Strategies for Successfully Increasing Engineering Study Abroad Participation

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Abstract

Studying abroad provides students with many benefits including the ability to work within culturally diverse settings, live and work in ambiguous circumstances, and creatively solve problems. This in turn benefits industry by increasing the cultural competence, intercultural communication skills, and adaptability of the future workforce. However, the many barriers to study abroad faced by engineering and computer science (CS) students result in only 11-13% of bachelor degree recipients in these fields nationally having studied abroad. In contrast, at Vanderbilt University typically 20% or more of our engineering/CS students study overseas. Participation continues to rise with ~30% of current seniors having studied abroad. To achieve these results, strategies to address curricular integration, language barriers, and financial obstacles are used and are described in this report.

Motivation

The overwhelming majority of Fortune 500 companies have business outside the United States, which emphasizes the need for a workforce with the cultural competence, intercultural communication skills, and adaptability necessary to succeed in global endeavors. Our school of engineering's leadership, believing study abroad to be beneficial to students in developing these and other attributes, initiated an effort some years ago to identify and develop more engineering-specific study abroad options. Students, frustrated that their liberal arts peers had more opportunities to study abroad, simultaneously pushed for more opportunities to earn engineering credits while studying abroad. Faculty, comprising a globally diverse group of scholars with collaborators around the world, have been increasingly supportive of this effort. Indeed, in 2007, the School of Engineering appointed a faculty liaison to the Global Education Office. This partnership and the actions described in this paper have steadily increased the percentage of our engineering students who study abroad, in the time it takes to change a student culture and dispel deep-rooted beliefs that engineers cannot study abroad.

Barriers

In comparison to their liberal arts peers, students in engineering have a far greater number of specific courses required, longer prerequisite streams, and at many institutions a greater total number of credit hours required. These constraints result in a substantial difference in scheduling flexibility for engineers, which is further aggravated at some institutions by a limited number of course sections within a year or semester. The demands of an engineering curriculum can limit opportunity for foreign language study, which in turn also limits options for study abroad. Consequently, it is more difficult for engineering students to spend a semester at another institution abroad without affecting time to graduation.

As for all students, financial concerns can also limit access to overseas education. Not only is the cost of studying abroad often higher than domestic study but visa restrictions and lack of connections can make it impossible to engage in compensated work while studying abroad.

National Results

It is difficult to determine the percentage of undergraduate engineering students in the U.S. who study abroad. The general difficulty arises from matching the cohort of engineering (including computer science) students who study abroad with the appropriate denominator. Given the attrition of students starting engineering study who do not graduate in engineering, it can be difficult to decide what to use as the reference value. Some of the difficulty also arises from the inclusion/exclusion of computer science within data sources regarding engineering. Acknowledging these difficulties, the following sources and methods provide relevant data that illustrate the low study abroad participation of US students in general and of US engineering students in particular.

The 2016 Fast Facts portion of the Institute of International Education's Open Doors 2016 report[1] notes that of all U.S. bachelor degree recipients, 15.1% study abroad during their undergraduate program. This of course includes all majors from humanities to engineering to education.

The Open Doors report also indicates that, of the 304,467 US students studying abroad in 2013/2014, 4.6% were engineering majors and 2.1% were math or computer science majors[2]. If we grossly approximate that the split between math and computer science is equal, then we can estimate that (4.6% + 1.05%)*(304,467) or 17,202 engineering/CS students studied abroad in 2013/2014. The same approach gives 19,118 for 2014/2015.

According to the National Center for Education Statistics, in 2014/2015, 96,858 bachelor degrees were conferred in engineering and 59,581 in computer and information sciences[3]. If we make the assumptions that all students who studied abroad actually graduated and that the 17,202 engineering/CS students who studied abroad in 2013/2014 likely graduated in 2014/2015, then we can roughly estimate that 17202 / (96,858 + 59,581) or 11% of U.S. bachelor degree recipients in engineering/CS studied abroad. Unfortunately, this estimate for engineering/CS is tainted by the inclusion of information science students in the denominator.

