Global Science and Engineering Program: A Model for Uniform, Institution-wide STEM Internationalization

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GLOBAL SCIENCE AND ENGINEERING PROGRAM: A MODEL FOR UNIFORM, INSTITUTION-WIDE STEM INTERNATIONALIZATION

Abstract

Comprehensive globalization in engineering design and manufacturing in the last decades has led to fundamental new imperatives, as we consider how to effectively train and prepare our Science, Technology, Engineering and Mathematics (STEM) workforce to succeed in this diverse, multicultural, widely-distributed, multi-lingual research, design and production network. In order to take STEM internationalization to the next level, we must make internationalized tracks available as a regular, attractive option to *all STEM majors*; doing this efficiently will require developing a comprehensive, uniform approach to STEM internationalization at the institutional level. In this paper, we discuss our development of the Global Science and Engineering Program (GSEP), a broad internationalization initiative uniformly spanning all engineering, math, and natural science programs offered at Northern Arizona University. To help pave the way for others, we pay particular attention to critical GSEP design features and rationale.

1.0 Introduction

Globalization has been the predominant economic theme for the past decade, leading to broad global distribution of research, design, and production teams and facilities spanning the full spectrum of science and engineering disciplines [1]. Modern STEM graduates will be expected to communicate and collaborate across cultural, linguistic, and national boundaries on a daily basis; and globalization of the labor market means that U.S. STEM graduates must be prepared to compete with international candidates for choice positions [2][3].

While other countries have invested heavily in developing globally competent engineers, institutions in the United States have generally been slow to respond to this trend, leaving our graduates ill-prepared to compete in the modern global marketplace. In Germany, for instance, upwards of 25% of all engineering students engage in at least one study-abroad or international internship experience [4]; by sharp contrast, only 3.5% of U.S. engineering students go abroad during their studies [5].

Given the recognized national urgency of better preparing our engineering graduates for global practice [6][7][8][2][9], it is surprising how little progress has towards this goal has been made on a broad national level. Some institutions have introduced initiatives to incorporate basic exposure to global perspectives into a broad range of undergraduate programs, usually through some combination of on-campus international activities, special courses, or augmentation of regular course materials to incorporate global themes. At Northern Arizona University, for example, our campus-wide Global Learning Initiative [10] engages faculty from all disciplines to ensure that all students have multiple, substantive encounters with global perspectives through special curricular elements, activities, and assessments that translate the themes of diversity, sustainability and global engagement into the applied language and practices of various specific disciplines. Most institutions also have some sort of international office that encourages students to engage in some sort of study or internship abroad. Although such broad efforts are certainly important, they fall well short of providing focused, specific preparation for STEM practice in a global economy; nearly all U.S. engineering graduates still leave college with little or no significant international exposure.

A small but growing handful of institutions have begun responding to these new imperatives by exploring a variety of more intensive international training programs. For instance, Iowa State University's Language and Cultures for the Professions initiative [11] encourages students to incorporate specialized language study and cross-cultural coursework into their studies, as well as providing help in finding internships abroad. Similarly, the GEARE program at Purdue [12], [13] offers engineering majors the opportunity to integrate introductory language study, a semester of study plus summer internship abroad into a four-year curriculum. The International Plan at Georgia Tech [14] offers students a range of options for internationalizing their studies, requiring a combination of globally-focused coursework, basic foreign language exposure, and a total of 26 weeks of study, research, or work abroad. Many of these programs have been inspired by the International Engineering Program (IEP) [15], [16] at the University of Rhode Island, an early pioneering effort in engineering internationalization that still remains one of the most comprehensive and cohesive program models today.

