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Spanish for STEM in US Higher Education: A Historical Review and Future Perspectives

Abstract: This article examines the long tradition of Spanish-language learning for scientific and technological purposes in the United States. It provides a review of some of the historical approaches for designing course offerings and programs of Spanish for STEM (science, technology, engineering, and mathematics) at the college level. These historical approaches help us better understand the unique challenges Spanish for STEM educators and scholars have faced at different times and the perspectives that have shaped the current state of the field. The author also describes current pedagogical models within the field of Languages for Specific Purposes (LSP) but also International Engineering Education (IEE) and Cultures and Languages Across the Curriculum (CLAC). Finally, the author articulates future perspectives and possible directions of the field, including more emphasis on needs-analysis curriculum design and more active engagement with developments in other geographies, language traditions, and areas of LSP. This article seeks to encourage the growth of Spanish for STEM at institutions of higher education, whether in language departments or science and engineering programs.

Keywords: curriculum design, languages for science and technology, scientific Spanish, Spanish for Specific Purposes, Spanish for STEM, technical Spanish

In the 2018 report titled *Branches from the Same Tree*, the National Academies of Sciences, Engineering, and Medicine advocated for a more integrative approach to higher education in the United States, in particular across the traditional disciplinary boundaries that have separated the humanities and arts from the sciences, technology, engineering, mathematics, and medicine. A crucial recommendation included in the report stated that institutions should provide an academic experience that prepares students for the twenty-first century by "strengthening their critical thinking, communications skills, ability to work well in teams, content mastery, motivation, and engagement with learning" (National Academies, 2018, p. 178). In this context, the Languages for Specific Purposes (LSP) field seems particularly well-positioned to answer this call since it proposes a "holistic approach to language learning through its integration of language, culture, communication, content, and context" for applications in fields that include, among others, engineering and medicine (Grosse & Voght, 2012, p. 201).

Addressing the need to establish bridges between languages and STEM (science, technology, engineering, and mathematics), the American Academy of Arts & Sciences has recognized that if more researchers were able to communicate their findings across non-English speaking countries and access the work of scientists published in non-English journals, the competitiveness of the United States in scientific and technological innovation would improve (Commission, 2017). For example, a significant amount of the research from Spanish-speaking countries is in medical fields, agriculture, and applied sciences, and it is regularly published in Spanish (Plaza et al., 2013; Santa & Herrero Solana, 2010). Such works provide invaluable knowledge about current and past realities faced by Spanish-speaking communities. STEM practitioners in the United States who have access to this body of knowledge will undoubtedly do better, more informed science. The American Council on the Teaching of Foreign Languages

(ACTFL) has stated a similar position when defending language learning as a core component of general education in the country, given that it allows access to information and promotes collaborations across fields, including STEM (2013).

Moreover, the Universal Declaration of Human Rights, of which the United States is a signatory, recognizes the "right to science" of all human beings (Chapman, 2009). If the United States is to move in the direction of effectively recognizing the "right to science" of all its peoples, including its non-English-speaking population in general, and its large Spanish-speaking population in particular, much work is needed. As a natural extension of the core components of this human right, the United States would be called upon to provide access to scientific and technological knowledge and to foster its circulation in languages other than English, as well as to promote the participation of non-English speaking communities in decision-making about science (Chapman & Wyndham, 2013). Such a monumental effort would require a serious commitment by policymakers and the unrelenting work of trained professionals in languages for science and technology. Scientific and technical translators and interpreters will be essential but insufficient without more scientists, engineers, technicians, science policymakers, and science communicators with language skills.

Curricular offerings of languages for STEM at US colleges and universities have an important role to play in all of the previous scenarios. Languages for science, technology, and engineering have been part of the growing number of LSP courses and programs in the United States. However, such offerings represent only a minimal percentage of LSP offerings as a whole (Long & Uscinski, 2012). The status of Spanish for science and technology among Spanish for Specific Purposes (SSP) and Spanish for the Professions (SP) is no different. This current study encourages the growth of Spanish for STEM in the United States by looking back at the history of the field in order to push forward towards wide-ranging curriculum design and implementation informed by the successes, and missteps, of past and current approaches.