Given that most third-party study abroad providers and host institutions abroad set grade point minima for study abroad participation in the 2.7 - 3.0 range on a 4.0 scale and that addressing the individual challenges of studying abroad requires a sufficient amount of self-efficacy, the assumption that students who study abroad graduate is likely to be well founded. However, if the assumption that all students who study abroad graduate is unpalatable, we can consider the American Society for Engineering Education's data regarding the total full-time bachelor degree enrollment in engineering and CS within engineering, which was 543,942 in the fall of 2013[4]. From this, we can roughly estimate that one fourth of this number, or 135,986, were juniors. Attrition makes this likely an overestimate of the number of juniors; inability to declare a major in the first year may make this an underestimate. Assuming stable fall/spring enrollment and that those studying abroad were likely juniors, then we can roughly estimate that 17,202 / 135,986 or 13% of engineering/CS students studied abroad.

Data for 2015/2016 are not yet available in the IIE's Open Doors report and in the NCES Digest of Education Statistics.

Calculating Participation at Our Institution

To determine participation of our students in study abroad programs, the number of all engineering undergraduates, including computer science students, in a given graduating class who study abroad for a minimum of four weeks is divided by the total number of students in the cohort. Participation by graduating class is given in Table 1:

Table 1: % of Engineering/CS Graduating Classes Studying Abroad

Class of	% Studying Abroad
2012	20.1%
2013	20.2%
2014	15.3%
2015	24.1%
2016	26.0%
2017	30.3%*

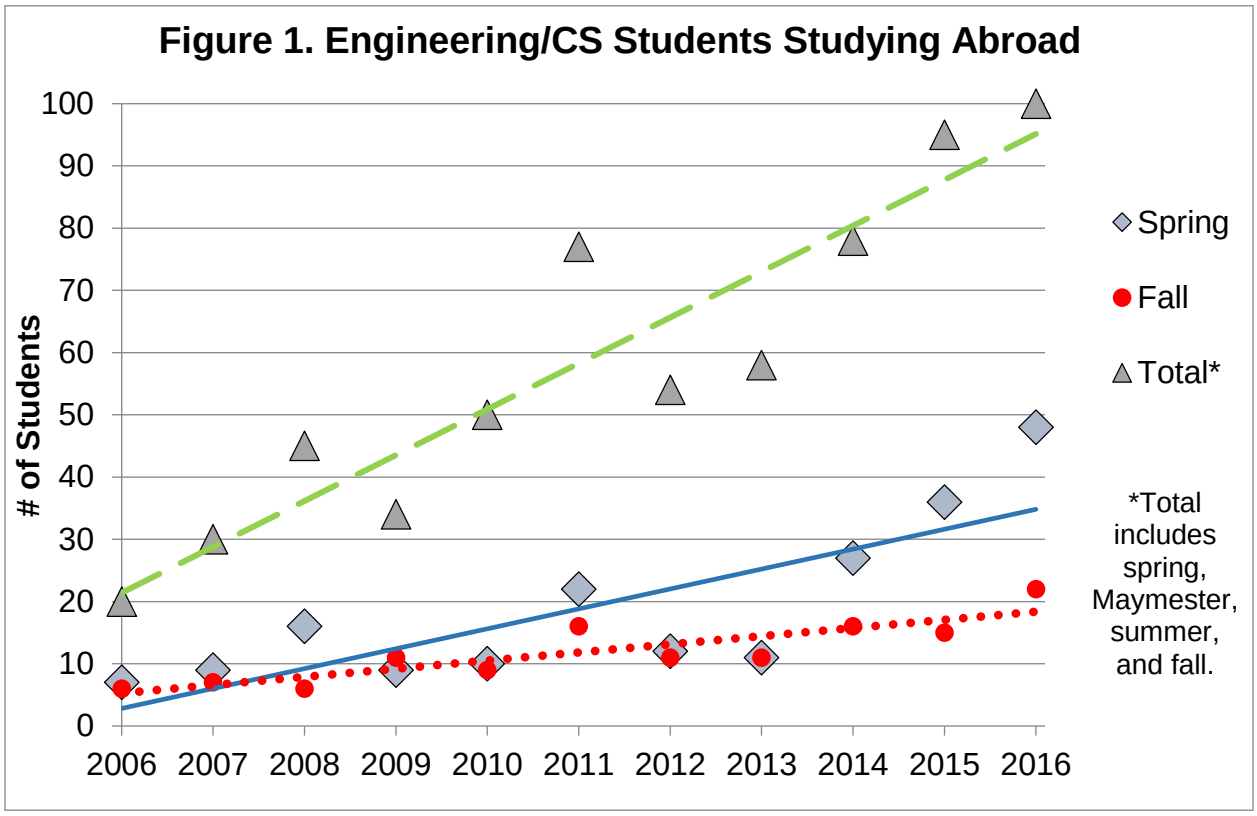
*Based on estimated number of graduates. No members of the Class of 2017 are currently abroad.