Despite these successes, the number of institutions offering comprehensive, broadly-accessible internationalized training remains relatively small, and internationalization at most institutions, if available at all, is limited to one or two select programs. One obstacle to broad, nationwide deployment of internationalization in STEM education is the custom-constructed, mix-and-match nature of many existing programs, which often began as experimental initiatives based on a particular existing relationship to a particular university abroad. This often makes such initiatives both difficult to scale beyond the natural capacity of the initial partnership and, more importantly, difficult to expand to other departments, colleges, or institutions. What is needed is a robust, broadly-applicable model for pursuing internationalization of STEM education on a college-wide basis.

In this paper, we provide a starting point for this conversation by discussing our development of the Global Science and Engineering Program (GSEP), an ambitious internationalization initiative uniformly spanning all science, technology, engineering, and math (STEM) degree programs offered at Northern Arizona University. As a top-down initiative that offers comprehensive internationalization tracks on a broad, college-wide scale, GSEP has had to overcome a range of challenging curricular and logistical obstacles. At the same time, GSEP demonstrates that addressing these challenges uniformly at a college or institutional level, rather than in just one or two select degree programs, offers economies of scale that can make the cost of establishing such large-scale programs surprisingly modest while greatly increasing their accessibility and impact.

In the next section, we begin by describing our Global Science and Engineering Program in detail, followed by a discussion of program design considerations, rationale, and the importance of program scalability and efficiency. In Section 3, we discuss strategies for establishing collaborations with study and internships partners abroad, which remains as a major challenge in developing large-scale initiatives.

2.0 The Global Science and Engineering Program (GSEP)

As noted in the introduction, there are many possible approaches to internationalizing engineering education, and several other institutions have developed successful models in this area. Our own experimentation with internationalization spans nearly 15 years, and the design of GSEP is informed both by our successes and failures in the area, as well as by insights and inspiration adapted from initiatives elsewhere. In this context, the GSEP initiative is primarily motivated by one compelling question:

What would it take to move STEM internationalization to the next level, moving from small-scale program-centric initiatives to a broad college or campus-level model that makes intensive internationalization a routine enhancement available in every STEM degree program?

This focus moves program design and internationalization pedagogy into the spotlight; our aim has been not merely to design "yet another program", but to understand how specific aspects of program scope and design influence the scalability, operational efficiency, and long-term sustainability of internationalization initiatives. GSEP is our attempt to realize this broad vision of a uniform, scalable "production" model for intensive internationalization, and our hope is that a clear discussion of not just GSEP program structure but also its design rationale will help others in planning their own initiatives.

2.1 GSEP Program Structure

The primary goal of GSEP is to *make internationalization a routinely available, easily-accessible option for all STEM majors on our campus*. GSEP creates parallel internationalized tracks for all STEM degree programs (Figure 1) on our campus that augment the core STEM degree with intensive foreign language learning, cross-cultural training, and an immersive international professional experience. Particular emphasis is given to lowering barriers to program participation by providing (just as for conventional degree tracks) pre-planned, turn-key curricular plans for every supported degree program, routine support from the college's professional advising staff, and comprehensive planning and logistical support for the year abroad. The overall aim is to maximize program accessibility and volume by making the international tracks no more difficult to negotiate than conventional degree programs.

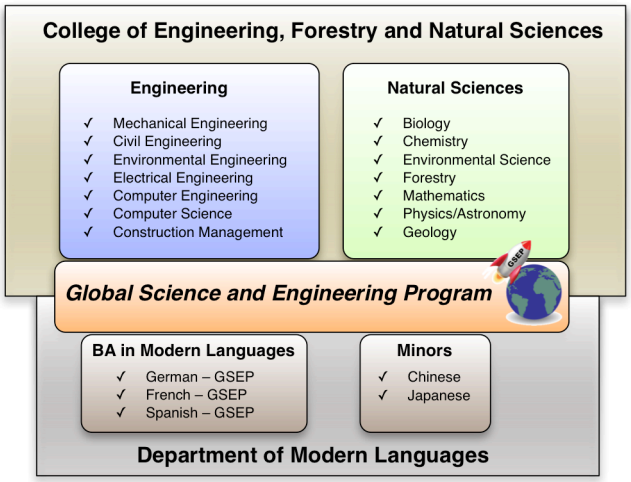

Figure 1: GSEP spans *all STEM degree programs* on campus, and offers five language options.