In the present work, I describe different approaches for Spanish-language learning for scientific and technological purposes in the United States at the higher education level. First, I review some historical trends to design offerings and programs of Spanish for STEM. Then, I discuss current efforts to promote the teaching of Spanish for technical and scientific applications in the United States, including pedagogical models that have been proposed in recent years. I mention some of the unique challenges that these kinds of offerings and programs face. Finally, I discuss some possibilities to facilitate the proliferation of Spanish for science and technology course offerings at institutions of higher education. The goal is to provide a comprehensive overview of Spanish for STEM education in the United States as a roadmap—and perhaps as inspiration—for educators who are currently working or considering working in this area of LSP.

Engineers Abroad and the Need for Technical Spanish: 1910s–1930s

Language education for what we now call STEM fields of study has an extensive history in the United States. Long before we started talking about LSP in the 1960s, colleges and universities across the United States were offering a significant amount of scientific language courses. In two separate articles from the 1920s, Edwin B. Williams (1925, 1929), a professor in the Department of Romance Languages at the University of Pennsylvania, described the state of scientific language education in US colleges and universities. Williams surveyed language departments and engineering schools across the country. The information collected showed a

modest but growing interest in scientific Spanish courses and a more robust set of scientific German and French offerings. In 1925, 260 students were enrolled in scientific Spanish classes (up from 10 in 1922) in the surveyed schools. By contrast, there were 2155 students enrolled in scientific German classes and 849 students of scientific French (Williams, 1929). The disparity between languages was most likely related to the perceived relevance of each of them in scientific and technical fields, a perception that was reflected in the goals of scientific language courses as described by the respondents. In the case of German and French, the main goals were to develop reading and translation skills to broaden the influence of American scientists and keep up with scientific contributions published in these two languages. Meanwhile, for Spanish, reading comprehension, vocabulary growth, and conversation skills for traveling were the top goals reported (Williams, 1929). It is striking that one of the most commonly stated objectives of scientific Spanish courses was to improve conversation skills for travel. As we will see, this can probably be explained by the low number of technical personnel that participated in US enterprises in Spanish-speaking regions. This emphasis shaped the most prevalent teaching approaches in these years, and it can be seen in the learning materials available from the era.

One of the earliest examples of learning materials explicitly designed to support Spanish for science and technology course offerings was generated by Cornélis DeWitt Willcox, an army officer and professor of Spanish and French at the US Military Academy. Willcox published *A Reader of Scientific and Technical Spanish* in 1913. The text was meant to support undergraduate college students "who mean to practice the Engineering Profession in the Spanish-speaking Americas" (Willcox, 1913, Preface section). The term "practice" is key here, as it refers to the real need for engineers with Spanish language knowledge to support the expansion of US economic interests in Spanish-speaking countries.

It is worth noting that, during the first three decades of the 20th century, the US interventionism in Latin America intensified, bringing a significant increase in the country's presence in the region, both militarily and economically (O'Brien, 1996). At the same time, many of the political regimes in Latin American that embraced positivism relied on US technology to carry out their modernizing projects (O'Brien, 2007). In the case of Spain, the distancing period that followed the Spanish-American war came to a relative halt at the end of World War I, when there was a jump in the participation of US companies in the Spanish industrial, mechanical, and chemical sectors (Álvaro Moya, 2012). Technological knowledge and mechanization were at the center of such growth, including the construction of port facilities and railroads, the exploitation of mines and agricultural fields, and the production of machinery and chemical products. In practice, all these undertakings required a specialized workforce that could support them. As a result, many US technical workers participated in small and large enterprises throughout the Spanish-speaking world. The Panama Canal, built between 1904 and 1914, is just one example. After the US occupation of the Canal Zone, American surveyors, geographers, engineers, machinists, doctors, and nurses, among others, traveled to the area (Greene, 2009). It is estimated that as many as six thousand Americans worked on the canal at any time (Greene, 2017). Hence, the need for technical practitioners with the requisite language skills was real and immediate.

