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Designing a Year Abroad Program in Mechanical Engineering

Dr. Jan Helge Bøhn, Virginia Polytechnic Institute and State University

Jan Helge Bøhn is an associate professor of mechanical engineering at Virginia Tech. He received his BS in Computer Science, and his MS and PhD in Computer and Systems Engineering from Rensselaer Polytechnic Institute, Troy, New York, in 1988, 1989, and 1993, respectively.

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Abstract

The departments of mechanical engineering at Virginia Tech (USA) and Technische Universität Darmstadt (Germany) developed two independent education-abroad programs where the final year of engineering coursework in each program was completed abroad in a foreign language. At the completion of each program, the student would receive two degrees at the same level in mechanical engineering, one from each university. The dual MSME degree program was approved in 2006, and the dual BSME degree program graduated its first cohort in May 2009. After transferring more than 13,000 semester credit hours, the dual BSME degree program was suspended in June 2018 due to a disagreement on how to compute credit transfers. This paper analyses the design of these programs, looking at what makes them attractive to students, and reviews the challenges of course credit transfers. It then proposes how to design a full-immersion education abroad program with a self-sustainable support infrastructure.

Introduction

Global competency continues to be desired objective in US higher education, and the percentage of US citizens holding a passport has now topped 53% in 2025 [1], [2]. That is up from 3% in 1989 [3]. There are 19.4 million students enrolled in US higher education (Fall 2025; [4]), of which 298,180 study abroad for credit each year (2023/2024, [5]). Only 2.4% of those that study abroad go abroad for an academic year or more [5]. Among these students, English language programs or destinations dominate. In engineering, most students going abroad are part of an international field trip, a summer research experience, or a semester of general electives. Too often the academic credits earned abroad cannot be applied towards their engineering degree due to the limited number of general electives in their degree program. This is unfortunate. 64.1% of all US students that study abroad, do so in Europe [5], where it is the norm that undergraduate courses are all taught in the local language, and where only a small subset of the graduate courses are taught in English.

This focus on Europe as an education abroad destination is understandable. The United States and European economies are the most integrated in the world, and their transatlantic trade reached $2.1 trillion in 2024 (European Union, Iceland, Norway, Türkiye, Switzerland, and United Kingdom; [6]). This represents 29% of all US trade [7].

The European Union was launched on January 1, 1993 to create a single market with the free movement of people, goods, services, and money. This includes the ability of engineers practicing across Europe. The focus on engineers grew out of the need for European countries to collaborate to rebuild their economies after World War II. FEANI (Fédération Européenne

d'Associations Nationales d'Ingénieurs) was formed in 1951 to promote the engineering profession across Europe, facilitate mobility and recognition of qualifications, and maintain standards for education and practice; and in 1987 it created the EUR ING (European Engineer) title. The purpose was to recognize levels of professional engineering competence across Europe, with each level of competence consisting of engineering education followed by several years of supervised engineering practice. Given that each country had their own concept of what constituted engineering education, the number of years of supervised practice required for a given competency level of the EUR ING title would vary by country. While the EUR ING title did facilitate mobility of the experienced engineering workforce, it did not apply to other professions, new engineering graduates, nor to higher education in general. A broader approach was clearly needed, especially with the growing number of dual-income households in need of multiple formal competency recognitions to enable their workforce mobility.

The discussions on how to harmonize European higher education accelerated in 1997 with a French for-instance that Europe move towards the British model of a three-year technical bachelor's degree (with no general education) followed by a two-year technical master's degree. This concept formed the basis for the Bologna Declaration that was signed by 29 European countries on June 19, 1999 [8], and which formally initiated the ongoing process to harmonize European higher education. Today, 49 countries and the European Commission have signed this declaration and committed their universities to a steadily growing set of directives to facilitate increased harmonization, and ultimately student and workforce mobility across Europe.

Quality Assurance via the Bologna Process

Higher education worldwide is filled with rankings that purport to measure institutional quality, but that are inadequate for programmatic quality improvement due to the metrics used. The Bologna process, however, with its harmonization, opens the door for direct quality comparisons between degree programs by observing student mobility in higher education. The exchange of students for a semester or two between universities would enable the identification of strengths and weaknesses between programs. For instance, a subset of students could be exchanged during their senior year to evaluate their performance within the other university's capstone experience. This not only benefits the two programs by providing for continuous quality assurance measurement, evaluation, and improvement, but it also ensures that the quality of the student experiences is closely monitored and promptly remedied for the benefit of the participating students.

