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Competencies Beyond Countries: The Re-Organization of Engineering Education in the United States, Europe, and Latin America

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ABSTRACT

For over two centuries, the competencies that engineers have been expected to gain from engineering education have been associated with countries. Increased mobility in the workplace is generating pressure to expand competencies beyond countries. A key indicator of changing expectations is found in efforts by engineering education organizations to extend themselves beyond countries. This article compares the transformation of engineering education organizations in the United States with those in Europe and Latin America. In the U.S., organizations are attempting to expand directly from the country to the globe, relying upon prior acceptance of a redefinition of required competencies. In Europe, the re-definition of engineering competencies is taking longer to develop as participating organizations have worked first to define a new regional identity in terms of continental mobility and economic competitiveness. Finally, in Latin America, the re-definition of competencies awaits a resolution of a competition between alternative models of the region. This study of the expected competencies of engineers contributes to the research area of engineering epistemologies. Overall, the contemporary re-definition of competencies in engineering education is not a universal phenomenon but depends upon success in defining identities that extend beyond the country.

Keywords: competencies, organizations, countries, regions, U.S., Europe, Latin America

I. INTRODUCTION

For over two centuries, what it has meant to be an engineer, where engineers have tended to work, and what forms of knowledge engineers have come to value has varied significantly from country to country (Downey and Lucena, 2004; Lucena, 2007; Downey, 2007; Downey, Lucena, and Mitcham, 2007). As a result, systems of engineering education have largely been country-based systems, each with a distinctive, historically-based configuration of educational institutions and advocacy organizations. Even when political and technocratic elites have imported programs and curricula as models for domestic engineering education, elites in the borrowing countries have transformed these foreign elements by integrating them into their own systems of engineering education (Karvar, 1995).

Yet the exclusive association of engineering education with countries is now undergoing significant change. A key driver of this trend is the increased mobility of engineers in the workplace, a process that scaled up dramatically during the 1980s and 1990s (Lucena, 2006). Today, engineers throughout the world must take it for granted they will work in other countries or be employed alongside people who have been trained in other countries (Downey and Lucena, 2005). Multinational firms have made it clear they prefer mobile engineering talent, for such mobility promises a diversity of engineering skills at manufacturing and R&D sites throughout the world.

The increased mobility of engineers poses new and difficult challenges to country-based systems of engineering education and training, whose advocates now face the fearful possibility that their graduates may not possess competencies recognized as valuable in other countries or by international employers operating within their own country. Still other graduates appear increasingly likely to leave their home countries, especially as their talents are recognized as valuable abroad (Lucas, 2001; Meyer et al., 2003; Fuess, 2001). Hence engineering education advocates the world over have been rethinking the competencies of engineers and the contents of engineering education in a rapidly-evolving and increasingly international environment while hoping their own graduates will want to stay (Friedman, 2006; Downey, 2005).

The analysis below accounts for efforts to redefine the competencies of engineers in the United States, Europe, and Latin America by identifying and following the emergence and transformation of organizations devoted to engineering education. Organizations provide an especially helpful window onto the redefinition of engineering competencies because they typically serve as sites for designing, contesting, and approving competencies.

The United States, Europe, and Latin America offer examples of three different types of deliberations and outcomes in the redefinition of engineering competencies. In the United States, advocacy organizations have come to agree on the redefinition of engineering competencies. They also appear to be coalescing in the cooperative formation of a new field of engineering education research and practice, while attempting to move directly from a country to a global level. In Europe, the redefinition of engineering competencies is taking longer to develop as participating organizations have worked first to define a new regional identity in terms of continental mobility and economic competitiveness. Finally, in Latin America, the redefinition of competencies awaits a resolution of a competition between two distinct models of the region. Comparing these three cases calls attention to the extent to which extending the definition of engineering competencies *beyond* countries depends upon parallel successes in defining engineering identities *within* countries.

Engineering educators in regions such as Africa, East Asia, and South Asia are beginning to build regional networks or links to international networks. Although we do not analyze these regions in this paper, in our conclusion we suggest our findings offer insight into the types of issues likely to emerge in efforts to redefine engineering competencies elsewhere in the world.

II. HISTORICAL ETHNOGRAPHY

The methodology used in this research is historical ethnography. Recognizing the limitations that ethnography presents in understanding and representing the experiences of those people who are no longer living or available, anthropologists and sociologists developed historical ethnography as a methodology that brings ethnography to the archives and vice versa (Assad, 2002; Vaughan, 2004). Recently, historical ethnography has been used to account for how global processes are always grounded in local practices, such as conferences, meetings, and document editing. As sociologists Zsusa Gille and Sean O Riain point out, "by locating themselves firmly [through historical ethnography] within the time and space of social actors 'living the global,' ethnographers can reveal how global processes are collectively and politically constructed, demonstrating the variety of ways in which globalization is grounded in the local" (Gille and Riain, 2005). For the past two decades, we have used historical ethnography to produce accounts of engineers and engineering education in different countries that are now incorporated in the course *Engineering Cultures* (Downey et al., 2006).