Willcox's (1913) reader provides a valuable window into the teaching methodology of scientific Spanish courses of the time, focused on improving reading comprehension and vocabulary acquisition. The preface again gives us more clues. The ideal student for Willcox was one who had advanced knowledge of Spanish and understood the technical and scientific content. The reader would then be used to establish a connection between these two areas. The

organization of the reader is also telling. The reader is composed of chapters based on scientific disciplines (e.g., physics, chemistry, geography), engineering subjects (e.g., topography, mining, land surveying), modes of transport and infrastructure (e.g., rails, automobile, bridges), and military topics, including a chapter on submarines and one titled "The Siege of Santiago de Cuba" ("La campaña de Santiago de Cuba"), that addresses technical issues related to a key episode of the Spanish-American War. Each chapter contains authentic texts, including texts originally written in Spanish for native speakers, that come from various sources, mostly manuals and textbooks. The reader also includes a comprehensive Spanish-English list of technical terms at the end (Wilcox, 1913, pp. 527–588).

The combination of authentic technical texts and a bilingual vocabulary directly speaks to the goal of focusing on reading comprehension and vocabulary growth; it also points to two main challenges that the reading/vocabulary approach to scientific and technical Spanish education faced, and that similar approaches will continue to encounter. Williams (1925) highlighted the first one as a primary concern expressed by those he surveyed: the lack of specialized educators to offer these courses (p. 239). Under this model, effective educators would be required to have advanced Spanish language skills and a broad knowledge of technical content. The need for such a combination generates a set of questions related to recruitment (Where do you look for and how do you attract and retain such candidates?), specialization (What kind of educational background would be ideal? What language/scientific specialization?), logistics (Will the candidate be placed in a language or STEM administrative unit? Will the candidate only teach Spanish for science and engineering courses?), and institutional sizes (How can a small- or medium-size institution support and offer these courses?), to name a few.

A second challenge is addressed by Willcox (1913), who recognized that "[i]n a work of this sort, the difficulty is not one of inclusion, but of exclusion. And once the subject is decided on, another difficulty presents itself: how much space shall be allotted to each head?" (Preface section). As one can imagine, selecting the breadth and depth of scientific content for this type of text is no trivial matter. As we will see in the coming sections, this is a matter with which Spanish for STEM educators continued to struggle and that more recent approaches have sought to tackle.

Readers similar to Willcox's were published in the following years (Alonso & Hershey, 1928; Sparkman, 1919), serving as textbooks to the industrial Spanish and scientific Spanish courses offered at the time. This early focus on reading/vocabulary of scientific Spanish courses follows a trend of Spanish language learning in the United States, which at the time had the reading method in a prominent place. Nevertheless, it contrasts with the rise of the "direct method" and the "natural method," which advocated for a more balanced emphasis on the four skills (reading, writing, speaking, and listening), taking place simultaneously (Long, 1999). Despite its downsides, the reading/vocabulary approach of scientific and technical Spanish offerings would be prevalent for many years to come. Moreover, scientific and technical readers show how the use of authentic materials has been a deep-rooted characteristic of Spanish-language learning that focuses on science and technology.

Technical Translation and Dictionaries, 1940s–1950s

One problem related to scientific readers that became obvious in the 1940s, when World War II accelerated scientific research production, was how quickly the text selections became outdated. Around this time, Stanley T. Ballenger, at the North Carolina State College of Agriculture and Engineering of the University of North Carolina (now North Carolina State University), highlighted a "dearth of texts" for scientific Spanish courses, leaving instructors to assemble their own collections (Ballenger, 1940, p. 145). A look at the 1940–1941 catalog of Ballenger's institution shows the important role of technical language courses with respect to the overall language offerings there. The catalog includes offerings of scientific, technical, and industrial German, French, and Spanish at different levels (North Carolina State College, 1941). According to their descriptions, Spanish courses were mostly focused on acquiring practical vocabulary and developing reading skills, following a common trend. However, an advanced scientific Spanish course was also offered, in which translation was a central component.

