical skills in their core discipline, mathematics, or computer skills. Nevertheless 60.2% of respondents reported significant gains in the ability to solve complex technical problems, and 71.6% returned with a significantly improved understanding of engineering processes. In work-related soft skills, students also returned with solid gains in skills: 93% reported significant improvement in their ability to function professionally in a unfamiliar environment, 69% gained in their ability to handle uncomfortable professional situations, and 38.1% made considerable progress in their ability to take the initiative to address professional problems. Roughly one third of participants (35.3%) acquired more presentation

skills in a professional setting, and 58.6% returned with substantially higher motivation to excel as an engineer. Students also made impressive gains in their cross-cultural skills: 74.5% significantly improved their ability to accept cultural differences, and 76.2% reported considerable improvement in their ability to work effectively with persons from a different cultural background. Given that 95% of all respondents valued their study-abroad experience as a language-learning opportunity, it is surprising that only 68.6% reported substantial gains in their linguistic skills.

Transitioning from Research to Internship

As the data above show, the internship experience is clearly a highlight in the students' capstone year abroad. Additionally, the continuation of research at home and abroad can, in an ideal scenario, extend productively to this internship, and the student can leverage his/her research for the job search. Thus, IEP Mechanical Engineering & German majors who completed research projects in the Institute for Vehicle Technology[18] often have a competitive edge in applying for and landing internships at *AUDI*, *BMW*, *Daimler*, or *Bosch*; Computer Engineers or Electrical Engineers who participated in research at the Institute for Data Technology & Communication Networks[19] or the Institute for Communications Technology[20] built this opportunity into their resumes and have moved on to *SAP* or *Siemens*. Chemical Engineering majors who joined research groups in the Institute for Chemical & Thermal Processing Technology built a strong research portfolio for themselves for their ensuing internships at *Bayer* and *BASF*. Industrial Engineering majors who are usually drawn to more management-related projects, Mechanical Engineers with a business interest have found excellent opportunities in the Institute for Automotive Management and Industrial Production[21], a research institute at the TU Braunschweig that does contract work for *VW* and even has its own research facility at the *Volkswagen AutoUni*[22] campus in Wolfsburg. Since those students had been trained during the semester at Braunschweig on projects the institute undertook for *VW* or similar applied topics, they could seamlessly transition to *VW* or to automotive suppliers like *ZF* and *Conti* for the internship part of their year abroad.

The sequence of research to internship does not always have to be so spectacular and include renowned brands. As is well-known, the enormous success of the German economy is due

predominantly to the success of the numerous small and medium size high tech and manufacturing companies, which may not be as well known as a *Bayer*, *BMW* or *Siemens*, but who are leaders in certain niche markets. They have proven to be excellent hosts for our undergraduates since they have a strong interest interacting with them and integrating them into their company life and culture especially if they have an employee championing the internship program because s/he is an alum of the IEP. Examples for mid-sized companies in which alums play a major role in placing our students are the automotive supplier *IAV*, *Beinbauer Automotive*, *Hilti*, a world leader in leading-edge technology for the construction industry, and the electric power company *TenneT TSO Offshore*.

From the Local to the Global

The research to internship sequence can be made even more valuable for students who made initial contact with a company in the U.S., then pursued research in a relevant institute at the TU Braunschweig, and finally interned at the parent company or subsidiary in Germany. Several of our Mechanical Engineering majors pursued this route first interning in the summer for *Hexagon Metrology* in Rhode Island then doing research in the Institute for Production Metrology[23] and finally moving on to *Hexagon's* site in Wetzlar, Germany. Others started out at the local Rhode Island super finishing company *Supfina*, completed research in the Institute for Tool Machines and continued working for the company's parent in Wolfach, Germany. When those students returned to URI for their 5th year of studies, they often participated in a capstone design project which was also sponsored by the same company for which they had interned both locally and globally. Several of them were hired upon graduation by those companies if they did not decide to pursue a master's degree elsewhere. Again, tying together experiential learning through a meaningful sequence of research and internships during study abroad gives the student a competitive advantage on the job market.[24]

Undergraduate Research Linked to a Greater Cause

It can also happen that a student's international research project is part of a larger agenda between the home campus and the campus abroad. This was the case for an Ocean Engineering

& Chinese major who studied at Zhejiang University simultaneously pursuing research in the university's newly established Ocean College. This College received significant help from the University of Rhode Island department of Ocean Engineering to establish their curriculum and has been sending their faculty to our campus to learn from us while also receiving Ocean Engineering faculty to teach and help build the curriculum from scratch. In this scenario, the undergraduate researcher who had been trained at home in certain geo-technical methods and had taken the courses the host university wanted to "import," was even able to play a role in the process of curriculum transfer. The additional benefit for the student in this scenario was that the research experience in China made it easier for her to find an internship at Offshore Pipelines & Risers, Inc. in Hangzhou which is a start-up out of our academic partner university in China, Zhejiang University.