The initial exchange programs between the mechanical engineering departments at Virginia Tech (USA) and Technische Universität Darmstadt (Germany) had quality assurance as a goal. The design of the exchange curriculum was easy enough. It would need to be a one-year exchange instead of a one-semester exchange due to the difference on timing of the semesters: The

Virginia Tech academic year consists of an August-December fall semester and a January-May spring semester, while the Technische Universität Darmstadt academic year consists of an October-March winter semester and an April-August summer semester. This makes mid-August the natural common brake in their two respective academic-year schedules.

In the case of the dual Master of Science in Mechanical Engineering (MSME) degree program, this meant that the first year would be all coursework at one university, followed by the second year at the other university with additional coursework and a thesis. The coursework was chosen so that it satisfied both the underlying MSME degree requirements, with one thesis being submitted at both universities. The thesis advisory committee consisted of a co-chair from each university that was responsible for complying with their respective university's regulations, and a second member from each university. Hence collaboration between faculty members at the two universities was ensured. The thesis would include a statement in the preamble confirming that it was submitted in partial fulfillment of two degrees and that it was being archived at the libraries of both universities in the context of a formal dual MSME degree program. The latter was to ensure that the two thesis copies could not be construed as plagiarism. The degrees awarded were the MS in Mechanical Engineering degree from Virginia Tech and the M.Sc. degree in the field of Mechanical Engineering degree from Technische Universität Darmstadt.

In the case of the dual Bachelor of Science in Mechanical Engineering (BSME) degree program, the exchange was scheduled for the senior year because that is when both programs have their capstone experience, most required courses have been completed, and the coursework largely consists of technical electives. If necessary, a course or two could be swapped between junior and senior year if a match could not be found at the university abroad. In essence, the foundational coursework in mechanical engineering was completed at one university, followed by the senior year with technical electives and the capstone experience at the other university. At Virginia Tech the capstone experience consisted of a senior design experience, whereas at Technische Universität Darmstadt it consisted of a bachelor's thesis. The work quality, quantity, and content of these two capstone experiences were similar and did not require adjustments.

The senior year would also provide the time need to complete additional language courses in preparation for the exchange. The language of instruction for the undergraduate courses at Technische Universität Darmstadt is German, so the US students will need to have language instruction accessible prior to the exchange if needed. English language skills is not an issue for the students from Technische Universität Darmstadt because they learn this starting in primary school.

The language of instruction for the graduate courses at Technische Universität Darmstadt was originally German, so the program required the US students to complete their language training prior to arriving at Technische Universität Darmstadt. From a practical point of view, these

students would therefore have to begin their language training at undergraduates. More recently, following a trend across Europe to facilitate graduate student mobility, a minimal core set of graduate courses at Technische Universität Darmstadt are now offered in English to enable the completion of the degree requirements without necessarily having the traditional choice of technical electives. For a full access to the electives offered, including those that are only offered in the local language, integrated language training remains essential.

For both the dual BSME and the dual MSME degree programs, integrating the language training for the US students is essential to gain the full impact of the education abroad experience, especially if they are to truly claim to be both US and German engineers. Of course, this additional effort required by US student, makes it more difficult to recruit US students to these programs, which, in turn, places the financial sustainability of these programs at risk. Most bilateral international student exchange programs are financially based on exchanging equal number of students from each university, whereby the exchanged students merely "swap seats" with respect to tuition.

Indeed, recruiting US students to full immersion exchange programs is challenging due to their poor foreign language skills. In our case, only 2.5% of US high school students study German, and approximately 60% of these students do not retain enough to continue their language studies but must start over. Though all the German language coursework that will be needed is available at Virginia Tech, few US students find study abroad appealing enough to endure language training prior to departure. Hence, without additional incentives, only infrequently would there be a seat available to an incoming student from Technische Universität Darmstadt. Fortunately, as we suspected and quickly confirmed, the prospect of earning a dual degree and becoming a true a US and German engineer, clearly provides the incentive needed to endure the necessary language studies.

The EU-US ATLANTIS Program

The establishment of a standard two-cycle Bachelors-Masters educational system across Europe also opened the door for extending the student mobility to the US. It was in this context that the US Department of Education and the European Commission established the EU-US ATLANTIS grant program. The 2006 call for proposals focused on creating consortia between two European universities and one US university to establish two undergraduate dual degree programs: one for each US-EU pair, and with all the participating students attending a semester at the other EU university. The coursework at the degree-granting European university should be in that language, while the semester at the other European university should include some local language and culture training.