As described by Ballenger, the course had two distinct parts. On the one hand, students attended regular class sessions where they discussed a variety of scientific texts compiled by the instructor, including selections from scientific journals, experimental reports, and bulletins. Vocabulary played an important role, too. However, rather than stressing acquisition by memorization, students examined some of the mechanisms behind technical word formation. On the other hand, students worked on individual translation projects relating to their particular interests, and they had weekly one-on-one meetings with the instructor to discuss their work. At the end of the course, the successfully completed translations were published by the Translation Service, an initiative of the Department of Modern Languages at this institution. The Translation Service provided an opportunity for language students enrolled in scientific language courses (German, French, and Spanish) to perform translations of scientific texts into English. The service was a joint effort between the language department and numerous experimental stations and research centers, which provided guidance on the scientific texts to be translated. Copies of the resulting texts were added to the catalog of the institution's library, the Library of the US Department of Agriculture, and the Library of the American Documentation Institute in Washington, D.C. (Hinkle, 1951). The approach of this course and the Translation Service provide an early model of languages for STEM in general, and Spanish for STEM in particular, focused on technical translation and a project-based methodology. Additionally, due to the flexibility allowed by the individual projects in terms of scientific content, this approach could serve as a model to attract students from a wide range of disciplines and interests.

The perceived lack of course materials extended to glossaries and dictionaries. Nonetheless, by this time, a substantial amount of resources had been published. For example, a list of "Scientific and Technical Dictionaries of the Spanish and English Languages," published in the July 1944 issue of the *Bulletin of the New York Public Library*, included 225 entries in about 50 different scientific and technical fields (Sánchez et al., 1944). Reviews and lists of some of these works appeared in journals directed towards language instructors, like *Hispania* and the *Modern Language Journal* (Handschin, 1944; Johnston, 1957; Zeydel, 1943), highlighting a small, but persistent, interest in this type of materials in the language-learning profession.

The slow but progressive change of teaching approaches that we see around this time not only extends to translation; more emphasis was also starting to be placed on speaking skills. In a brief article from the late 1940s, Fritjof A. Raven (1948) described an intensive Spanish course at the Massachusetts Institute of Technology that emphasized an "oral method, supplemented by

use of a concise outline grammar and supported by intensive oral drill" (p. 176). In practice, this approach included a combination of in-person sessions and individual work in a "phonograph room." In this room, students had access to recordings for the Army Specialized Training Program (ASTP), a text with "phonemic" transcriptions of the recordings, mimeograph copies of transcriptions using standard orthography, and two types of recorders (a SoundScriber and two wire recorders). Students were expected to listen to the recordings and then record themselves as they repeated the material. Students had access to the room at assigned times and during evenings and weekends for additional practice. Here we can see how the introduction of technology started to allow flexibility beyond regular classroom meeting times. Even though the course was not focused on technical texts or specialized vocabulary, it is relevant to our discussion because it describes how the ASTP was being adapted to serve the specific needs of engineering students in an institution that lacked a more developed language program. It is worth noting that this is precisely the boom period of the ASTP and audiolingualism, an approach that "featured memorization of dialogues, pattern drills, and emphasis on pronunciation" (Long, 1999, p. 389). Although short-lived, the ASTP influenced many of the subsequent pedagogical approaches by advancing the use of authentic materials, technology, and contemporary cultural components in the language classroom, as well as incorporating communicative assessment criteria and encouraging out-of-class communicative experiences (Velleman, 2008).