Integration of the Research Project with the Advanced Technical German Course

Being engaged in a research project at the university where the students complete their study abroad semester in the target language is a demanding task, especially if the work is being conducted in the target language. To prepare the students for this particular challenge, they enroll in a course "Advanced Technical German" which continues the linguistic preparation begun in their German for Engineering content based courses at the University of Rhode Island. The program at the Technische Universität Braunschweig's Language Center focuses on preparing the students for weekly visits to research institutes, where they get tours of the institutes in German; back in the class, the students have to give a report about what they have learned. That way, they are not only exposed to interdisciplinary thinking since they hear about research in many different engineering disciplines, but they can also already practice their language skills in a safe environment when they have to give a presentation of their own research project to the researchers in their institute and to their classmates in "Advanced Technical German." Most importantly, however, the "Advanced Technical German" course is just one of the courses which were developed with the needs of foreign exchange students in mind. As mentioned above, other complementary classes all URI students take at the partner university in Braunschweig are the "Intercultural Partnership Course" and the "German History and Civilization" course. In her article on "The Sheltered Program at the *Technische Universität Braunschweig*, Germany. Facilitating Studying and Working Abroad: Best Practices," Christina Neidert emphasizes that

the integrated course offerings make an additional learning outcome possible as a result of being immersed in a research group while simultaneously reflecting on the cultural values of the host country. Thus learning takes place which goes far beyond just gaining technical and linguistic proficiency. To illustrate this point, Neidert summarizes the added value of an integrated curricular design which benefits URI students studying in Braunschweig; her statement can be read as a synopsis of what has been discussed in the international engineering education community as getting exposed to different "engineering cultures."[25]

The third of the best practices Neidert lists at the end of her article is the "Focus on the connectedness of cultural values and engineering tasks:"

> Students not only learn about German culture, attitudes and values by participating in the intercultural program and the cultural studies course, they also experience them by interacting with German students, engineers and researchers. Cultural values embedded in German society can be perceived in many different contexts in the sheltered program: e.g. attitudes towards conserving energy and protecting the environment. In the cultural studies class, they discuss why the anti-nuclear energy movement has lately gained momentum, how that has affected stocks of wind energy or solar energy companies, and how the German government subsidizes these forms of power generation. During the institute presentations in the Advanced Technical German class, they learn how German and European regulations impact the development of new engines as well as product design and production methods and materials. All of this information leads students to understand how certain values pervade society, how they are reflected in German or European regulations, and how this provides a framework that substantially influences engineering tasks.[26]

Experiential Learning in Context

The sequences of experiential learning at a university research institute followed by applied research or hands-on practical internship experience in a company as described above are part of a carefully designed and executed long-term study and work abroad program for engineers. Consequently, the Education Abroad community has developed standards of good practice which confirm that a high quality program design is crucial for the success of the student's experience abroad and the desired learning outcomes.[27] In addition, ABET as well as the academic

engineering community has long called for providing students with ample opportunities to apply their technical skills in real world scenarios.[28] The list of ABET desired student learning outcomes is reflected in the program design of the interdisciplinary IEP which bridges engineering with languages and cultures and provides research and work experience in multi-disciplinary and multi-cultural teams in a global context.

Similar to ABET, the American Council on the Teaching of Foreign Languages (ACTFL) released new national standards which are undergirded by five goals, described by the five "Cs." Foreign language learning, just as studying engineering, can be much accelerated and equally benefits from an authentic context in which it can be applied. Students participating in the IEP setting described above use their linguistic skills to communicate with native speakers of the language in an authentic context and thus their language proficiency becomes a 21st century skill.[29] Each ACTFL standard is met by the goals and the practice of the IEP curriculum which integrates language with engineering classes, and research with internship experiences in the target country and language: IEP students "communicate" in languages other than English; they gain knowledge and understanding of other "cultures"; they "connect" with other disciplines and acquire information; they develop insight into the nature of language and culture by "comparing" the foreign with their own; and they participate in multilingual "communities" like multi-cultural research teams at home and around the world.