One of the first 2006 grants went to Virginia Tech, Technische Universität Darmstadt, and Kungliga Tekniska Högskolan (Sweden). We were able to develop the Virginia Tech - Technische Universität Darmstadt dual BSME degree program with a semester at Kungliga Tekniska Högskolan and graduate 16 students on time. However, we were unable to identify a Virginia Tech - Kungliga Tekniska Högskolan dual BSME degree solution. Furthermore, the extra semester at a second European university was unsustainable without a significant supplemental stipend for the participants, which in our case was an US$18,000 stipend per student from the ATLANTIS grant. The extra semester added significant cost of travel, living, tuition (at the home institution), and lost income, while the course credits earned that semester were not used towards either of the two BSME degrees. More detailed discussions on the logistic issues with this extra semester and the potential Virginia Tech - Kungliga Tekniska Högskolan dual BSME degree program can be found here [9], [10].

The Post-ATLANTIS Dual BSME Degree Program

As the ATLANTIS grant came to an end, the focus was on improving the dual BSME degree curriculum to ensure that it was sustainable without the stipends. The focus was on integrating language training for the US students without adding time to graduation, while keeping the overall costs down. The result was a program with the following features from a US student's perspective:

SPRING SEMESTER JUNIOR YEAR: This is that last opportunity to commence the language training. The six semester-credit-hour course (GER 1114) would count as a free elective, of which there are none in the Virginia Tech BSME degree program. Most students completed the Spanish version of this in high school, so they must complete this German version while at Virginia Tech to enter the dual BSME degree program. These course credits are also available as a Fall-Spring sequence at three semester-credit-hours each (GER 1104-1105) if that is more convenient.

SUMMER SESSION 1 (six weeks): The six semester-credit-hour course (GER 2114) would count as technical electives in the Virginia Tech BSME degree program if it was followed by at least one semester of engineering courses abroad in that language. This course is also available as a Fall-Spring sequence at Virginia Tech at three semester-credit-hours each (GER 2104-2105) if that is more convenient.

SUMMER SESSION 2 (six weeks): The six semester-credit-hour course (3000-level) is offered by Technische Universität Darmstadt on site in Germany. At this point the students can exercise their emerging language skills in their daily life outside of class. This course is also available as a Fall-Spring sequence at Virginia Tech at three semester-credit-hours (GER 3104-3105) each if that is more convenient.

EARLY FALL SESSION (six weeks): This three semester-credit-hour course is a standard technical German language course offered to all incoming international students at Technische Universität Darmstadt. This brings the students to the C1-level of the Common European Framework of Reference for Languages, which is required for enrolling in degree programs at Technische Universität Darmstadt. This also completes the requirements for a German language minor at Virginia Tech (24 semester credit hours).

WINTER SEMESTER (mid-October to mid-March) and SUMMER SEMESTER (April to August): Audit a weekly course for international students at Technische Universität Darmstadt to provide ongoing reinforcement and refinement of grammar and vocabulary, with emphasis on technical German.

From a quality assurance point of view, correlating US student performance relative to their formal German language training, we found it necessary to exceed to early standards for language training to the equivalent of a German minor at Virginia Tech, or specifically, 24 semester credit hours, followed up with ongoing weekly reinforcement and refinement sessions, as described above. A deeper discussion on this language program and the differences between US and German engineering courses can be found here [11].

The combination of earning the credentials as a US and a German BSME degree with a minor in German, clearly provided the incentive needed for the US students to endure the foreign language training. The enthusiasm for formal credentials matter, as we clearly observed when we added the German minor for work that they effectively already would need to complete. Enrollment in the dual BSME degree program grew to the point where most students taking German courses at Virginia Tech were mechanical engineers. While enrollments in German program across the US were in a decline and continued to close, the three faculty members in German at Virginia Tech enrolled more students than their 14 colleagues in Spanish. Indeed, the dual BSME degree program with Technische Universität Darmstadt accounted to 44% of all education abroad transfer credits at Virginia Tech.

Computing Transfer Credits

An integral part of the Bologna process was to establish a common European Credit Transfer System (ECTS) to facilitate credit transfer between universities. The standard was agreed to be that 60 credit points (CP) ECTS would be equivalent to the standard academic year. Hence a year of academic work in one country would be equivalent to a year of academic work in another country. That principle was more important, to gain agreement on harmonizing higher education across Europe, than looking the number of hours of student effort that was used in each country. Hence the following differences emerged:

Most countries in Europe (including Germany) define one academic year as 1,800 hours of student effort (total of all lectures, laboratories, and homework), which amounts to 30 hours of student effort per CP ECTS. However, the United Kingdom defines one academic year as 1,200 hours of student effort, which amounts to 20 hours of student effort per CP ECTS.

On the other side of the Atlantic, the US Department of Education defined 1 semester credit hour as 45 hours of student effort. For a typical 30 semester credit hour year, this amounts to 1,350 hours of student effort. In 2011, by recognizing the most lecture hours in the US are 50 minutes rather than 60 minutes, US Department of Education suggested that the expected student effort for one semester credit hour should be reduced to 37.5 hours, or 1,125 hours per academic year [12].