GSEP scholars may choose from five supported languages: German, French, Spanish, Chinese, and Japanese. The choice of these particular GSEP languages was driven by a strategic aim to (a) maximize coverage of languages and regions with strong global STEM leadership; and (b) leverage existing degree programs in our Modern Languages department. In the German, French and Spanish variants, GSEP scholars augment their primary STEM degree with a second BA in their chosen foreign language, performing both coursework and their internships in the foreign language while abroad; in Chinese and Japanese variants, GSEP scholars earn a minor in the language and, accordingly, pursue English-centric study and internships while abroad. The reasons for this two-tiered distinction between European and Asian languages are purely practical: our institution does not currently offer Bachelors degrees in these languages; and, even when these are added, it is questionable whether six semesters of study in these particularly

difficult languages [17] will be sufficient to prepare students to perform coursework or internships in the language. Finally, English is not supported as a GSEP language simply because extensive linguistic and cultural training is not necessary to prepare STEM majors for study-abroad, foreign internships and professional practice within the English-speaking world. Northern Arizona University offers many study-abroad programs in the UK and Australia that are easily accessible to STEM majors without further preparation.

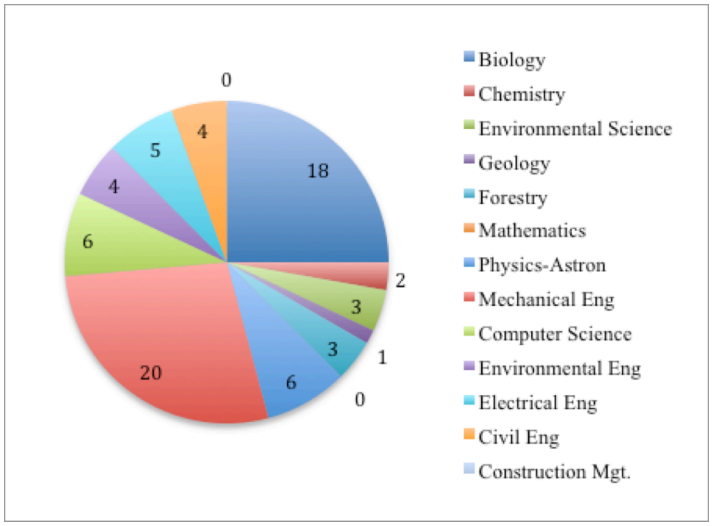

Figure 2a: Current GSEP participation by STEM major.

GSEP Status. GSEP was established in 2011, augmenting our existing conventional short-term internationalization offerings to become Northern Arizona University's signature STEM internationalization initiative. Student response has exceeded expectations, with about 50 freshman entering the program each year; we expect this number to grow to about 70-80 incoming freshmen annually as the program becomes fully established and begins drawing STEM majors to our institution expressly because of GSEP. We currently have 72 students in the program, spanning nearly all[1] STEM majors and languages (Figure 2). As the five-year GSEP pipeline fills to capacity, we expect GSEP to support between 250 and 300 students, sending approximately 50 students abroad each year.

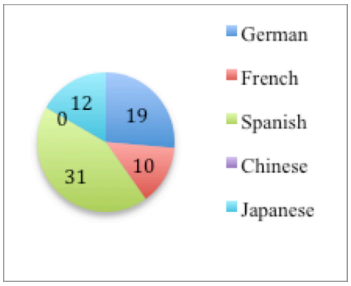

Figure 2b: Current GSEP participation by language.

2.1.1 GSEP curricular model

The GSEP program is based around a five-year curricular model, with an integrated fourth year of study and internship abroad as the program apex (Figure 3). This model is directly inspired by the International Engineering Program at the University of Rhode Island [15][16], where it has proven its effectiveness for comprehensive international preparation for over two decades.

