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Developing Linguistic and Intercultural Competence through an International Engineering Program: Rationale, Procedures, Lessons Learned

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Le français sur objectifs spécifiques (FOS) is a well-delineated subfield (Mangiante and Richer) and its pedagogical dimensions are well explored (Abry; Boukhannouche, Dufour and Parpette*; EME*, Mangiante and Parpette, Gourvès-Hayward and Morace). Yet in terms of programmatic and curricular offerings it remains a niche specialization. In 2014, *Points Communs,* the scientific journal of the FOS committee of the Centre de Langue Française of the Paris Chamber of Commerce (CCIP), bemoaned this dearth:

> "While the global demand for training has continued to grow with the acceleration of the globalization of economic exchanges and the encouragement of student mobility, while the Ministry of Foreign and European Affairs has recommended, from the beginning of the 2000s, taking into account the training demands of new groups of learners of French as a Foreign Language (FFL) as one of its stated priorities—and the French for Specific Objectives (FSO) constitutes one of the most encouraged responses—, this disciplinary field remains marginal in the training programs offered to students and professors in professional training. French for Specific Objectives does not manage to get out of a kind of didactic and scientific "niche." There are rather few researchers and doctoral students in FSO, few FSO modules in FLL Master's programs and, often, when they are offered, they are offered in competition with other courses; there is little diffusion of research in international conferences of the various professional associations of language teachers, or in the colloquia of didacticians." (Mangiante and Richer, 2-3, translated by this author).

Our search of Academia.edu (Academia) for its scholarship footprint and of the CCIP website for its recognition through professional exams (https://www.lefrancaisdesaffaires.fr/) shows that FOS for STEM education remains underdeveloped when compared to French for international relations, French for *hôtellerie-restauration*, *le français juridique*, *le francais des affaires*, all well-established domains of *français pour les professions*. In the US, there is only one up-to-date textbook for engineering in French (Erickson) while the precious few others are very dated (Blackbourn and Marin; Bouton and Clément; Locke; Vigner and Martin). The last issue of the *Revue Internationale d'Éducation de Sèvres* devoted to teaching sciences abroad in French dates back to 1997 (*Revue*); its most recent bibliography on *l'enseignement des sciences* to 2009 (Plumelle). Finally, a systematic search of *Le Français dans le Monde* (https://www.fdlm.org/) and the *French Review* yields similarly paltry results.

Yet FOS and other languages for specialized purposes for STEM presents opportunities for student recruitment and retention, for curricular and scholarly innovation, and for interdisciplinary initiatives (Sowa and Kraika). Therefore, this chapter is inspired by the relative paucity of resources on FOS and other languages for engineering *and* their potential for expansion. It presents a case study of the development of a global engineering program (GEP) with study in France and explores transferability by offering a "how-to" guide that applies to other languages. It may serve as a *vade mecum* since it includes 1) the multilayered rationale for offering a GEP across different languages, 2) a case study of application, 3) fundamentals to consider upstream, and, 4) a checklist to operationalize an GEP, again, for any language. In conclusion, we draw core lessons for institutions and programs.

I. Why Develop a GEP in Target Languages?

GEP innovators may consider these arguments to promote their program among, and mobilize support from, academic leadership, students, parents, degree programs, colleagues across departments and colleges, fund raising officers, alumni, and other stakeholders.

A. Disciplinary Rationale: Competencies for Engineering Education

In 1980, the Engineers' Council for Professional Development (ECPD, founded in 1932) became the Accreditation Board for Engineering and Technology (ABET) that today accredits 4,361 programs at 850 colleges and universities in 41 countries. In 1997, ABET adopted *Engineering Criteria 2000* (EC2000), "considered at the time a revolutionary approach to accreditation criteria" because "EC2000 focused on learning outcomes (what students learn) rather than what is taught. By implementing such fundamental changes, ABET moved away from a rigid process orientation toward a set of attributes that professionals must possess to excel in fields of critical importance to society" (https://www.abet.org/about-abet/at-a-glance/). Under EC2000, engineering programs develop student learning outcomes / competencies that vary by country and sub-specialization, but across engineering sub-specializations the need for knowledge, skills, and values is "listed as high priority by the United States National Engineering Education Research Colloquies" (Passow and Passow 476).