During the 1940s and 1950s, we can also see a modest recognition of scientific and technological developments in Spanish-speaking countries (Crawford, 1950; Nunn, 1946; Stevens, 1955, 1957), keeping interest in scientific Spanish alive. Although they never took a prominent place in the Spanish curriculum at most institutions, courses of scientific Spanish, technical Spanish, and engineering Spanish populated the catalogs of universities and colleges across the United States, along with similar courses in other languages, up until the later popularization of LSP.

International Engineering Education and the LSP Movement, 1960s–1990s

International Engineering

In an article titled "Languages for Engineers after the War," Walter Mitchell, Jr. (1944) described the changing world that American engineers were facing with the end of World War II, highlighting some consequences of their language deficiencies and advocating for not only an increase in technical language education at colleges and universities, but also a change in pedagogical approach. One complaint stands out: "Ordinarily far more time is spent compelling the student to memorize differences in conjugations of various tenses and developing an ability to write a foreign language accurately, than is devoted to speaking that language" (p. 385). Such assertion points to one of the driving principles of what will later be known as "languages for specific purposes," indicating that language education should respond to specific needs. Mitchell was certainly not alone. During the 1940s and 1950s, many pointed out the lack of internationalization of engineering education in the United States. Some initiatives were proposed at this time, but it was not until the 1960s and 1970s when we see a noticeable increase in the number of programs that embraced international engineering education (Jesiek & Beddoes, 2010).

At the beginning of the sixties, Victor Bobetsky (1960) reported the results of a survey about language learning at engineering schools. He found that language study was prevalent

among these institutions. Scientific and technical language courses were often available, with the highest number in German, French, Russian, and Spanish, in that order. In fact, the work being done on languages for science and technology in the 1960s played an important role in the origins of LSP as an academic field (Grosse & Voght, 1991). Bobetsky (1960) also reported that one school had initiated a program on "Engineering for International Service" (p. 218). The program, at Michigan State University, was a combination of technical coursework in an engineering field and liberal arts courses related to the region of the world of the students' interest. During the 1960s and 1970s, many other programs emerged, motivated by notions of international service and development and as a way for Americans to gain influence in the context of the Cold War. The 1980s saw the beginning of a shift in the justifications to support International Engineering Education (IEE), emphasizing the competitive advantage and professional mobility it could provide to students (Jesiek & Beddoes, 2010), in line with the rise of neoliberalism during these years. All of these programs formed the basis of current IEE initiatives.

Spanish for Science and Technology: Cluster Issues

During the 1970s and 1980s, and concurrent to the developments in IEE, interest in LSP drove the emergence of numerous course offerings and programs, and LSP itself was the subject of considerable discussion (Grosse & Voght, 1991). The creation of the Centers for International Business Education and Research (CIBERs) in 1989, supported by the U.S. Department of Education, gave a definite push for the consolidation of the field, with languages for business at the forefront (Branan, 1998). By the 1990s, Spanish for the Professions (SP) and Spanish for Specific Purposes (SSP) were led by business, with a growing interest in the health professions. The traditional separation between medical practice and STEM fields in the United States, as well as the practical needs in each area, determined two different realities with occasional intersections (for example, those that naturally occur in technical and medical translation and terminology). With origins that can be traced back to health education and promotion among Spanish-speaking communities in the United States, Spanish for the health professions became a thriving area in which related courses and programs were in constant expansion (Martínez, 2015). In contrast, the number of courses of Spanish for science and engineering did not see a similar trend.

However, the growth of the LSP movement in the United States did provide an opportunity to reexamine many of the approaches and methodologies used in the past in language learning for scientific and technical fields in general, and Spanish for STEM in particular. Maria Cooks (1998) addressed one of the long-lasting issues related to such course offerings: The limitations that come with their association with a particular specialized discipline. Instead of courses designed around traditional scientific and technical disciplines, Cooks (1998) proposed language courses based on "cluster issues" or "cluster areas," mentioning "energy," "food and biotechnology," and "the environment," among others, as possibilities (p. 407). By moving away from specific disciplines, such courses could attract students from a variety of fields, expanding their reach and relevance.