As indicated in Figure 3, students are recruited into the program as they begin their freshman year and are enrolled immediately in their chosen language study track, as well as beginning the usual curriculum within their chosen STEM major. In the second and third years, students continue with intensive language study and GSEP cross-cultural training (see next section) as they progress into the upper division of both their STEM and foreign language studies.

[1] Exceptions include Construction Management and Mathematics, where we've found it more difficult to articulate the value-added for internationalization. Chinese currently has no students due to reorganization of foreign language instruction in that area.

The fourth year is the apex of the GSEP curriculum, providing a full year of intensive language training, cross-cultural exposure, and professional immersion abroad. Destinations are chosen from a short list of special GSEP partner institutions at which the STEM degree programs have been vetted by our faculty, and for which we have developed a list of upper-division courses that are pre-approved for transfer towards GSEP's STEM and language degree programs back home. Following a semester of studies at a partner institution, participants are provided with an internship placement within their STEM discipline in a local company or research laboratory. During their year abroad, GSEP scholars regularly participate in "webinars" integrated into GSEP meetings for the on-campus participants, helping to engage, motivate, and prepare future cohorts for their upcoming year abroad.

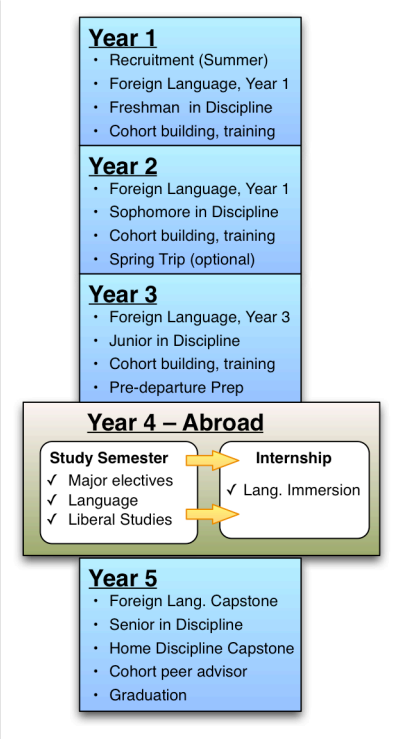

Figure 3: the GSEP curricular model

Finally, GSEP scholars return to NAU to complete Capstone experiences and remaining coursework in their fifth year. As experienced global professionals, these students continue to participate in GSEP meetings, serving as role models and mentors for younger GSEP cohorts.

The investment of an additional year of undergraduate study is rewarded with a second BA (or dual minor, in the case of Chinese and Japanese) in a foreign language, a formal Certificate in International Engineering and Natural Science … and, of course, an incredible international professional experience. The GSEP program is free of cost to all STEM undergraduates; participants simply pay regular tuition and fees at their home institution throughout, as well as covering their travel and accommodations while abroad.

2.1.2 GSEP's Program Highlights

The ultimate efficacy of any program is determined not only by overall program structure, but by the many detailed decisions involved in translating that concept into an implemented program. GSEP includes many carefully designed program features in both the on-campus and international segments of the program. These include:

Committed, immersive on-campus model. GSEP is based on a "committed participation model", based on our philosophy that true internationalization is not achieved via an isolated event or trip abroad, but involves the shaping of an entire professional world view and thus should infuse and influence the entirely of undergraduate training. More practically, the committed five-year program model creates a strong sense of identify within the cohort, contributing to program engagement and retention. Key elements of the GSEP on-campus preparatory program include:

- A required, repeatable 1-credit "GSEP seminar" course that provides the formal academic framework for GSEP cross-cultural training, including modules on history, major political movements, famous engineers or scientists, religious practices, and differences in professional communication and practice. The aim is to allow GSEP scholars to enter their foreign communities of practice as sensitive and knowledgeable colleagues.