At first glance, "foreign languages" rank low among the desired skills (Passow and Passow 489-90). But upon closer inspection, several skills that language education helps impart loom large: communication, teamwork, and ethics (born in part from the recognition of differences and power dynamics) rank among the top five skills sought in undergraduate education. These social dimensions of engineering expertise are paramount because the "boundaries drawn" between the technical and the social aspects of engineering expertise "are inevitably arbitrary" (Ib., 491). Social ingredients are heightened by the need to work in global teams. *Educating Engineers: Designing for the Future of the Field* (2008) states that "Today's engineers, situated in distributed, often global chains of supply and distribution [...] work with other technicians and managers who bring different viewpoints and sometimes different languages, cultures, and outlooks" (Sheppard et al. xvii). Engineering work is dispersed, outsourced, even fragmented across geographically distant institutions and caught in constant change; countless engineering projects, teams, and companies operate with expertise drawn from many cultures. According to the *Harvard Business Review*, global teams

> draw on the benefits of international diversity, bringing together people from many cultures with varied work experiences and different perspectives on strategic and organizational challenges [...] But managers who actually lead global teams are up against stiff challenges. Creating successful work groups is hard enough when everyone is local and people share the same office space. But when team members come from different countries and functional backgrounds and are working in different locations, communication can rapidly deteriorate, misunderstanding can ensue, and cooperation can degenerate into distrust (Neeley 2015).

Therefore, as ACTFL points out, "Many schools have established Global Engineering programs in view of the global trends in the profession, and where proficiency in a language other than English and study abroad are mandatory or strongly encouraged. The American Society of Engineering Education identified proficiency in 2 or more languages as a key attribute of a globally oriented engineer capable of effectively living, working, or performing in a global setting" (Lead). Indeed, in their *2015-2020 Strategic Plan*, Engineers Without Borders USA lists "multidisciplinary, cross-cultural and hands-on learning opportunities through engagement in EWB-USA programs" as one of their most important goals (EWB, 5).

In particular, English when used as *lingua franca* creates power imbalance between native and non-native speakers (Ruggiero). Global engineering teams should develop strategies for inclusiveness, "dial down dominance" (L1 speakers should slow down delivery, articulate more, user fewer idioms, cultural references and slang, seek confirmation of understanding, and rephrase others' statements for clarification), "dial up engagement" (L2 speakers should monitor their understanding) and "balance participation to ensure inclusion" (managers must monitor exchange flows) (Neeley; Neeley and Kaplan). "Active Learning Increases Student Performance" (Freeman et al. 2014) and immersion in another language, culture, and country is the ultimate active learning experience.

B. Institutional Rationale: STEM in Context, Student Care and Employability

Thanks to their insistence on the situated character of knowledge and the practice of science, humanities and social sciences (HSS) in general and language-intercultural education in particular may help engineers question *scientisme*—the naive belief that technical problems are amenable to exclusively or essentially technical solutions—and a decontextualized approach of their discipline. *Scientisme* was born during the first Industrial Revolution and expressed the idealistic belief that STEM progress would usher in comparable moral-social progress: individuals, communities and nations would be enlightened by science and reason, superstition and archaic traditions would yield to optimized social engineering, war and slavery would be confined to the dustbins of history... At the core of this *modernist* ideology of everlasting cumulative material and social progress lie the myths of Prometheus (accessing the mysteries of the material world) and Faust (emancipating humans from the old gods). Yet World War I, World War II, the Holocaust showed the permanence of Shadow, or evil, in human. Yet again, true to form, the human amnesia, arrogance, and naiveté that *scientisme* expressed, persist to this day through new avatars, artificial intelligence and transhumanism. Engineering students' grounding in HSS may help inoculate them against such hubris.