Cooks's (1998) vision offers a pathway for language departments that seek to diversify their offerings beyond the traditional two-tiered structure of a language sequence that then feeds into literature-focused courses organized by time periods and geographical locations, like the Modern Language Association (MLA) would recommend about a decade later (Ad Hoc, 2007).

Cooks's suggestion of thinking about "the environment" as a cluster issue anticipated the surging interest in, and development of, courses at the intersection of language learning and environmental studies. For example, beyond the growing number of Spanish course offerings specifically focused on the environment, with ecocriticism at the forefront, Luis I. Prádanos (2015) has proposed a set of strategies to incorporate an environmental perspective, with emphasis on sustainability, at all levels and areas of the Spanish curriculum, including SSP. As in the case of the environment, courses designed around clusters issues or areas have a great potential in the future of language learning in US higher education and will undoubtedly continue to grow, as they can be incorporated in current programs under existing structures. Current trends among language courses related to the environment show us the numerous possibilities of cross-curricular initiatives in language programs, including LSP (Melin, 2019).

Contemporary Approaches, 1990s and Beyond

International Engineering Programs

In the late 1980s and early 1990s, many internationalization initiatives of engineering programs took shape. The International Engineering Program (IEP) at the University of Rhode Island was one of them. Originated in 1987, this long-lasting program combines technical and liberal arts education, and has been used as a model by many other institutions (Grandin & Berka, 2014). Students who participate in the program receive dual degrees, one in engineering and one in a language, and are required to fulfill a series of requirements both on campus and abroad. The program features opportunities in German, French, Spanish, Chinese, and Italian. In the case of Spanish, students complete engineering courses in English, a traditional language sequence, and a Spanish for business and technology course on campus. Abroad, students take one or more language courses in conjunction with engineering courses in the target language and participate in an internship (University of Rhode Island, n.d.).

International Engineering Programs, like the one at the University of Rhode Island, present one of the most comprehensive approaches at the convergence of language learning and STEM education in US higher education. Nowadays, IEE is a vibrant and expanding field (Jesiek, 2018), in which there is a growing recognition that in order to educate truly global professionals, institutions of higher education should provide learning opportunities that will allow their students "to work, negotiate, define, and solve complex problems comfortably in languages other [than] their own" (Nugent, 2010, p. 269).

Spanish for STEM

The growth and popularization of LSP in the United States have provided a favorable environment for the development of languages for STEM offerings. A limited search in catalogs of institutions of higher education across the country revealed the presence of SSP courses with a focus on science, technology, and engineering in many of them. The majority of courses found were developed at large research institutions (Georgia Tech, Johns Hopkins University, Purdue University, Texas A&M University, University of Alabama, University of Connecticut, University of Virginia, University of Rhode Island), and less often at regional universities (University of Pittsburgh at Johnstown) and small liberal arts colleges (Scripps College).

However, the time seems right to perform a more comprehensive survey and analysis of the current state of LSP courses and programs related to STEM in US higher education.

It is worth noting that the quest to align the needs of learners with research-based LSP curriculum design has driven some recent developments in Spanish for STEM. Shannon Zeller and Maura Velázquez-Castillo (2018) have described the development of a certificate program directed towards animal science and veterinary students at Colorado State University. The certificate was made possible by a partnership between faculty members of the Department of Languages, Literatures and Culture, the Department of Animal Sciences, and the College of Veterinary Medicine. The needs-analysis process, which involved numerous stakeholders, resulted in a program that focused on addressing the workplace communication needs at livestock farms. A key step in identifying the language needs to be fulfilled required knowing the tasks that took place in these professional settings. To collect this information, curriculum developers conducted several interviews with animal scientists, veterinarians, technicians, operators, and workers, along with observations of routines and practices on site. The resulting certificate is constituted by four courses: two courses that develop language skills to perform the tasks identified in the analysis, one course on technical terminology and word formation, and one course on intercultural aspects in these settings (Zeller & Velázquez-Castillo, 2018). On the one hand, this program is a good example of how needs analysis can shape future curricula related to Spanish for STEM. On the other hand, it shows the convergences and intersections between this area and Spanish for the health professions, particularly in the realm of service-based approaches. More synergies between these two branches of SSP can help strengthen, multiply, and diversify future offerings, for example, in areas of technical communication, translation, interpretation, and vocabulary.