These participation rates are well in excess of the national estimates derived in the previous section.

For our purposes, international students, who make up ~19% of our undergraduates and who by virtue of coming to the U.S.A. for their undergraduate studies are already studying abroad, are treated in the calculations as though they were domestic students. That is to say, international students are included in the total cohort of students in the graduating class and are only included in the number studying abroad if they study four or more weeks outside the U.S.A. during their undergraduate years. Excluding our international students from the denominator or including all of them in the numerator as some institutions do would obviously increase our participation rates.

All academic programs outside the U.S.A. that are four weeks or longer are considered, regardless of engineering curricular content. So, for example, an engineering student studying a world language and no engineering in a program abroad for four or more weeks would be included as a participant.

Participation in study abroad for spring term, fall term, and total by year is shown in Figure 1 below. The total includes spring, fall, Maymester, and summer study abroad. Up through 2013, the total of students studying abroad in Maymester and summer exceeded the total of students studying abroad in the spring and fall terms. Starting in 2014, more students studied abroad during the academic year than in Maymester and summer combined.



Participation in study abroad is not uniform across majors. This was assessed by integrating across several years to minimize the effect of variations in small sample sizes. Comparing the sum of students in each major who studied abroad in 2010-2015 to the number of graduates in each major from 2011-2016 (their likely graduation years) reveals that computer engineering majors were the most likely to study abroad while chemical engineers and electrical engineers especially were the least likely to study abroad. In fact, electrical engineers were about half as likely to study abroad as all the remaining majors (biomedical engineering, civil engineering, computer science, engineering science, and mechanical engineering), which had very similar rates of study abroad participation. Differences may be due to the variations in the percentage of international students in each major who are already studying abroad by coming to our institution, curricular inflexibility, lack of relevant courses at our programs abroad, and differing perceptions about the ability of engineering students to study abroad while staying on track with their degree requirements.

For the years 2011 to 2016, 79% of graduates from the School of Engineering were in bachelor of engineering programs (biomedical, chemical, civil, computer, electrical, and mechanical) vs. 21% in bachelor of science programs (engineering science (ES) and computer science (CS)). In that era, the bachelor of engineering programs required 126-128 credit hours vs. 120 hours for ES and CS. The bachelor of engineering programs also had more constrained curricula with far fewer open elective hours than for ES and CS. Currently, enrollment in computer science is surging dramatically such that next year it is likely that CS will graduate more students than in

any other major. This increase in enrollment in one of our most flexible majors may possibly result in an even greater percentage of students studying abroad.

Programs Offered

Through our university's study abroad office, engineering students have access to 29 programs offering engineering courses in English abroad during either the fall or spring semesters. Of these, six are exchange programs, two are international programs of U.S. universities, and 21 are third party programs. These programs include both northern and southern hemisphere offerings, located in Africa, Asia, Australia/New Zealand, and Europe. Students also have access to an additional 93 programs that offer primarily or exclusively non-engineering courses abroad.

Maymesters

Through this university, a number of faculty-led Maymesters abroad are offered and many engineering students participate. These afford students the opportunity to study abroad without disrupting their normal fall/spring curricular progression in their engineering/CS degrees. These programs are typically also short enough that students may then return to the U.S. to participate in an internship or work. The Maymesters at this institution are primarily in the humanities and social sciences.

Transfer Credit Programs

In addition to the many programs offered through our institution, students are able to participate in study abroad programs hosted by other accredited U.S. universities and international universities with known positive reputations. Generally, accepted institutions are listed in the Shanghai Ranking Consultancy's Academic Ranking of World Universities (ARWU)[5] or the Times Higher Education World University Rankings[6]. Students seeking to apply credits from such programs toward their degree requirements must get the overall program approved by the engineering dean's office and then must have each course to be taken evaluated for transfer credit. Only credits for which grades of C- or above are earned may be applied toward the degree and such grades do not count in the institutional grade point average.

If a student wishes to participate in the fall or spring semester in a program that is not offered through our institution, he/she must apply for a leave of absence and demonstrate a compelling reason why she/he cannot use an institutional program. If approved, the student cannot use institutional financial aid or scholarships in the term away. They are required to register with the international safety support system to which our institution subscribes.