- Social events and outings aimed at building cohort identify and cohesiveness. Examples include mandatory regular meetings, international potlucks, group outings for hiking or sight-seeing, and international movie nights.
- The International House. GSEP participants have priority selection for residence in the NAU International House, located in our campus's most desirable dormitory and dedicated to providing a thoroughly multicultural, international living and learning experience.

Building and maintaining a strong, cohesive "international learning community" through a variety of rich, mandatory on-campus activities is a key element of the GSEP concept, and supports both retention and academic success by embedding GSEP scholars within a supportive social framework centered around international themes.

A language-immersed international professional experience. A full year of study and professional internship abroad represents the "capstone experience" of the GSEP program. GSEP requires one semester of study in a non-English-speaking country, and an international corporate or research internship of at least 20 weeks duration. To maximize the value of this substantial investment, the GSEP experience abroad includes several key features:

- Students must attend courses full time, and *at least two courses taken must be taught in the foreign language* to satisfy the requirements of the special BA in Modern Languages degree plans developed for the GSEP program.
- The study-abroad term is fully leveraged to allow students to finish two degrees in five years by prioritizing transferable coursework needed for graduation. This is particularly critical for engineering, where degree programs allow for few or no general electives, meaning that some required engineering coursework *must* be pushed into the semester abroad to make room for language studies in the first three years.
- Aside from the two required courses in the foreign language, students may elect to take some coursework in English (if such courses are offered at the partner institution) offering potential for a little (linguistic) relaxation in a full-time class schedule.
- Professional internship placements may be in either a corporate context or in a university or governmental research laboratory, depending on availability and the student's preferences. All internship placements are *required to be in a primarily non-English-speaking environment*; substantial credit towards the language degree is satisfied through this immersion.

Clearly, developing and maintaining a network of partnering institutions and internship providers that covers five languages and 14 STEM majors represents enormous logistical, financial and administrative challenges – especially given our goal of designing a largely self-supporting program concept that could serve as an easily accessible model for other institutions nationwide. Our approach in GSEP is based on the key observation that this is essentially a problem of scale. In particular, we have found that a broad, institution-wide approach can amortize a substantial investment in international relationships across many students and degree programs, while minimizing overhead through a comprehensive focus on efficiency, standardization, and integration with existing campus infrastructure. We examine this argument in more detail in the next section.

2.2 The Case for committing to a broad College- or Institution-wide Approach

In an age of limited resources, many engineering administrators and educators will be skeptical of committing to a comprehensive, STEM-wide internationalization effort. Wouldn't it be wiser to start with a small pilot, perhaps starting with one or two programs, then consider expanding it if successful? Northern Arizona University has invested nearly 15 years in exploring strategies for internationalizing engineering education, including an International Engineering and Science certificate program and an NSF-funded exploration of a comprehensive college-wide internationalization concept [18], [19]. Our experience suggests that, in fact, a truly robust program infrastructure is too costly to develop and sustain for just one or two degree programs, leading to inevitable compromises in program design and, ultimately, a resource-starved "death spiral" of decreasing participation and decreasing program resources. Instead, GSEP is based on a carefully designed generic program model with a uniform, shared core infrastructure that, with relatively modest incremental investments, can just as easily serve (and be amortized by) 14 degree programs as one – while at the same time offering internationalization opportunities across a much more meaningful percentage of degree programs.

This approach simply recognizes a fundamental principle familiar to any production engineer: mass production is far more efficient than producing individual prototypes, but requires both designing the product for the widest possible market and a comprehensive focus on process efficiency. This commitment to a "production philosophy" from the very outset – to "Going big" – represents a fundamental shift in the strategic approach to STEM internationalization at our institution, and has played a role in shaping nearly every facet of GSEP program design and implementation. Two fundamental tenets of this approach have been particularly important:

Focus on broad appeal, easy access. To ensure high volume, GSEP was designed to provide a compelling, attractive, turn-key vision for internationalization for *all STEM majors at our institution*. Particular attention was given to communicating the value proposition to both students and their parents: "Add one year of studies, get two degrees, an international certificate, and an unbeatable résumé". Barriers to participation were removed by minimizing complexity, planning investment and perceived risk for students with pre-planned curricular plans, no initial language requirements, and comprehensive advising and logistic support throughout.