An historical ethnographic map is similar to other types of maps in that its accuracy must be judged in relation to pre-existing maps (Downey, 1998). For instance, since one cannot judge the accuracy of a road map directly against reality, one must rely upon other, already trusted, exercises in mapping, e.g., walking the route or invoking GPS satellite technology. The value of a new ethnographic map lies not in its validity, i.e., its demonstrated fit with reality, or its reliability, i.e., its ability to replicate data. Rather, its contribution depends upon its plausibility, i.e., its demonstrated fit with other trusted maps, especially as it attempts to chart new terrain.

The historical maps provided below are not an exhaustive account of worldwide engineering education, but can be described as plausible to the extent they (a) identify and map key organizations involved in engineering education without omitting perspectives whose inclusion would surely lead the account in new directions, and (b) contain sufficient evidence about relevant organizations to enable readers to test alternative accounts but deem them deficient relative to this one.

Data collection for this paper has consisted of participant observation and detailed note-taking at more than 30 international conferences, workshops, and meetings of organizations devoted to engineering education; extensive archival analysis of conference and workshop proceedings and journals in engineering education; and tape-recorded interviews with key figures involved in the re-orientation of organizations devoted to engineering education.

Data analysis for the United States began with an overview of key reports and presentations expressing concerns about engineering education from the 1960s and concluded with data from the ASEE Global Colloquia series to assess U.S. strategies for scaling up initiatives from the country level to the global level. Data analysis for Europe focuses on evidence from meetings of the European Society for Engineering Education (SEFI) to follow reactions to emergent proposals for regional approaches to accreditation and competencies. Data analysis for Latin America consisted of carefully juxtaposing evidence from published sources with data from observations and interviews at meetings of Iberoamerican Society of Engineering Education (ASIBEI) and the Engineering for the Americas (EoA) project.

III. U.S. ORGANIZATIONS: FROM COUNTRY TO GLOBE

In the United States, reform activities relevant to our analysis started in the 1980s with initiatives to increase the flow of students through the engineering pipeline, shifted in the 1990s to attempts to create flexible engineers for a global economy, and then coalesced in late 1990s with the establishment of new accreditation criteria for engineering programs. The period since 2000 has been marked by efforts to institutionalize the new competencies by scaling them up from the country to the globe, including by professionalizing engineering education as an academic field (Steering Committee of the National Engineering Education Research Colloquies, 2006).

A. NSF/NRC Define the Problem

When the U.S. National Research Council published its nine volume study titled *Engineering Education and Practice in the U.S.* in 1985 and 1986 (National Research Council, 1985), the organizational structure of engineering education had been relatively stable for two decades. Engineers were taught in roughly 300 schools of engineering that graduated approximately 60,000 students per year. Schools were mainly organized by disciplinary departments, ABET served as primary regulator of engineering curricula, and disciplinary societies provided accreditation criteria that focused on resources and curricular credits (inputs) rather than the capabilities of graduates (outcomes).

After Sputnik (1957) and through the rise of the Cold War, the engineering sciences became a dominant concern in relation to the competencies of engineers (Seely, 1999). This emphasis was articulated in the 1955 Grinter Report (ASEE Committee on Evaluation of Engineering Education, 1955), endorsed by the ASEE Goals Report of 1968 (American Society of Engineering Education, 1968), and enforced by ABET input-driven accreditation criteria. But the decline of the Cold War and rising national worries about economic competitiveness led to concerns that engineering education in the United States was out of step with emergent national priorities.

The first reaction focused not on changing the content of engineering education but on making sure sufficient engineers were flowing through the engineering pipeline (Bowen, 1988; Lucena, 2005; Engineering Deans Council, 1989; National Science Foundation, 1987). Since that time, many U.S.-based organizations have been concerned with recruitment and retention issues rather than engineering competencies as they work to increase the number of women and minorities in engineering (Lucena, 2000; Task Force on the Engineering Student Pipeline, 1988; WEPAN, 2000; NAMEPA, 2003). By the early 1990s, the central concern had shifted to worries about the need to produce flexible engineers who could adapt to changing environments. Key engineering education leaders called for “a more flexible definition of engineers and engineering” (Schmitt, 1990). In part, this shift developed because demand for engineers was not increasing as previously predicted (U.S. House Committee on Science, 1993), especially as employers flattened their bureaucracies and changed work environments (Lucena, 2006; Bordogna, Fromm, and Ernst, 1993).