Curricular Integration

To assist students with curricular integration, engineering faculty and global education professionals collaborate to produce sample curricula that show how students can incorporate a fall or spring semester abroad in a standard four-year, eight-semester graduation plan. Such plans are constructed so as to not require additional summer study or application of Advanced Placement or International Baccalaureate credits.

The process of creating these sample curricula is labor-intensive. Starting with the curricular requirements at our institution for a specific major, noting prerequisite streams and limitations on when specific courses are offered, we then investigate the course offerings in that discipline as well as in mathematics in one of the study abroad programs. Note is made of the general level of each course and semester(s) offered. Courses that appear to be similar to disciplinary requirements such as heat transfer, statics, chemical process control, programming languages, etc. are then sent to the corresponding director(s) of undergraduate studies (DUS) for equivalency review as described below. Approved courses abroad are then integrated into a written sample curriculum plan, which invariably requires adjustment to the normal curricular progression. This revised four-year, eight-semester, curriculum plans is then sent to the DUS for his/her review and approval. Approved plans are then posted online as examples of how a student may incorporate study abroad at a given institution into a four year, eight regular semester curriculum plan that meets all degree requirements. Most plans are for fall or spring term of the junior year.

Course Evaluation

Faculty members evaluate all courses in their discipline to be taken abroad for equivalency to our courses and for suitability for degree credit. Students initiate the course evaluation request via an online form that is processed by the International Curriculum and Credentials Analyst (ICCA) in the Office of the University Registrar. The ICCA reviews the request and, if sufficient course information has been provided, will send the request and course materials to the appropriate department's director of undergraduate studies (DUS). As credit systems vary around the world, the ICCA also provides the suggested conversion to credit hours. If the course information is not sufficient, the ICCA will tell the student what additional details are needed to proceed with the request.

Faculty who serve as directors of undergraduate studies are encouraged to review syllabi and other course documentation obtained by students from the overseas institution. Details such as learning objectives and outcomes, pre-requisites, contact hours, textbooks used, and course deliverables are reviewed. Options for granting credit are multifaceted. Credit can be granted for major courses, minor courses, or elective credit where applicable. Additionally, credit granting options include credit for a specific course, non-equivalent credit which acknowledges that we do not offer the equivalent course but appreciate its value, and not credit eligible. The DUS also has the discretion to determine if the program will award more, or less, than the recommended credit hours for each course.

Occasionally, the process rotates through several departments in an attempt to find the most appropriate credit-granting disciplinary home. To avoid the same courses being submitted for evaluation each year, the results from each course review are valid for five years and cannot be re-evaluated within that time. In addition, to minimize confusion, courses can only be awarded credit through one department.

As needed, students may petition to have a course for which credit is granted through one program count toward the degree requirements of a different program. This process is done on an individual basis.

The benefit of this approval process is that the faculty as directors of undergraduate studies are empowered to make such decisions. It is expected that some faculty would be more generous with study abroad credit than others, but the variance is quite small due to accreditation limitations on what courses can count for certain major courses and types of electives. In this case, accreditation policies reduce potential inconsistencies and provide faculty some standards by which to grant study abroad credit.

Posting of Evaluation Results

Course evaluation results are posted to a searchable online database by the Office of the University Registrar (URO) with clear indication of the number of credit hours to be awarded in each degree requirement category. Courses are either designated as having a direct equivalent to a Vanderbilt course, or are listed as having no equivalent. In the case of non-equivalent courses, the DUS will indicate for the registrar to post how the course will count at Vanderbilt. In some cases, the course will be determined to fulfill a specific category of elective within the department's major, in other cases it may only be listed as having general credit toward graduation, and in rare cases the course may be listed as not being eligible for any credit.

This database of course evaluation results is helpful in the planning and application phase for students and assists faculty and staff in advising students. Our engineering students are strongly encouraged to review their four-year, eight-semester, curriculum plans with their academic advisors. The goal of this exercise is for students and their advisors to identify which courses have flexibility to be taken in alternate terms and which courses must be taken on the normal degree schedule. The sample curricula allow students to begin to visualize how courses can be moved around from their normal degree plan. The academic review of the four-year plan confirms where the flexibility is in each student's academic schedule and helps Global Education Office (GEO) advisors guide students toward the programs that best meet their individual academic needs.

Language

Language barriers have been addressed by identifying and establishing relationships with 29 programs at overseas universities where students can study engineering subjects in English. At the same time, those programs in countries in which English is not an official language also include the opportunity and in most cases requirement to study the host-country language. Adding an English-language engineering program in Spain in spring of 2014 was particularly helpful as many students wished to practice their Spanish language skills while enjoying opportunities to travel in Europe and complete engineering degree requirements.