Languages Across the Curriculum

Since the 1990s, most Spanish for STEM efforts in US higher education have been centered around the continuous developments in IEE and LSP. However, the 1990s also saw the rise of Languages Across the Curriculum (LAC) initiatives, which have provided a framework for other approaches. Languages Across the Curriculum emerged as a curricular response to "students' insufficient language competence and the disjointed nature of their education," proposing that students "engaged in active and relevant uses of their language skills as they apply them to subject areas of their choice" through a "content-driven, task-oriented, and learner-centered approach that prepares students for real-life use of a language" (Kecht & Von Hammerstein, 2000, p. xxi).

Motivated by the possibilities of LAC and the 2007 call from the MLA to reexamine language programs (Ad Hoc, 2007), Barbara Domcekova (2010) and her colleagues at Birmingham–Southern College developed a LAC model that consisted of one-hour-a-week Spanish "enhancement sections" that accompanied environmental studies and chemistry courses taught in English. The enhancement sections included the reading of authentic materials, as well as pre-reading and post-reading activities, and discussion. Although students enrolled in the enhancement sections were usually enrolled in the corresponding science course, the Spanish courses were open to any student with the necessary language proficiency. Both language and science faculty members co-taught the enhancement sections. Science instructors had sufficient Spanish proficiency, given that they also participated in a Spanish for professors course offered at the same institution. This close collaboration poses some challenges. Domcekova identified

three they had to face related to faculty compensation, visibility/publicity, and scheduling. The author described the need to increase the program's visibility on campus to grow enrollments and maintain its viability, especially as faculty had not received additional compensation for their participation. Those who participated in the program hoped that larger enrollments could compel the administration to address compensation issues. Finally, this model "requires additional cooperation between the science and language faculty and coordination of multiple schedules" (p. 142), highlighting the need for a strong commitment on both parts to make it work.

More recently, I have described a model, also inspired by LAC, that sought to address some of the obstacles that have prevented the growth of Spanish for STEM offerings in the United States (Pérez, 2018). I proposed a course that moves away from scientific content areas while emphasizing modes of scientific communication. Instead of the traditional focus on disciplines (e.g., biology or chemistry), the course was organized around learning scenarios anchored in genres (e.g., science news article, science documentary film, research poster) and learning experiences (e.g., conversations with scientists). Given that the course was not linked to a particular discipline or theme, it could attract students from various backgrounds and with a range of interests. Students were asked to shape the course's scientific content by selecting, analyzing, and presenting authentic materials about the topic or subject of their interest. The instructor could then concentrate on the discursive mechanisms of the texts and communication skills. In this model, instructors do not need to be experts in any particular scientific or technical field, but they should become familiar with how the three modes of communication (interpersonal, interpretive, and presentational) work in the context of scientific communication.

Standalone courses based on this model can be offered at one single administrative unit. This approach seems particularly suitable for language departments at medium or small institutions, where hiring decisions are heavily based on the ability of candidates to teach a wide range of courses. Additionally, courses that appeal to a wide range of students can maximize the enrollments needed to offer them. Nonetheless, this model presents some shortcomings. Its emphasis on genres of scientific communication favors the development of interpretive and presentational skills, over interpersonal ones. Moreover, it focuses on advanced Spanish for STEM courses and does not offer obvious strategies for its implementation at the novice and intermediate proficiency levels.