Engineering practices, challenges, solutions, and trade-offs are shaped by technical *and* sociopolitical forces: "Scientific discourse and knowledge making are inextricably linked to visions of social, political and ecological order" (Miller 4). Science is objective but scientists are imperfect humans embedded in relations of power and interests, and the mental-emotional dimensions of their preference formation weight heavily on decision-making (Kahneman and Tversky). Indeed, beliefs are formed by complex interactions between biology (e.g., gender), belonging (networks of reference), business (material and immaterial interest), biography (life experience and interpretation) and belief-formation (forces that shape decision-making). B(eliefs) in engineering derive from B^5, not just from $d=\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$.

Due to crowded engineering curricula, a competency gap affecting listening and speaking skills, oral and written communication, teamwork skills and emotional-social intelligence may hinder engineers' preparation: "The sum of the existing literature referencing intrapersonal and interpersonal competencies suggests an emerging consensus within the engineering ecosystem that such competencies are important in the engineering profession. This consensus has not translated into engineering education, which has traditionally focused on developing technical skills and largely neglected developing a more holistic skillset" (Huerta et al. 637). HSS can help develop the *whole* person by "integrating active-learning pedagogies to develop a wider range of competencies. Active-learning pedagogies have largely been successful in enhancing lifelong learning, design, problem-solving, communication, and teamwork while also improving students' awareness of societal and global issues, ethics, and professionalism" (Huerta et al. 638).

Engineering programs are also concerned about the high drop-out rate among their students, a powerful indicator of their performance in terms of preparing their charges for the rigors of engineering education. Language-intercultural education may help alleviate some student stress due to its grounding in communication, connectedness, sensitivity, and values. This is especially important during the freshman year, when the new environment, academic pressure, financial commitment, etc. often stress students. Colleges acting *in loco parentis* are concerned about their students' mental health and mobilize various tools to help reduce anxiety, including student health services, mindfulness, and classes with human-centered experiences. While an experience abroad carries its own challenges, it also gives students the thrill of novelty, fresh friendships and activities, freedom and personal responsibility, and other aspects of personal growth that are critical at that age.

Opening the engineering curriculum may also help reverse the sclerosis of the "pipeline" training of modern engineers: one point of entry, one direction, one outlet, and over-emphasis on calculus. As several luminaries of the American Society for Engineering Education underline, the last meta-reform of the profession dates back to 1955 and today, "[t]he curricular structure is rigid, with long prerequisite chains and few free electives" (Sorby, Fortenberry and Bertoline). For them, engineering teaching should include EDI, different learning styles, gender equality, accountability, stress management, and *global perspectives*.

Engineering schools also seek to differentiate from competitors to attract the best students. A linguistic-intercultural competence program adds value to a STEM curriculum by making students global. GEP graduates are more marketable as they align their core competencies with the trends identified by leading professional organizations. The National Association of Colleges and Employers (NACE) identifies core competencies for career readiness. Over the past five years, it consistently ranked "Teamwork/ collaboration" and "Global/multi-cultural fluency" among the top competencies sought by companies.

C. Humanistic and Pedagogical Rationale

The necessity of a deeper engagement between STEM and the HSS is recognized notably by the Liberal Education/Engineering & Society (LEES) Division of the American Society for Engineering Education (ASEE), which "provides a vital forum for those concerned with integrating the humanities and social sciences into engineering education [to] emphasize the connectedness between the technical and non-technical dimensions of engineering learning and work" (https://sites.asee.org/lees). The modernist-progressist assumption that characterizes the practice of science as ahistorical and above the tensions and contradictions of society, is dated (Mayo and Larke; Nair and Henning). It would treat sociocultural forces as "mostly invalid disturbances" (Von Storch et al. 113), when in fact scientific practices are "context-dependent" (Janasoff 130). The HSS often embrace a critical stance, which may help scientists understand that the scientific is political, for instance bio-, energy and geoengineering, or medical technologies. HSS contribute to critical pedagogy (what engineering for whom and for what purposes? what teaching methods?), heuristics (what engineering solutions in situations of imperfect knowledge and power imbalances?), and epistemology (what constitutes engineering knowledge?) (Heywood, Johri and Holds).