In this context, NSF emerged as a major player in engineering education by funding the Engineering Education Coalitions, a program whose main goal was “to produce new structures and fresh approaches affecting all aspects of U.S. undergraduate engineering education, including both curriculum content and significant new instructional delivery systems”(National Science Foundation, 1993). By the mid-1990s, NSF had spent more than $200 million in funding six coalitions (Coward, Ailes, and Bardon, 2000). NSF also positioned itself as a coordinator of systemic reform, supporting two conferences in the mid-1990s that brought together educational administrators, policymakers, corporate officials, and accreditation officers (National Science Foundation, 1995; Peden, Ernst, and Prados, 1995).

B. ABET Redefines Competencies

The development of ABET’s new criteria for engineering programs in 2000 (EC 2000) marked an important milestone, transforming ABET from a conservative regulator of engineering curricula to an agent of change. Most importantly, ABET redefined its relationship with engineering programs by basing its new criteria on outcomes rather than inputs (ABET, 2002). This shift was, in large part, a response to concerns about the quality of engineering graduates from representatives of major U.S.-based multinational corporations. As ABET past president Eleanor Baum explained in a keynote speech at the 2000 Global Engineering Education Conference in Wismar, Germany,

> “This whole process [ABET accreditation] began in my country with a long conversation between CEOs of large corporations and deans of engineering and the question we asked was ‘do you see engineers having the correct set of attributes for the next 20 years?’ We thought that we would hear about the need for new technologies but to our amazement the leaders of industry in the US wanted overwhelmingly what we call ‘soft kills’ that engineers need to be successful” (Lucena, 2000).

EC2000 was so significant because it sharpened a focus on student competencies. As Prados et al. put it, “Because EC2000 focuses on the learning outcomes of graduates rather than on the structure of educational curricula and programs, it provides a useful framework for evaluating the equivalence of preparation of engineering graduates from diverse educational systems and supports the development of processes for international recognition of engineering educational credentials” (Prados, Peterson, and Lattuca, 2005).

By the mid-1990s, ABET leaders had accepted the view that the international challenge of competitiveness was in part a problem of competencies in engineering education. Having become the default agency for defining the necessary competencies of U.S. engineers, ABET also became more aggressive about extending its influence beyond the U.S. In 1989, the Washington Accord was established as a mutual recognition by organizations representing a host of participating countries, including ABET in the U.S. It established the educational component of professional formation for all signatories, and required them to have well-developed, peer-reviewed systems for accreditation of engineering degree programs (Jefferies and Evetts, 2000;

ABET, 2003). Initially, other members in addition to the U.S. included Australia, Canada, Ireland, New Zealand, and the United Kingdom. Hong Kong joined in 1995 and the advent of EC2000 attracted South Africa (1999) and Japan (2005). Since 2000, Germany, Korea, Malaysia, Singapore, and Taiwan have become provisional members as they work to complete their accreditation systems.

ABET has thus become an energetic international organization, attempting to lead by example. Its reach was further extended through a 'substantial equivalency' program, which was formed in 1990 and awarded substantial equivalency to more than 130 programs worldwide by 2005. ABET also established a Memorandum of Understanding process to "facilitate the establishment of quality assurance organizations in these countries through the sharing of best practices, development of accreditation processes, and training opportunities for relevant constituents." Directly tying accreditation to the demonstrated competencies of graduating engineers, ABET both enhanced its role and gave itself the perpetual challenge of making sure that ABET-accredited programs emphasize the proper competencies.

C. ASEE Builds Supporting Research

When the ABET EC2000 criteria first circulated for review in 1996, it attracted relatively little attention from engineering educators. The majority of ASEE conference papers continued a tradition of reporting on innovations in engineering pedagogy. Prior to 2000, papers relevant to EC2000 were framed in terms of a longstanding administrative mentality, examining whether or not institutions would be ready to meet and implement the criteria (Collins and Ackerman, 1996; Besterfield-Sacre et al., 1997). For example, in 1996 Gloria Rogers reported that "unfortunately few engineering colleges are prepared to deal with the challenge of providing evidence in a systematic way which validates student achievement in the areas defined by [EC2000's] 'Criterion 3 Program Outcomes'" (Rogers, 1996).

Yet by 1998, educators were beginning to deal with the challenges of EC 2000 (Leonard, Beasley, and Scales, 1998). At the 1999 ASEE annual meeting, reports were surfacing of trial experience with the new criteria and guidelines (Parten and Bredeson, 1999; Wilding et al., 1999). The focus was on how to structure a plan, match program outcomes with EC2000 desired competencies, and indicate plans for assessment. A further shift away from institutional readiness began with new attention to faculty development (Brent et al., 2000; Fromm and McGourty, 2001). But what counted as faculty development for engineering educators was still somewhat hazy, largely limited to attendance at education-related conferences or participation in on-campus faculty development programs.