Throughout the years, LAC has seen steady growth and a push to emphasize intercultural competence and multicultural perspectives. It is now commonly referred to as Cultures and Languages Across the Curriculum (CLAC), and it works more like an umbrella framework that encompasses a diverse array of offerings. Institutions that have implemented LAC/CLAC programs have done so in a wide variety of forms, providing dynamic environments where offerings at the intersection of languages and STEM are frequently included (Zilmer, 2018).

Future Perspectives

The development, challenges, and new directions of LSP and SSP have been the subject of numerous works recently (Brown & Thompson, 2018; Grosse & Voght, 2012; Long & Uscinski, 2012; Sánchez-Lopez, 2019). Although Spanish for science and technology is by no means independent of these trends, it faces some particularities of its own. There are many possibilities and directions of Spanish for STEM in US higher education that can be explored. Possible development areas include those related to translation and interpretation, technical communication, and public dissemination of scientific and technological knowledge (Pérez,

2017). Moreover, the development of Spanish for STEM courses and programs, as with LSP more generally, should be informed by a needs-analysis process in order to identify and meet the needs of students, the community, and the society at large (Sánchez-López, 2010, 2019).

Many of the pedagogical models that are being proposed in LSP could support offerings in this particular area, including content-based instruction (Klee, 2015), languages across the curriculum (Klee & Barnes-Karol, 2006; Plough, 2016), project-based learning (García González & Veiga Díaz, 2015), and service-based and community-based language learning (Clifford & Reisinger, 2018; Sánchez-López, 2013), including heritage learners (Ruggiero, 2019). Given that numerous intersections could be found between Spanish for the health professions and Spanish for STEM, particular attention should be paid to developments in Spanish for the health professions, an area of SSP that has seen significant growth in terms of programs, number and type of courses, and enrollments (Hardin, 2015).

When it comes to programs and curricular design, Michael S. Doyle has advocated for the centrality of Spanish for the Professions and Specific Purposes (SPSP) in future Spanish curricula, either as part of standalone SPSP certificates or within more general programs (Doyle, 2017). He has also called for a continuous examination of the Spanish curriculum to ensure its relevance and centrality, an approach he describes as "curriculum development activism" (Doyle, 2019). On her part, Gwendolyn Barnes-Karol (2017) has invited us to reimagine the relationship between LSP and literature courses, thinking about a more holistic approach that enhances the advantages of both. Spanish for STEM is called to have a stake in all of these developments.

Although the goals of Spanish for science and technology approaches vary widely around the world, as Spanish for STEM courses and programs in the United States expand and evolve, more synergies and convergences with approaches in other countries would be expected, particularly with those from Spanish-speaking regions (Gómez de Enterría Sánchez, 2009; Hamel, 2006; Martínez Lara et al., 2010; Vivanco Cervero, 2006). Spanish for STEM educators would also be wise to look at developments and methodologies proposed in other languages, particularly German and French, but also Russian and Japanese. For example, there is a strong, continuing, and substantial body of literature about scientific and technical German, and more recently German for science and engineering, in the United States. Educators in this area have proposed a wide range of approaches, including languages across the curriculum (Kirchner, 2000), problem-based learning (Neville & Britt, 2007), first-year LSP courses (Von Reinhart, 2001), and the development of technical presentational skills (Rarick, 2010), among others.

Finally, the availability of learning materials, or lack thereof, continues to be one of the main obstacles to the growth of Spanish for STEM course offerings and programs in US higher education. As more approaches are explored and implemented, new materials that are based on best practices, are informed by proficiency guidelines, adhere to standards for learning languages, and are supported by current research need to be developed. This is a critical step that should be addressed promptly.

The paradigm shift brought by the LSP movement goes far beyond a name change from scientific and technical Spanish courses to Spanish for science and engineering, or Spanish for STEM more generally. It has broadened the perspective, pedagogical approaches, and opportunities of this area that will continue to grow as more and more students, educators, scientists, engineers, communicators, administrators, policymakers, and the society in general see the value of Spanish for STEM education. The science and technology domain of language

learning cannot be overlooked in the pursuit of cultural competence and global engagement in which US institutions of higher education have embarked.

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