Both the language and the technical learning experiences are integrated into each semester of the five-year program. Language learning is further augmented by the design of content-based language courses, allowing the students to enhance their language skills in courses infused with technical materials.[30] IEP language learning also focuses on cultural issues and cross-cultural communication, helping to prepare students for their year abroad as exchange students and professional interns. In the final year, after students have strengthened their language abilities with a year of in-country use, students are prepared to deal with sophisticated texts selected from the history of the culture and literature of their chosen language. By graduation most students have gained advanced-level proficiency in the language, backed by direct experience with engineering as it is taught at a technical university and as it is practiced in the country of their choice. Students in study abroad situations tend to interact and speak more; they use language

more as a tool than as an end in itself if they are engaged in a pragmatic, natural environment where problem solving in a team is required; where they can go beyond simplistic and superficial language use; where their interaction fulfills a real-world purpose, e.g. solving a technical problem in an institute or corporate team environment, that is, in a context they are passionate about.[31] We can only verify this claim from experience showing that the linguistic gains are highest for our students after the six month internship, which is also the time when they separate from their peer cohort at the partner university and are sent to their internship hosts.

For exceptionally motivated students the IEP experience with its year-long immersion in the language and culture, research and work environment abroad can lead to the desire to obtain a graduate degree as many IEP graduates have done; or to pursuing the dual path in more depth through the dual master's program which was established between the University of Rhode Island and the Technische Universität Braunschweig in 2006.[32] The integration of research, internship, and graduate school work might in certain cases lead to a change in career path, e.g. from biomedical engineering to attending Medical School.[33] Whatever choice the student might make, the undergraduate research and internship experience is in many cases a key catalyst for an exceptional career path.

Conclusion

The efficient design and implementation of study abroad experiences for engineering students is crucial to a high success rate and scalability of an international engineering program with a long-term study, research, and internship abroad component. An integrated program design, carefully coordinated with the partner university faculty and institute staff as well as company hosts abroad, has the potential to maximize effective learning in context. It also empowers student learners to develop 21st century skills and to apply them in local and global communities, contexts, and cultures. Tapping into the passion a student has for his/her first major and encouraging the student to combine the first with a second major gives the choice of majors a professional purpose. Giving students with a dual major an opportunity to apply their knowledge in a foreign country, first in a research, then in a corporate environment, sends them on a promising career trajectory. A program design which additionally requires immersing students in

long-term research and internship experiences in the target foreign language and culture catapults the engineering students' real-world experience into yet another dimension of learning.

[1] For information about the special language courses developed for engineering students, see Grandin, J.M. and Kirchner, D., "German and Engineering – ein interdisziplinäres Programm an der University of Rhode Island, in *Wirtschaftsdeutsch International: Zeitschrift für sprachliche und interkulturelle Wirtschaftskommunikation*, WDi 1/99, pp. 109-119; Grandin, J.M.and Dail, J. "German and Engineering at the University of Rhode Island: Preparing Students for the Global Workplace, in Lernwelten: Eine Zeitschrift des Goethe-Instituts für Deutschlehrende in den USA, Heft 3, 2000, pp. 9-10; and von Reinhart, W., "German for Science and Technology: Teaching Strategies for Beginning Students, *Die Unterrichtspraxis/Teaching German*, 34.2, 2001, pp. 119-32.

[2] For a more detailed description of the International Engineering Program, its components and its history, see Grandin, J.M., *Merging Languages and Engineering: Partnering Across the Disciplines*. Syntheses Lectures on Global Engineering, ed. by Gary Downey and Kacey Beddoes, Morgan & Claypool 2013.

[3] Initially the Chinese program offered a Bachelor's degree in Engineering with a minor in Asian Studies. The B.A. in Chinese was approved in 2011, and the first dual degree recipients in Chinese and Engineering graduated in May 2012.

[4] See e.g. Beddoes, K., Jesiek, B. K., Borrego, M. "Identifying opportunities for collaborations in international engineering education research on problem- and project-based learning," *Interdisciplinary Journal of Problem-based Learning*, 4 (2) 2010: 7-34.

[5] Caroline Baillie et. al.,"Guest Editors' Foreword: Advancing Diverse and Inclusive Engineering Education Practices through Interdisciplinary Research and Scholarship," in *Journal of Engineering Education*, vol. 100 (1) 2011, No. 1, p. 9, and Litzinger, T.A., "Engineering education centers and programs: A critical resource," *Journal of Engineering Education*, 99 (1) 2010, 3-4.

[6] Research Internships in Science & Engineering (RISE) see https://www.daad.de/rise/en/.

[7] UROP International, see http://www.rwth-aachen.de/go/id/wmy/lidx/1/.

[8] See DAAD Undergraduate Scholarship at https://www.daad.org/undergrad.

[9] Compare with values of an international research experience as described in Chang, Y., Atkinson, D., Hirleman, Dan E., "International Research and Engineering Education: Impact and Best Practices," *Online Journal for Global Engineering Education* http://digitalcommons.uri.edu/ojgee/4.2 (2009) 1-8.