As programs prepared for ABET evaluations, attention increasingly shifted to assessing student learning. Believing that rational arguments would help convince skeptical engineering science faculty of both the need for and benefits of change, advocates re-articulated engineering education as a 'rigorous' research enterprise. As Smith et al. described the research underway at their own institution, "[W]e are endeavoring to create a rigorous empirical foundation to describe learning and teaching practices in the engineering education community and use the resulting insights to create conversations among change agents that will result in change at multiple levels" (Smith et al., 2004). One initial urge was to apply models and methods from other areas of engineering research. For example, Besterfield-Sacre et al. proposed that learning and assessment could be enhanced by borrowing mathematical models from industrial engineering (Besterfield-Sacre et al., 2002).

But the educational research enterprise quickly expanded, and the ASEE re-positioned itself as the principal site for research publications on engineering education. Since 2000, the organization has invested significant resources into organizing and making available online the published proceedings of ASEE conferences. And in 2003 the *Journal of Engineering Education*, under the leadership of Jack Lohmann, transformed itself into the "research journal" of engineering education. According to Lohmann,

> "the subsequent introduction of EC2000 by ABET in the 1990s was a major driver to improve the quality of engineering education…The dialogue and decisions made in the 1990s paved the way for engineering education to become a field of scholarly research and professional achievement by the beginning of this decade…What we are witnessing is the emerging discipline of engineering education, a discipline supported by a growing community of engineering scholars dedicated to the advancement of engineering education through research … [T]he journal was repositioned again in January 2003 and introduced a more focused mission: 'to serve as an archival record of scholarly research in engineering education'" (Lohmann, 2005).

In 2007, ASEE introduced the new electronic journal *Advances in Engineering Education* as a site for recording documented applications in engineering education. The main objective of most of these advances lay in the development and realization of competencies.

D. Convergence to Form a Discipline?

The sociologist Andrew Abbott uses the metaphor of "settlement" to describe how academics settle a territory, defining foci of study and building institutional structures for research and teaching (Abbott, 2001, , 1988). In some cases, the settlement gains disciplinary status. By working with the ASEE and launching their own initiatives, various organizations are contributing to ongoing efforts to settle engineering education as disciplinary field.

At the university level, the main development has been to establish organizations (centers, institutes, and departments) to conduct research on engineering education, sometimes transforming organizations designed to promote engineering education on campus into full-fledged NSF-supported research units with specific foci. These organizational arrangements include individual centers (such as those at Tufts University, Georgia Tech, and Penn State), multi-university centers (such as the Center for the Advancement of Engineering Education (CAEE) with the participation of University of Washington, Colorado School of Mines, Howard University, Stanford University, and University of Minnesota), and partnerships among public schools, universities, and the public sector (such as Project Lead the Way) (NAE, 2004). Two universities, Purdue and Virginia Tech, established Ph.D. degrees in engineering education and transformed their freshman engineering programs into graduate research departments. As suggested by the title of Purdue Professor Philip Wankat's 2004 ASEE paper, "The Emergence of Engineering Education as a Scholarly Discipline," discipline building is a quite explicit goal (Wankat, 2004).

At the same time, the National Academy of Engineering (NAE) transformed itself from a purely honorary body to an advocate for engineering education by modifying the interpretation of its membership criteria to recognize contributions to engineering education, and it used its status as an honorary body to establish a $500,000 prize for contributions to engineering education (National Academy of Engineering, 2001). The NAE has also attempted to anticipate what competencies will be needed in the future through the scenarios developed in the report The Engineer of 2020 (National Academy of Engineering, 2005, , 2004). And finally, to advance high-quality research the NAE established the Center for the Advancement of Scholarship on Engineering Education (CASEE) in 2002 “as a mechanism to foster a climate of continuous improvement in engineering education” (NAE, 2004).

Many activists involved in these previous efforts have also come together in the NSF-supported Engineering Education Research Colloquies (EERC) “to collaboratively develop a national research framework and agenda to conduct rigorous engineering education research” (Steering Committee of the National Engineering Education Research Colloquies, 2006). The EERC Steering Committee identified five “priority research areas, emerging from a process of refinement in which more than “fifty-five desirable outcomes (i.e., competencies)” were divided into the three categories of outcomes, namely those that “have already been widely discussed,” “are newly identified in the literature and are currently part of the national debate,” and “future outcomes that are being discussed locally or will be required to advance the future of engineering education…” (Ibid.). The NSF-funded 1st International Conference on Research in Engineering Education (ICREE) was held in June 2007 to craft a more detailed agenda for the field. With the question of competencies temporarily settled in the U.S., ICREE participants focused their discussions on how to both nurture engineering education as a recognized discipline and advance the production and dissemination of high-quality research.

Beyond ASEE and NAE, the major American professional engineering societies have expanded their activities in engineering education, especially to re-structure engineering education in their fields and define how discipline-specific competencies measure against EC2000 (Committee on Academic Prerequisites for Professional Practice, 2004; Zukoski, Armstrong, and Rousseau, 2002; Armstrong, 2005). The IEEE, in particular, which has supported the annual Frontiers in Education (FIE) conference since 1971, undertook its own international activities in accreditation through the Global IEEE Leadership in Accreditation initiative (IEEE, 2006; Jones, 2006).