When the dual BSME degree program was created with the grant from the US Department of Education in 2006, we used the US Department of Education and SACCS definition of a semester credit hour (45 hours of student effort) and the standard definition used in Germany and across Europe for the definition of one CP ECTS (30 hours of student effort), to correlate the content of content in the Virginia Tech and Technische Universität Darmstadt BSME degree program. That is, we equated one semester credit hour (USA) to 1.5 CP ECTS (Germany) as we compared are correlated the actual content of our two BSME degree programs down to a 0.1 semester credit hour resolution. These correlations were approved by each department involved, in some cased even comparing the instructors' lecture notes to examine the scope and detail of material covered. Hence, for the Virginia Tech BSME degree, the German students would transfer in 81 semester credit hours (62.3%) from Technische Universität Darmstadt and earn 49 semester credit hours (37.7%) at Virginia Tech. The 49 semester credit hours included 19 semester credit hours of US general education. This made sense and it mirrored other ratios at that time:

> Georgia Tech [13]:
> 30 CP ECTS (max load) = 21 semester credit hours (max load)
> 30 / 21 = 1.43, rounded off to 1 semester credit hour = 1.4 CP ECTS
>
> Number of weeks in an academic year, including exams: 47 at TUD = 32 at VT
> 47 / 32 = 1.47

Together with the downsizing of the semester credit hour from 45 hours to 37.5 hours of student effort, the amount of credit transfer between the US and the UK had grown significantly, dominating the credit transfers between the US and the other European countries, due to the low language barrier between American and British English, relative to the other European countries. In this case, we were now looking at 30 semester credit hours over 1,125 hours per year in the US being equated to 60 CP ECTS over 1,200 per year in the UK. For simplicity, this annual

workload can be justifiably approximated as one semester credit hour being equivalent to two CP ECTS. Hence norm became to apply this 1:2 ratio to all transatlantic credit transfers, regardless of their respective annual student workloads.

By 2015, the climate at Virginia Tech had changed, with a new president, provost, registrar, Dean of Engineering, and Department Head of Mechanical Engineering. The previous administrators' enthusiasm for education abroad was not shared by the new cohort of administrators, and, nationally, the enthusiasm for education abroad was entering a decline, which further affected the prioritizations of the new university administration. The definition of semester credit hours was changed from hours of student effort to minutes of scheduled lecture or laboratory time in response to the clarifications by the US Department of Education [12]. And the conversion factor was fixed at one semester credit hour being equal to two CP ECTS. The reasoning was that one standard academic year in Europe equals one academic year in the US, or, rather, 60 CP ECTS is equivalent to 30 semester credit hours.

This might not be of much consequence when transferring credit for a single course abroad, but it has a massive impact when the number of credits transfers is large, such as for a dual degree program. In our case, the consequence was the German students would now need to complete an additional 21 semester credit hours at Virginia Tech to earn their US BSME degree. This was unacceptable to the German students, and by 2018 the dual BSME degree program was suspended.

Conclusion

The paper has presented and discussed the design and evolution of dual BSME degree program between a US and a German university. The key to success was a close university-university partnership with a strong focus on continuous quality assurance and improvement, combined with providing the participating students with strong and markable credentials. The program successfully navigated two ABET (2007, 2013) and three German accreditation cycles (ZEvA) with peer university evaluations, in all cases called out with rave review. The program was shut down due to after a change in interpretation of credit transfer calculation policy.

The downfall originates with the EU decision to equate academic years in different European countries even though their respective expected hours of student effort vary greatly, ranging from 1,200 hours to 1,800 per year. While this was out of necessity to unite the European countries around a common credit transfer standard, the consequence is that the US has chosen to follow the EU and treat all the CP ECTS the same, regardless of the variation of expected student efforts that underlie them. While this is of minor consequence when transferring a summer course or two, it has a major impact when transferring a full semester or full academic year of credits.

Until this mismatch between expected student effort and credits between countries is rectified, perhaps we should look are enabling asymmetric student exchanges. Such asymmetry might to reflect a perfect partnership, but it would enable large-scale student exchanges—and the close partnership between the two universities—to continue while the credit transfer mismatch is being rectified. For instance, in the case of Virginia Tech and Technishe Universität Darmstadt, this might play out as follows: Use the tuition revenue from the Virginia Tech → Technische Universität Darmstadt Dual BSME degree program to fund the tuition expense needed for the Technische Universität Darmstadt → Virginia Tech Dual MSME degree program.

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Figure 1. The first (2007-2008, middle row) and second (2008-2009, front row) cohort of the Technische Universität Darmstadt (Germany) → Virginia Tech (USA) Dual Bachelor of Science in Mechanical Engineering Degree Program (ATLANTIS version).

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