Focus on uniformity and efficiency. To reduce overhead, every effort was made to design all possible aspects of the GSEP program and its infrastructure to be as generic and uniform as possible: All GSEP participants in all disciplines follow the same general path through the program; the model GSEP curricular plans that help guide students in each degree program all follow a similar design; the customized foreign language degree plans developed for GSEP are essentially identical across languages; all GSEP students go abroad in the same (fourth) year; mandatory group meetings ensure that all students receive the same consistent preparation; and program policies are uniform across all disciplines. Efficiency is further maximized by carefully working to leverage existing on-campus resources: all mundane logistics (travel, visas, lodging, etc.) are handled by existing international student services in our Center for International Education; existing professional advisors in the college were trained to routinely handle most aspects GSEP curricular advising based on the detailed model plans developed for each degree program. The focus on efficiency extends to international partnerships as well: students may choose from a closed set of designated GSEP partner institutions where we focused investment to develop deep infrastructure for GSEP; and partner institutions were

carefully selected to maximize the number of GSEP degree programs covered by the institution, the ability to help arrange internships for GSEP students, and the capacity to accept larger numbers of exchange scholars as our program expands. This sometimes involved conscious sacrifices of expediency for long-term efficiency, e.g., forging a single new partnership rather than spreading GSEP scholars over a collection of existing partnerships; or declining a partnership with an institution where a faculty member happens to have a connection but that otherwise fails to meet the above criteria.

Adopting this "production philosophy" has made it possible to develop and launch GSEP simultaneously across all STEM disciplines in our institution very quickly (within one year) while minimizing program development costs, and spreading those costs across many programs served.

The one aspect of GSEP program development that has proven difficult to streamline is the development of foreign academic and corporate partnerships. In the following section, we discuss our partnership development strategy in more detail, and outline ways in which consortia or other institutional collaborations could play a key role in reducing this substantial challenge.

3.0 Strategies for Developing International Partnerships

Developing a robust network of international academic and corporate partnerships to support foreign study and internship elements is undoubtedly one of the most daunting challenges in the development of any international initiative. While consistent focus on efficient, large-scale program design can streamline program startup and control overhead for on-campus program elements, there really is (currently) very little support for efficiently developing study and internship opportunities for students abroad. Enormous amounts of time must be invested in researching potential partners in targeted countries, initiating and developing new connections, and ultimately, following up with costly in-person visits as these connections mature into viable partnerships. Developing reliable corporate internship providers is even more daunting; simply identifying a list of potentially suitable internship providers in a particular region is difficult due to limited local knowledge. Finally, unlike the on-campus elements discussed earlier, these challenges don't scale efficiently: the effort of establishing partnerships essentially grows linearly with the number of disciplines and languages covered by an initiative.

Although development of GSEP's international partnerships has certainly been a difficult challenge, we have found that, here too, careful attention to strategy and program efficiency can significantly streamline this effort. In particular, we offer the following strategic guidelines as best practices for developing international partnerships.

Select academic partners strategically. Academic partnerships should be selected strategically, based on a combination of location (proximity to potential internship opportunities), quality of STEM programs and laboratories, and (importantly), coverage of all targeted disciplines in a single partner. Institutions with which an existing exchange relationship exists, or where a faculty member has a contact should certainly be considered, but ultimately the goal is to cover all targeted disciplines and languages with as few, maximally-broad partnerships as possible. In our experience, this sometimes meant establishing new partnerships with strong coverage of all of GSEP's 14 disciplines rather than spreading students across several existing partnerships.