E. From Country to Globe

In contrast with counterparts in Europe and Latin America, engineering educators in the United States have not built organizations with a regional identity. With the exception of the Engineering for the Americas initiative (see below), the extrapolation is directly from the country to the globe as a whole. In 1995 Canada, Mexico, and the U.S. signed a mutual recognition agreement (MRA) to facilitate mobility of professional engineers under the North American Free Trade Agreement (NAFTA). This MRA does not include a definition or desired competencies for a ‘NAFTA engineer,’ only minimum educational and professional requirements. This MRA has not yet produced the desired levels of mobility.

The ASEE has been most active in this respect, organizing annual Global Colloquia on Engineering Education on other continents. By 2010, global colloquia will have been held in Berlin (2002), Nashville (2003), Beijing (2004), Sydney (2005), Rio de Janeiro (2006), Istanbul (2007), Cape Town (2008), and Budapest (2009). While their main stated purpose is “[t]o unite the diverse elements of the international engineering education world"(ASEE and AaeE, 2004), these meetings also help cement ASEE leadership in engineering education reform and research by highlighting U.S.-based work on competencies in engineering. With EC2000 criteria as a backdrop for these meetings, the first Global Colloquium in Berlin persuaded many European engineering educators that accreditation criteria and processes were becoming a necessity given an increasing number of cross-Atlantic collaborations in engineering education (Petersen et al., 2002). Held in the U.S., the second Global Colloquium was designed to illustrate to international attendees different components of the U.S. approach to accreditation and research, including tracks dedicated to continuing education, accreditation, education reform, technology education, education R&D, and graduate engineering education. At the fourth Colloquium, ASEE led the creation of the International Federation of Engineering Education Societies (IFEES) to coordinate the activities of engineering education societies worldwide (Hubband, 2005). The IFEES governing board was elected at the fifth Colloquium in 2006, and this same event served as a site for discussing how to regionalize engineering education in Latin America, as discussed below.

The movement from country to globe also follows the continued efforts of multinational corporations to cultivate the competencies of future engineers. At the 2006 ABET Annual Meeting, Wayne Johnson, Hewlett Packard's Vice President for University Relations Worldwide, presented on HP's global reach in ICTs and the associated challenge of finding talented engineers who meet both ABET EC 2000 criteria and the company's desired abilities for engineers, including "managing the customer experience, managing virtual relationships, creativity, adaptability, and versatility" (Johnson, 2006). As US corporations continue to both move from country to the globe and challenge educators with new competencies, engineering education organizations will continue to wrestle with the implications of these trends for their research and reform agendas.

The movement from the country to the globe has also provided opportunities to other programs and organizations not explicitly aimed at producing competencies for industry such as the Global Engineering Education Exchange Program (GE3) (Gerhardt, 2001), Engineers Without Borders-USA (EWB-USA) (Engineers Without Borders-USA, 2000), and the Engineering Projects in Community Service (EPICS) (Coyle, Jamieson, and Oakes, 2005).

In sum, engineering educators in the United States have responded to both national concerns about economic competitiveness and specific concerns from major corporations about the employability of U.S.-educated engineers by coming to agree on the redefinition of competencies in engineering education. Acceptance of the competencies described in EC2000 as desirable goals for U.S. engineers has helped to both ground efforts to build an academic field of engineering education and scale up acceptance of these goals from the country to the globe. Yet as engineering education organizations and multinational corporations continue to propose and refine new competencies, the reform and research agendas of the emerging academic discipline of engineering education will continue to evolve.

IV. ORGANIZATIONS IN EUROPE: ADDING A REGIONAL DIMENSION

In Europe, contemporary initiatives to rethink and redefine the competencies of engineers are part of the larger problem of the "European dimension." The formation of engineers has long been organized along national lines, as evidenced by the diversity of identities shown in Table 1.

Akademiingeniør	Engenheiro	Inženyr
Bachelor of Arts	Europa-Ingenieur	Inžinier
Bachelor of Engineering	Ingenieur (grad.)	Inżynier
Bachelor of Science	Ingeniør	Magister Inżynier
Civilingeniør	Inginer	Master of Arts
Civilingenjör	Insinööri	Master of Engineering
Diplom-Ingenieur	Ingeniero Químico	Master of Science
Diplom-Ingenieur ETH	Ingeniero Superior	Okleveles mérnök
Diplom-Ingenieur (FH)	Ingeniero Técnico	Okleveles üzemmérnök
Diplomi-Insinöör	Ingénieur civil	Sivilingeniør
Diplomirani Inženir	Ingénieur diplomé	Teknikfræðingur
Doktor-Ingenieur	Ingénieur industriel	Teknikumingeniør
Dottore in Ingegneria	Ingénieur technicien	Verkfræðingur

Source: Siemens

Table 1. Some different titles for engineers in Europe

The term “formation” is therefore used in Europe to refer to variable combinations of formal education and practical training, while the term “engineer” and its many analogs may refer to both an educational qualification and a job classification. Key variables in formation processes include length of time to degree (generally either three to five years but sometimes six) and proportions of classroom and practical training (Downey and Lucena, 2004).