The language profession has long embraced interdisciplinarity, cross-departmental collaboration, and innovative pedagogies. In Europe EMILE (*Enseignement d'une matière intégrée à une langue étrangère)* and CLIL (Content and Integrated Language Learning), in the US CBI (content-based instruction), LAC (Language across the curriculum), WAC (Writing across the Curriculum) and other modalities have long engaged with HSS and STEM. In addition, the French excellence in key engineering disciplines—notably nuclear, aeronautics and mechanical, civil and architectural, and medical—makes French an attractive language for students. President Macron's initiative *Make our Planet Great Again* in favor of climate change technologies should further sensitize language students.

Finally, Michael Byram's canonic model of intercultural skills—*savoir*, *savoir apprendre*, *savoir comprendre*, *savoir-faire* (or *savoir s'engager*) and *savoir être*—applied to STEM can help develop intercultural citizenship and communicative competence with various stakeholders (Wagner, Cardetti and Byram). The development of such skills can't be expected to flow incidentally from a scientific curriculum: developing relational skills is hard since the current structure of incentives is geared toward the status quo, and because professional routine, defensiveness around the mathematical-logical intelligence and one's professional expertise can run deep (Berdanier). Yet, foreign exposure widens engineering students' other forms of intelligence (Davis and Knight; Yu): L2-cum-IC training invites openness to the Other, decentering of self, navigating ambiguity and complexity, developing multiple strategies, tapping into one's diverse identity, and fostering emotional flexibility. Engineers will then recognize that 5 Ps—people, paradigms, procedures, products (outcomes), and power—drive individuals and organizations.

II. A Mainstream Engineering University Innovates

The Missouri University of Science & Technology (S&T), chartered in 1870 as the Missouri School of Mines and Metallurgy, celebrated its 150th birthday in 2021. It is organized in three colleges: The College of Engineering and Computing (CEC), the College of Arts, Sciences and Education (CASE), and the Kummer College of Innovation, Entrepreneurship, and Economic Development. It is a public research university, 8000 students and about 800 faculty strong, with about 6,000 undergraduate students and a dynamic Greek and associative life. Engineering shapes its institutional identity. Over 20 research and design labs, and 650 foreign students (spring 2022) bring depth and diversity to campus.

Humanities and Social Sciences (HSS) are in a minority position, especially as many students across all majors hail from Missouri, with varying degrees of exposure to (and interest in) language education in high school, and in cases, none. S&T is representative of many public institutions with a largely state-based or regional enrollment, where the secondary status of language education reflects the nation-wide crisis of humanities. However, starting in 2019 S&T developed a new vision for the internationalization of the student experience that materialized as the creation of the global engineering program (GEP). It consists of a BS in an engineering discipline (120+ credits) plus a BA in multidisciplinary studies (45 credits including 30 credits in the target language and culture). Its year abroad (1st senior year, Ecuador, France, or Spain as of fall 2022) includes a fall semester of classes and a spring internship. Due to staffing limitations, only French and Spanish are currently supported for this BA. Missouri S&T Chancellor Mohammad Dehghani explains his vision for a holistic engineering education thusly:

> Issues related to the impact of technology on the environment, global health, privacy, natural resources, space exploration and more all demand serious investigation of the role science and technology play in our world. And broader questions of economics, diversity and community development require insights provided by humanists and social scientists as well as scientists and engineers. (Dehghani)

The GEP seeks to better serve our students, respond to their interest, globalize public education, connect the Colleges, tap into the dynamics of interdisciplinary collaboration, and make the university more competitive.