Overcoming Financial Barriers

In the past, the prospect of the burden of student loan debt led some accepted students to decline their offer of admission from the university, even when this university was their first choice. Also, undergraduate students with significant loan debt will often abandon dreams of future

studies in graduate or professional school or forego particular career choices[7]. The need to pay off need-based student loans can become a real barrier to a desire to teach, or practice medicine in an underserved community, or work in a nonprofit or service agency—among many other career choices[8].

Starting in fall 2009, our university eliminated need-based loans in financial aid packages, replacing them with grants and scholarships for the approximately 64% of undergraduates who depend on some sort of financial support. Since its official fundraising launch the year before, the financial aid program has supported more than 8,900 undergraduate students. In the 2016-17 academic year, the financial aid program is providing aid to 3,058 students. These scholarships are essential to creating and sustaining a dynamic mix of students and increasing the university's competitiveness and selectivity. An important element of this program includes study abroad activities where the same financial aid covers fall and spring semesters abroad as on campus and provides a competitive scholarship for summer programs. About 30% of students who apply for one of this institution's scholarships for summer and Maymester study abroad receive an award with awards averaging about $7,200 to $8,500, depending on type of summer or Maymester program and demonstrated need.

Additional Strategies

Additional strategies also help increase participation. For example, given that civil engineers must learn U.S. design codes in their spring structural design class (SD), they are not able to study abroad in the spring of their junior year. In the fall of the junior year, students must take structural analysis which is the prerequisite for the SD class. There are only one or two of our approved programs that offer an equivalent of this prerequisite course. To support participation in other study abroad programs in the fall of junior year, faculty in civil engineering make special arrangements to offer essentially a private online U.S. course for students abroad. On-campus classes are video-taped and made available online for our students abroad. Teaching assistants hold video-conference office hours, and a variety of class materials are made available online. Assignments are submitted online. Exams are proctored either by host university or program provider staff or are proctored via video camera. Typically, no more than two civil engineering students a year need this accommodation.

At the start of every regular academic semester, the School of Engineering in partnership with the study abroad office hosts two information sessions specifically for engineering/CS students interested in studying abroad. It should be noted that one important key to the success we have had in increasing the numbers of engineering/CS students studying abroad is having at least one dedicated champion within the School of Engineering as well as within the Global Education Office (GEO). This allows for effective collaboration and coordination of efforts.

Helpful strategies that are not specific to engineering include having the GEO staff available to advise on a variety of programs in a given geographic region, offering a study abroad fair once each fall and spring term, being available to speak to student groups about our study abroad options at after-hours events and meetings, giving special presentations to first year students, presenting to parents, and attending university admissions events to speak with prospective university students about our study abroad programs. Anecdotally, the admissions events show a

marked increase in prospective engineering students who exhibit a strong desire to study abroad during their university career.

Returning students, who universally encourage others to study abroad, volunteer as study abroad ambassadors to share their experiences. The GEO also hires 6-8 returning students as paid peer advisors throughout the year and they are especially helpful in reaching out to students who may not naturally come to GEO. Both the ambassadors and peer advisors serve as panelists in the information sessions noted above. Their experience, excitement, and peer status are very encouraging of others considering study abroad.

Benefits to Students of Study Abroad

While we do not measure changes in student understanding or global awareness as a result of study abroad, the literature reveals that some of the benefits of studying abroad for students are an increase in global engagement and the ability to live and work in ambiguous circumstances[9]. Surveys also show that students report an increased sense of independence and self-confidence as result of facing, and overcoming, the day-to-day challenges of living and studying abroad. In fact, in a recent IES Abroad alumni survey, 84% of respondents reported that studying abroad helped them develop job skills[10]. Having this experience allows many study abroad alumni to develop useful skills that are sought out by future employers. These include the ability to be flexible, work within culturally diverse settings, and use creative problem solving[11]. Even short term study abroad is beneficial as, among other things, it increases student cross-cultural understanding and confidence to engage in longer study abroad experiences[12],[13].

Benefits to Institution of Study Abroad

In addition to the obvious benefits to students, and thus indirectly to our institution, of increased cultural competency and adaptability and more diverse approaches to the practice of engineering, the institution accrues some benefits. Having an effective study abroad program that engineering/CS students actually use is helpful in recruiting. Also, having students study abroad reduces the demands on our educational resources, some of which are quite taxed by enrollment surges. In particular, a dramatic increase in computer science majors is hurting student:faculty ratios and straining classroom capacities. Having these students abroad for a term improves student:faculty ratio for those remaining on campus.