During the 1980s, the decline of the Cold War and rise of economic competitiveness as an organizing framework for international relations provided a powerful additional stimulus to initiatives promoting European economic integration, culminating in 1992 with establishment of the European Union (EU), an assembly of countries with different languages and divergent cultural and socio-political interests, but with a commitment to building a regional entity and cultivating collective economic benefits. Since the 1980s, advocates for engineering formation in every country have been grappling with the question: What is the relationship between preparing engineers to serve the home country and preparing engineers to serve Europe?

A. European Commission Establishes Thematic Networks

As Europe began to gain quasi-country status as a geographical entity, the image of personal and professional “mobility” across the national borders of EU members was increasingly construed as a “right” all Europeans should enjoy (Maas, 2001). Yet a 1988 European Community directive granting mobility to professionals who had been qualified in their home country illustrates the complexity of realizing this image: “that a citizen who is awarded a professional diploma by a ‘designated authority’ in one member state for a practice of a profession . . . should have the right to practice the corresponding profession in another member state provided the award of the regulated professional qualification involved satisfactory completion of a post-secondary course of education and training of at least three years’ duration, or a part-time equivalent, at a university or establishment of higher education or an establishment of similar level” (Jefferies and Evetts, 2000), p. 103). As engineering educators in Europe grappled with East-West integration during the early 1990s (Pudlowski, 1997), the meaning and realization of mobility surfaced as a core issue.

In 1996, the European Commission approved a thematic network in higher engineering education (H3E), in part to address the question of mobility. Within H3E, Working Group 2 became the key site for negotiating the European dimension in engineering education. Its responsibilities included developing a list of “qualification attributes” for engineering education and practice to be used with the European Credit Transfer System (ECTS), establishing agreements on mutual recognition of diplomas and degrees, and achieving recognition of distance learning courses (Heitmann and Augusti, 2001). A common list of qualification attributes and academic credits were to help facilitate mobility of engineering students and graduates within Europe, yet agreement on engineering competencies for Europe was still a decade away.

One possible direction for building the European dimension in engineering education was to follow ABET by building a European system of accreditation for engineering education. But as Augusti later explained, “the Working Group 2 had decided that the vast diversity of programs and models across Europe, as well as the deep involvement of national governments, made it difficult to establish a homogeneous accreditation process and common criteria” (Augusti, 1999). As noted by Heitmann and Augusti, the WG2 instead focused on coordinating country-based systems in order to “mak[e] the national systems and approaches more transparent and compatible,” while opposing the establishment of standardized European accreditation procedures (Heitmann and Augusti, 2001). In sum, beginning three years prior to the Bologna Declaration in 1999, European engineering educators were directly grappling with the challenge that mobility posed to both country-based engineering education systems and common European engineering competencies.

B. Bologna Declaration Reaffirms the Challenge of European Integration

In 1999 the ministers of 29 countries from the EU took a dramatic step toward the integration of higher education across Europe. It set an objective of adopting by 2010 a European Higher Education Area that would overlap and even extend beyond the geographic boundaries of the EU: “a common framework of readable and comparable degrees, implementing a two-cycle system in series, based on 3-4yr BS and graduate degrees, implementing the European Credit Transfer System, eliminating obstacles to free movement of teachers and students, and including a European dimension into the quality assurance of higher education”(European Ministers of Education, 1999). Yet their promotion of a U.S.-styled B.S./M.S. system reflected some of the tensions inherent in their position.

At subsequent meetings, the ministers of education welcomed new countries, many of them not EU members, into the Bologna Process while also reaffirming their commitments by defining further goals for the European Higher Education Area (EHEA). One goal is to establish national quality assurance systems, including by defining “the responsibilities of the bodies and institutions involved” and articulating features of evaluation systems such as “internal assessment, external review, participation of students and the publication of results; a system of accreditation, certification or comparable procedures; international participation, [and] co-operation and networking” (Conference of Ministers Responsible for Higher Education, 2003). A second goal is to define a framework of comparable and compatible qualifications for higher education. Such a framework should, for example, “describe qualifications in terms of workload, level, learning outcomes, competences and profile” and clarify differences in the desired outcomes of first and second cycle degrees “in order to accommodate a diversity of individual, academic and labour market needs” (Ibid.). A third goal is to promote the European dimension within country-based systems of higher education, including through “a substantial period of study abroad in joint degree programmes as well as proper provision for linguistic diversity and language learning, so that students may achieve their full potential for European identity, citizenship and employability” (Ibid.). In sum, through the Bologna process, governments of European countries have clearly expressed a desire for Europe-wide competencies and processes that will ultimately yield a European identity and mobility.