Prioritize academic partnerships. The best and most reliable avenue to developing internships for students is through academic partners with knowledge of and connections to local companies,

government agencies, and research laboratories. Academic partners are often able to immediately offer internship placements as research assistants in applied research laboratories on campus, and local collaborative research projects with industrial partners can pave the way into corporate contexts. In short, program development strategy should prioritize academic partnerships, leverage these to place initial cohorts of students, then supplement these with independently developed internship opportunities over time.

Focus on reciprocity to stimulate collaboration on internships. Many academic partners may be hesitant to offer help on placing foreign students in internships, especially if local degree programs require an internship placement for their own students. GSEP offers students coming on reciprocal exchange from GSEP partners help in finding internship placements in laboratories and companies in our regional network of internship partners. This truly collaborative model benefits both sides of the relationship, and effectively leverages local knowledge and connections on both sides.

Work with upper administration to develop a viable funding model. Even the most efficient program design must account realistically for compensating leaders, basic administrative support, and providing adequate operating funds … including the substantial cost of developing overseas program elements. A common financial model for many successful study-abroad programs is based on a commitment by university administration to return some part of tuition paid by participants *during their year abroad* to support the program; this is how GSEP is funded as well. The case for this arrangement is compelling: students use few campus resources while abroad and, given the five-year program, the university is still collecting the very same four years of tuition monies as it does from conventional students. Basing program funding directly on the number of students served provides a strong incentive for program growth and directly rewards streamlining and efficiency.

Our overall experience has been that forming academic partnerships based on reciprocal exchange agreements is not difficult, once the arduous work of identifying strategically suitable academic partners has been done. Many foreign institutions in Europe and Asia have far more demand for exchange study slots at U.S. institutions than they can provide, and are eager to engage with new high-quality partners. Three specific features of GSEP program design have been particularly helpful in simplifying development of foreign partnerships:

1. Strong student preparation. The fact that the GSEP model sends students abroad in the fourth year, *after three years of foreign language and STEM training*, means that they have substantial competency both in the target language and in their STEM disciplines. This eases partnership development enormously: coursework does not have to be available in English, many more internship options in non-English speaking contexts become available, and internship providers are eager to accept interns able to contribute real work.

2. Longer internships. In most of the engineering world outside the U.S., employers expect interns to commit at least four months to a practical experience; it is very difficult to find U.S.-style 8-12 week summer internships abroad. The six-month internships planned into the GSEP model accommodate this expectation, opening many more internship opportunities while also providing GSEP scholars with a truly meaningful professional immersion experience.

3. Built-in lead time. GSEP policy requires students to be accepted into GSEP a minimum of 18 months before going abroad, regardless of language proficiency when entering the program. This not only provides time to complete cross-cultural training elements of the program, but also gives plenty of time to plan for the year abroad, including the internship component. This long pipeline also helped simplify program startup, allowing time to focus on putting in place on-campus elements and carefully build partnerships before the first cohort went abroad.

In sum, a consciously strategic approach, supported by a program design aimed specifically at avoiding past obstacles in establishing successful partnerships has been critical to establishing the growing GSEP network of academic and internship partners.

3.1 The need for an effective resource for streamlining international partnering

Regardless of strategic approach and solid program design, the fact remains that establishing international partnerships has been by far the most arduous and costly part of launching the GSEP initiative. More broadly, this "cost of entry" must be recognized as a major obstacle to making comprehensive STEM internationalization options like GSEP a common offering at U.S. institutions. The fundamental problem is one of information access and coordination. In essence, each institution must "re-invent the wheel", sifting through endless and often confusing websites to discover the programs, courses, and research strengths of potential partner institutions; working to find and make contact with the appropriate person or office, communicating back and forth to clarify needs and offerings, working to discover potential internship options, and ultimately negotiating a partnership agreement. What is needed to streamline this process is an efficient web-based clearinghouse, a "common marketplace" of internationalization opportunities where institutions can describe their programs, courses, facilities, and other features in a uniform fashion. Given just a few simple search and filtering tools, an institution seeking to launch or expand an international initiative could quickly identify potential partners based on a variety of criteria: region, language, programs/disciplines available, and so on. Of course, all successful partnerships ultimately depend on personal connections between collaborators; the main goal of this resource is simply to tremendously streamline the process.