III. Defining the Fundamentals

A. People: clarify staff issues, their responsibilities, incentives, accountability standards and procedures. The institution should not appoint junior professors or novice staff because a GEP is complex, time-consuming, and runs against the logic of the tenure process that rewards scholarship and teaching before service.

B. Location: the institution should situate the GEP and its team across existing programs, departments, and colleges, and maintain synergy over time.

C. Investment: resource allocation, institutional messaging, language policies and incentivization of stakeholders should be congruent over time.

D. Community: GEP innovators should engage with our epistemic community and community of practice, starting with the best-known program in the US (University of Rhode Island), leading journals (*Journal of International Engineering Education, European Journal of Engineering Education* and *Advances in Engineering Education*) and conferences (ACIEE, ASEE, ASEE/IEEE Frontiers in Education Conference).

E. Vision: GEP managers need to delineate their vision:

   a. Is it a one-way (study abroad) or a two-way (exchange) program?

   b. Is it a semester- or year-long program? A full academic year adds an invaluable professional internship but pushes off the student's graduation schedule by one semester and may be dissuasive. A semester-long program is easier to sell to students but lacks professional experience. A number of engineering students already complete their 4-year BS in 9 or 10 semesters, due to the difficult compact curriculum. The GEP adds more time, credits and tuition (not to mention study abroad expenses) to a rigorous 4-year program.

   c. If there is an internship component, who will help GEP students identify and navigate internship offerings? What is the plan B if once abroad GEP candidates do not secure an internship with a company? Can they conceivably work in their host institutions' laboratories and research centers?

d. Will incoming and outgoing students pay home university or host university tuition?

e. What is the framework for the language curriculum? Will GEP students receive a certificate (minimum credit load), a minor, a secondary bachelor's (highest load) in their target language? Can the GEP use pre-existing frameworks within the university or will it have to create new ones? What faculty supervision will GEP students receive? How will their semester(s) abroad be assessed?

f. What is the distribution between target language and English classes while abroad?

F. Timing: Arguments supporting study abroad during the sophomore or junior year.

a. There are more general STEM classes abroad at this level before students get too specialized.

b. Students have more HSS electives to fulfill earlier in their curriculum.

c. Engineering advisors can be reluctant to see their seniors depart because they want to control the quality of their upper-division courses. Upper-division, specialized degree classes are often defined as "residential" by degree programs.

d. *Curricular residency*—students mandated to take N credits in their home institution in their senior year—may also keep students from studying abroad later in their cursus.

Arguments for sending students later with more focus on their level of linguistic proficiency:

e. Many host universities abroad require the ACTFL advanced low or mid-level from their international students. But freshmen who start a language in college seldom reach that level in time. A summer language intensive (in the US) or immersion (abroad) may be considered. But this added education and cost may derail the project for some students, especially first-generation, minority students, students from less well-off families, etc.

f. Engineering students are eager to be admitted in their degree program, which prioritizes the mathematic, physics, and other STEM-related prerequisites during their first two years, thus crowding out language classes.

G. Credit allocation:

a. A semester abroad requires a 12-15 credit load for students to keep their student's status, financial aid eligibility and satisfy their visa requirements. The GEP should consider the distribution of engineering and language credits earned abroad. GEP candidates may be scared away by an all-L2 curriculum abroad.

b. Will STEM classes taken in the L2 be considered for both engineering and language credits?

c. Will engineering program grant credit for work abroad? Or would work abroad "just" satisfy experiential learning requirements?

d. A second semester raises issues of engineering credit allocation for the spring internship. In order to be able to complete their language education (e.g., minor or secondary BA), students should be able to sign up for directed studies for their spring internship. This raises policy issues for language faculty: will language faculty be mandated and compensated to work with GEP students? Will these independent studies be counted for their work productivity? What type of deliverables, and scholarly standards may be accepted for internship credits?

H. Finances: GEP managers should work with the financial aid office and donors to assess and help cover the extra cost of a program abroad and communicate to stakeholders.

a. This raises the issue of equity for less well-off students. Given the extra expenses of the GEP and travel abroad, eligibility for the GEP may turn out to be based on the financial possibilities of students and excludes students from some social and ethnic groups.