The down side of having students study abroad is the loss of tuition revenue. While a $500 per student study abroad fee is retained by the university along with a fraction of the tuition paid, this does not begin to balance the loss of revenue.

Future Goals

To continue to support and encourage engineering/CS students to study abroad, our future goals include better tracking individual student interest and following up with specific students, developing more curricular examples for more majors in more locations, and seeking established English-language programs in mainland China and South America. We will continue to work with faculty colleagues to find creative solutions to barriers to engineering study abroad. In

addition, we continue to improve our ability to address safety and security concerns. We will also need to monitor and address the impact of potential changes in international relations on study abroad participation.

Conclusions

While there are substantial barriers to study abroad for engineering/CS students, focused effort on the part of a university to facilitate study abroad can result in much higher participation than seen nationally, as is the case for this institution. Specific strategies employed include identifying many programs abroad where engineering courses are taken in English, developing examples of how courses abroad can be integrated into our curricula, streamlining the course evaluation process, and making course evaluation results highly accessible and searchable online, In addition, incorporating Maymester and summer programs, allowing transfer credit for programs not offered through this institution, providing financial support for study abroad, and offering distance learning when needed for a specific requirement also supports study abroad participation. The net result is that here at Vanderbilt University, students in the School of Engineering study abroad at two to three times the national rate with clear benefits to students and the institution.

References

[1] Institute for International Education, Open Doors 2016 Report, Fast Facts, http://www.iie.org/Research-and-Publications/Open-Doors/Data/Fast-Facts#.WJ9YXhsrLct, accessed 8 Feb. 2017.

[2] Institute for International Education, Open Doors 2016 Report, U.S. Study Abroad: Fields of Study, http://www.iie.org/Research-and-Publications/Open-Doors/Data/US-Study-Abroad/Fields-of-Study/2004-15, accessed 8 Feb 2017.

[3] National Center for Education Statistics, Table 322.10 Bachelor's degrees conferred by postsecondary institutions, by field of study: Selected years, 1970-71 through 2014-15, https://nces.ed.gov/programs/digest/d16/tables/dt16_322.10.asp .

[4] 2013 Profiles of Engineering and Engineering Technology Colleges: Engineering by the Numbers, Brian L. Yoder. American Society for Engineering Education, https://www.asee.org/papers-and-publications/publications/college-profiles/13EngineeringbytheNumbersPart1.pdf

[5] Academic Ranking of World Universities (ARWU), Shanghai Ranking Consultancy. http://www.shanghairanking.com/. Accessed 3 Feb 2017.

[6] Times Higher Education World University Rankings, https://www.timeshighereducation.com/world-university-rankings. Accessed 3 Feb 2017.

[7] Constrained after college: Student loans and early-career occupational choices. J Rothstein, CE Rouse. Journal of Public Economics, 95(1-2):149-163. DOI: 10.1016/j.jpubeco.2010.09.015. Feb. 2011.

[8] Improving college access and choice. The state of college access and completion: Improving college success for students from underrepresented groups, Perna, L. W., & Kurban, E. R.., eds. pp. 10-33, Routledge Press, New York (2013).

[9] Annie Murphy Paul, "How studying or working abroad makes you smarter," Time (April 29, 2014). http://time.com/79937/how-studying-or-working-abroad-makes-you-smarter/

[10] IES Abroad Recent Graduate Survey, 2012. https://www.iesabroad.org/system/files/recentgraduatessurvey.pdf and IES 50-year Alumni Survey, 2002. https://www.iesabroad.org/study-abroad/why/alumni-survey-results

[11] AAC&U-commissioned surveys of employers, 2013 and 2015. http://www.aacu.org/sites/default/files/files/LEAP/2013_EmployerSurvey.pdf http://www.aacu.org/sites/default/files/files/LEAP/2015employerstudentsurvey.pdf

[12] Assessing the Impact of Short-Term Study Abroad, Carley S, Tudor RK. Journal of Global Initiatives: Policy, Pedagogy, Perspective, 1(2): Article 5 (2006).

[13] The Benefits of Short-Term Study Abroad, Lewis TL, Niesenbaum RA. http://chronicle.com Section: The Chronicle Review Volume 51, Issue 39, Page B20 (2005).