Advocates for increased Europeanization in engineering education, which included prominent officers of the European Society for Engineering Education (SEFI), responded quickly to the Bologna Declaration by establishing a new thematic network: Enhancing Engineering Education in Europe (E4) (Enhancing Engineering Education in Europe (E4), 1999). In order to increase mobility and facilitate integration, E4 established the following activity areas and corresponding working groups: 1) employability through innovative curricula, 2) quality assessment and transparency for enhanced mobility and trans-European recognition, 3) engineering professional development for Europe, 4) enhancing the European dimension of engineering education, and 5) innovative learning and teaching methods.

Cognizant of significant differences among engineering education systems within Europe, these groups found themselves facing challenging questions concerning the competencies of engineering graduates. For example, should engineering programs facilitate mobility via common core curricula? Should "qualification attributes" vary by engineering specialty? What methodologies should be used to assess the acquisition of competencies? How should competency development continue after graduation? How can education and work exchanges across Europe enhance competencies? What are the most effective learning and teaching methods to achieve the desired competencies? (Ibid.) The European Society for Engineering Education (SEFI) would become the site where these questions would be debated.

C. SEFI Strikes a Balance

SEFI, with formal names also in French and German, was founded in 1973 “to contribute to the development and improvement of engineering education in Europe” (SEFI, 2006). For almost three decades, most SEFI educators were largely unconcerned with regional competencies. Their initial responses to Bologna were characterized by resentment at the top-down approach initiated by the EU’s ministers of education. The official SEFI position, articulated in a 2000 Opinion on the Joint Declaration of the European Ministers “welcome[d]” the Declaration and “strongly support[ed] the idea of the creation of a European Higher Education Area.” Yet this early official Opinion also reasserted the value of country-based systems of engineering formation. “The SEFI view” reported the Opinion, was that “the existing European system of longer integrated curricula leading straight to a Master’s Degree in Engineering should be maintained, possibly in parallel with a two-tier Bachelor/Master system … [and] the specific qualities of the present, existing, application-oriented Engineering degrees should be recognised and safe-guarded” (SEFI, 2000).

At the 2001 SEFI meeting in Denmark, widespread concern was evident about a move toward educational integration led by government ministers and seemingly focused on universities. The SEFI President expressed dissatisfaction that the “Declaration was prepared by [the] Association of European Universities” and “engineering schools and educators were not at all involved” (Lucena, 2001). However, select constituencies within SEFI found the Bologna process to provide new opportunities for visibility and enhanced status. For example, representatives of the German *fachhochschulen* became champions of the Bologna process since it allowed them to offer graduate programs in engineering for the first time and achieve the status of “universities of applied sciences.” In Italy, the Bologna process offered opportunities for system-wide reform. Yet in France, the *grandes ecoles*, whose elite status has long depended on their independent identities, made relatively few efforts to introduce a European dimension into their curricula.

SEFI meetings became foci for European debates about the desired competencies of engineers, tensions between national systems and the desire for European integration, and the development of regulatory systems. A key step towards resolving these debates was widespread reaffirmation of long-cycle programs of five to six years, leading to a diploma equivalent to the M.S. in a 4+2 plan and providing the only route to doctoral degrees in engineering.

By 2005, SEFI was the main European site for the implementing the Bologna Declaration in engineering education. Indeed, at the 2005 meeting held in Ankara, Turkey, the SEFI General Assembly adopted an ambitious and complex mission to serve as the

> “main advisor within Europe in the area of Engineering Education (EE). . . . SEFI[‘] goal must be that of becoming THE promoter of the multicultural European EE community and THE modern organization in this arena, an association attractive for EE teachers, students and engineers. . . . EE has to be considered as a research field like other “classical” engineering fields . . . in this area, SEFI can play a primary consulting, development and innovation role, contributing to National, European and International policy development” (capitalization in original) (SEFI, 2005).

In other words, challenged by the integration of European higher education, European engineering educators transformed SEFI into a proactive organization that could help mediate national and European interests and developing proposals to enhance European engineering education amidst existing tensions.

D. ESOEPE Fosters Accreditation and Research

In 2000, regulatory bodies for engineering diplomas in France, Germany, Italy, and Portugal and the United Kingdom joined with the European H3E network to establish the European Standing Observatory for the Engineering Profession and Education (ESOEPE) whose founding Members included Engineering Council (UK), Commission des Titres d’ Ingenieurs (France), Akkreditierungsagentur für Studiengänge der Ingenieurwissenschaften und der Informatik (Germany), Ordem dos Engenheiros (Portugal), Collegio dei Presidi delle Facoltà di Ingegneria (Italy), and the Thematic Network of E4 (European Union). The purpose of the agreement was “to build confidence in systems of accreditation of engineering degree programmes within Europe” by assisting with planning, development, and systematic exchange, but without harmonization.