[10] See http://www.forumea.org/documents/ForumEA-Guidelines-UndergradResearchAbroad.pdf, accessed 2014-01-05.

[11] See http://www.ictv.tu-bs.de/index.php/institut.html.

[12] See https://www.tu-braunschweig.de/iwf.

[13] See how a meaningful and long-lasting partnership between institutions can be set up in chapter 7, "Partnering with Universities Abroad," in Grandin, J. M., *Merging Languages and Engineering: Partnering Across the Disciplines*, pp. 29-35.

[14] The University of Rhode Island sends two undergraduates for one semester to the Technische Universität Braunschweig in exchange for receiving one graduate student for a year and a summer who completes the dual master degree between both institutions in an engineering discipline or completes a one-year MBA program at URI.

[15] Some of the data of this longitudinal survey have been discussed in another context in Berka, S., Papa, E., von Reinhart, W. (2013) **"**Is the International Engineering Program Producing Graduates for the Rhode Island Workforce? Do the Skill-Sets They Perceive to Have Gained Match Business Needs?" *Proceedings of the ASEE International Forum*, Atlanta, GA, June 22.

[16] The German university system only provides records of the courses a student has passed, i.e., classes in which a "Schein" was earned. There is no official record of courses a student did not pass or did not complete.

[17] A significant number of Chinese IEP students are also in the Chinese Language Flagship Program aiming at the highest possible linguistic proficiency in Chinese. Engineering students make the second largest percentage after business majors in this honors program.

[18] See http://www.iff.tu-bs.de/index.php?id=950.
[19] See https://www.ida.ing.tu-bs.de/.
[20] See http://www.ifn.ing.tu-bs.de/en/ifn/.
[21] See https://www.tu-braunschweig.de/aip/index.html.
[22] See http://www.autouni.de/content/master/en/home.html.
[23] See http://iprom.tu-bs.de/.
[24] For a more in-depth discussion of how a student's time abroad relates to the making of global careers, see Norris E.M., Gillespie, J. "How Study Abroad Shapes Global Careers," *Journal of Studies in International Education* 13(3) 2009, 382-397.
[25] E.g. in Downey, Gary, Lucena, Juan, Engineering Cultures Online 2.0; an online course developed at Virgina Tech and Colorado School of Mines. Lectures available in Purdue University's online portal GlobalHub at http://globalhub.org/resources/11, accessed January 4, 2011 and Downey, Gary L. and Beddoes, Kacey (eds.) *What is Global Engineering Education For? The Making of International Educators*, Morgan & Playpool Publishers, 2010.
[26] Neidert, Christina M. (2011) "The Sheltered Program at the Technische Universität, Germany. Facilitating Studying and Working Abroad: Best Practices," *Online Journal for Global Engineering Education*: Vol. 6: Iss. 1, Article 3. p. 6. Available at: http://digitalcommons.uri.edu/ojgee/vol6/iss1/3.
[27] See http://www.forumea.org/standards-standards.cfm.
[28] See ABET criteria on student learning outcomes at http://www.abet.org/uploadedFiles/Accreditation/Accreditation_Step_by_Step/Accreditation_Documents/Current/2013_-_2014/eac-criteria-2013-2014.pdf.
[29] The 21st Skills Map. Designed in Cooperation with the Nation's World Language Educators, spear-headed by ACTFL and the Partnership for 21st Century Skills (P21at http://www.p21.org/storage/documents/Skills%20Map/p21_worldlanguagesmap.pdf.
[30] See: Rarick, Damon O., "The Student Centered Classroom Made Real: Transforming Student Presentations in an Advanced Course on Technical German," *Die Unterrichtspraxis/Teaching German* 43.1 (2010), pp. 61-69.
[31] These observations have also been attested to by researchers at Brigham Young University when observing language learners in service learning projects abroad. See: Martinsen, Baker, Dewey, Bown, and Johnson, "Exploring Diverse Settings for Language Acquisition and Use: Comparing Study Abroad, Service Learning Abroad, and Foreign Language Housing," in *Applied Language Learning* 2010, Vol. 20, Nos. 1 & 2, pp. 45-69.
[32] For an account of how to build a dual degree program on the graduate level, see Grandin, J.M. "International Dual Degrees at the Graduate Levels: The University of Rhode Island and the Technische Universität Braunschweig, *Proceedings of the ASEE Annual Conference*, Honolulu, Hawaii, June 2007.
[33] See the chapter on Sareh Rajee's extraordinary career in Grandin, J.M., *Going the Extra Mile: University of Rhode Island Engineers in the Global Workplace*, Rockland Press Rhode Island, 2011.