One promising effort in the right direction is the Global Engineering Education Exchange (Global E3) [20] consortium hosted by the Institute for International Education. Global E3 essentially provided a standardized umbrella of reciprocal exchange, allowing (only) engineering students from schools within the consortium to study abroad at other consortium schools without paying tuition. A simple search mechanism helps students filter available partner schools based on region, discipline and other criteria. Global E3 consortium participants pay a substantial membership fee each year; the network currently includes about 60 institutions around spanning the globe. While Global E3 provides an effective, turn-key way for institutions to offer individual engineering students a path to internationalization *without* the need to establish any sort of local internationalization initiative at all, it is not really designed to support the kind of direct institutional partnership-building that large-scale initiatives like GSEP require. In particular, initiatives that include language training like GSEP will generally want to develop custom, focused exchanges in specific regions with specific partners that are well-matched to their particular program model. What is needed, therefore, is an informational resource similar and complimentary to the Global E3 consortium, but aimed at streamlining matchmaking between institutional long-term institutional partners rather than between individual students and one-off experiences abroad.

4.0 Conclusion

In this era of rapid globalization, developing a globally competent STEM workforce has become an urgent national priority. Modern engineers and scientists will need to be able to work seamlessly across national, cultural and linguistic boundaries to collaborate in globally distributed research and design teams. Although a number of institutions have developed successful engineering internationalization programs of some sort, both the number of such programs and the volume of students they serve must be increased dramatically if American engineering graduates are to fill leadership positions in growing international engineering enterprises.

The Global Science and Engineering Program (GSEP) represents our exploration of a "production model" for internationalization that uniformly serves 14 STEM disciplines. Like all production frameworks, GSEP is based on maximizing volume while minimizing production costs. In practice, this means applying a maximally generic internationalization framework to as broad a population of students as possible to create an economy of scale that can justify an extensive support infrastructure, extensive specialized on-campus programming for the cohort, and investment in a strong network of international partnerships.

This focus on a production philosophy also embodies the central strategic insight that we offer in this paper, namely that when it comes to launching a successful internationalization initiative, "going big" with a comprehensive uniform, college-wide initiative that establishes a common infrastructure shared across many constituent degree programs may ultimately be *easier, higher quality, and more sustainable* than small-scale efforts at the program or department level. Shifting our thinking and program design from small-scale experimentation to broader, campus-wide initiatives is ultimately the key to taking engineering internationalization to the next level.

A significant remaining obstacle to large-scale internationalization efforts is the difficulty of establishing a international academic and internship partnerships. A focus on strategic partner selection can minimize partnerships needed to serve many disciplines, but ultimately the effort and cost of establishing partnerships remains substantial. We suggest that a coordinated international effort to standardize and streamline the partnership development process is needed to address this remaining hurdle.

As a broader vision for the future, internationalization must become a common, universally accessible enhancement to all existing professional degree programs on campus, much like the Honors Programs commonly available at every institution. Following this paradigm, international tracks (a) should complement (rather than replace) existing degree programs; (b) should be explicitly credited on diplomas and via other formal certificates; and (c) should be supported by an explicit administrative and support infrastructure separate from and complementary to the academic units served.

Finally, there is no reason that college-wide programs like GSEP can't be extended to other professional programs where international preparation in becoming vital as well. We are currently evaluating an expansion of GSEP to the Business programs on our campus, which would further expand access to internationalization, while increasing program volume to further amortize program infrastructure investments.

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