I. Language preparation raises important issues:

a. Programmatic: is the institution's language offering ready for preparing GEP students? Does it need overhaul? What new, specialized classes ought to be developed?

b. Curricular: what mode (f2f or distance) of delivery is the most efficient? How does the department insure deeper and individualized language exposure for busy GEP candidates? How does it help candidates who fall short of the language proficiency required by the host university?

c. Co-curricular: what language enrichment for the GEP?

IV. Recurring Steps for Multiple Stakeholders

GEP innovators should advertise their program through the relevant campus cycles and processes: recruiting, advising (freshmen advisors and degree program advisors), orientation and placement, financial aid, outreach to visiting students and families, institutional marketing, website and social media, etc. Of particular importance are the recruitment office, admissions/enrollment team, the new students and transfer students' office, freshmen advisors, engineering chairs and advisors.

GEP managers will focus on student information, cultivation, and recruiting. They should identify visiting high school students and freshmen in the "nooks and crannies" highlighted above and maintain a master list of candidates. On-going data management and cultivation of GEP candidates are time-consuming tasks. Cultivation can also come through co-curricular offerings, speaker's series, GEP cohort activities, pizza socials, etc. The tasks around recruiting are both quantitative and qualitative. Quantitative: interested students should be contacted several times during their freshman fall semester (welcome information email, GEP information, invitation to language/GEP events). Generic mass emails have a paltry RoI: better to customize each email with the student's name and key information. Address the points of concern: partner and city information, semester abroad information, language-related issues, articulation with primary major, graduation schedule, cost, financial aid, how to join the program, how to leave it, etc.

GEP managers will serve JEDI (justice, equity, diversity, and inclusiveness) by cultivating, notably, the campus chapters of the National Society of Black Engineers (*Hidden Figures*, Zelik), the Society of Hispanic Professional Engineers, and the Society of Women Engineers (*Hidden Figures*). They will be involved in campus outreach and marketing events, student and family visits, open house, promotion days, and information fairs. They will collaborate with their study abroad office and become familiar with their policies and resources (GE3, Magellan, Terra Dotta). Reassure candidates and parents regarding safety, health coverage, medical evacuation services abroad and your university's student safety committee(s). Become familiar with the Department of State country security ranking and the CDC guidelines for COVID, and other sources of risk assessment.

GEP innovators may explore joint events with degree advisors, visits of degree programs, a board of advisors (university leaders, staff and faculty, alumni, industry and students' representatives). They should know Campus-France and the visa application portal (https://france-visas.gouv.fr). They will know their host institutions in France, visit them ahead of time, and seek the *Bienvenue en France* label that certifies French universities for best service to international students. And the same for other countries of destination.

They will maintain a master calendar and a language, cultural and logistical guide and FAQs for candidates. They will organize pre-departure preparation for candidates, trouble-shoot with students abroad, and support them. They will organize post-return debriefing and (try to) hire GEP returnees as ambassadors to assist with the following cohort of GEP candidates. These initiatives are predicated on a GEP budget that has enough autonomy to adjust to these many tasks.

In conclusion, developing an GEP is a major endeavor that demands much engagement and collegiality from GEP managers but shouldn't be busy at all for language and engineering colleagues. GEP managers will want to develop their program in the C.O.R.E. of their school: curriculum, operations, research, and engagement. Building procedures (e.g., co-advising GEP candidates) rather than structures (committees) seems easier. The GEP success across the 4 Rs (recruitment, retention, reputation, research) is predicated upon departmental synergy, team-spirit, curricular maturity, SLA pedagogy, and buy-in among stakeholders (Streiner and

Besterfield-Sacre). Managers will no doubt run into institutional contradictions, gaps and inertia, different personalities and working styles, and everyone's busyness. They will succeed if the organization acts coherently over time and if they can garner collective support to serve students contemplating engineering study abroad.

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