ESOEPE rapidly developed its EUR-ACE framework for the accreditation of engineering degree programs and graduates, including a pioneering list of desired regional competencies (EUR-ACE, 2005). Accredited degree programs at the European level were to include outcomes in six categories. Under *Knowledge and Understanding*, graduates should “demonstrate their knowledge and understanding of their engineering specialisation, and also of the wider context of engineering." *Engineering Analysis* centers on the ability "to solve engineering problems." For *Engineering Design*, graduates should "be able to realise engineering designs consistent with their level of knowledge and understanding, working in cooperation with engineers and non-engineers." Through *Investigations*, graduates of accredited programs "use appropriate methods to pursue research or other detailed investigations of technical issues." To prepare for *Engineering Practice*, graduates should "be able to apply their knowledge and understanding to developing practical skills for solving problems, conducting investigations, and designing engineering devices and processes." Finally, the achievement of *Transferable Skills* includes "soft skill" competencies in areas such as teamwork, communication, safety, ethics, engineering in context, project management, business practices, risk management, and life-long learning.

The European Commission welcomed the EUR-ACE outcomes by funding its implementation. EUR-ACE is coordinated by the European Network for the Accreditation of Engineering Education (ENAEE). This network was recently founded by various national accreditation agencies for engineering education and engineering organizations like SEFI. ENAEE has replaced ESOEPE. According to a senior member of H3E and E4, "even with the EUR-ACE standards the national regulations and accreditation procedures will dominate. EUR-ACE will be a label on top and for those countries which do not have an accreditation procedure so far, allowing their universities to apply for a EUR-ACE label" (Lucena, 2006).

In parallel with the experience of ABET's EC2000 in the U.S., articulation of the competencies of the European engineer through the EUR-ACE project had the effect of justifying new types of engineering education research. When the E4 network expired in 2004, engineering educators gained approval for the new thematic network Teaching and Research in Engineering in Europe (TREE) to "contribute to the development and enrichment of the European dimension in engineering education" along four lines or dimensions. These include quality assessment and assurance, developing and promoting research in engineering education, developing recruitment and retention strategies, and continuing education (TREE, 2005).

E. Covergence?

Another organization involved in the development of European engineering education is the International Society for Engineering Education (IGIP), founded in 1972 (International Society for Engineering Education, 2006). After separately promoting the development of engineering education in Europe until 2006, SEFI and IGIP are now "working for convergence … towards a common pan-European (international) Association for Engineering Education … [and] to form a common European voice within the world of Engineering Education Associations" (IGIP-SEFI, 2006). Both organizations have committed to organize common events, such as the 2007 SEFI and IGIP Joint Annual Conference, "Joining Forces in Engineering Education Towards Excellence," and to jointly manage projects on engineering education research, such as those supported by the EC Thematic Networks (SEFI, 2007). This important collaboration emerges at a time of growing agreement over the competencies of a European engineer.

The very existence of TREE and the new collaboration between SEFI and IGIP suggest that the conceptual problems of the European dimension in engineering education may largely be resolved, grounding a shift in focus from the definition of competencies to the development and implementation of research-oriented activities and reforms. Engineering education in Europe is becoming both one and many at the same time.

V. ORGANIZATIONS IN LATIN AMERICA: COMPETENCIES IN SEARCH OF A REGION

The enormous energy invested in efforts to reform engineering education in the United States and Europe around new definitions of competencies has put great pressure on advocates for engineering education in other parts of the world to respond in kind. Latin America is no exception. Again, these efforts take place as economic competition increasingly defines international relations (Downey, 1998), pp. 26-41). The recent coalescence of regional activities in Europe makes it clear that the scale and power of the U.S. and the EU as economic forces is prompting other areas of the world to forge larger territorial units to maintain their identities. And while India and China may be able to go it alone, such is not the case for most Latin American countries. The primary challenge to advocates of engineering education in Latin America is to figure out how to rethink the competencies of engineers when a single regional identity has not yet coalesced. What engineers will need to know in order to serve effectively depends crucially upon whom and what ends they will be asked to serve.

A. From Infrastructure to Industry

Although engineers in different Latin American countries are educated in institutions with distinct historical trajectories, one common phenomenon since the 1980s has been a tension between those institutions and organizations oriented toward public civil infrastructures and those oriented toward private industry. Marked by a shift from the expansion of state infrastructure and import substitution prior to the 1980s to the privatization of state enterprises and free-market trade, the post-1980s period challenged engineering schools in many Latin American countries with the problem of competencies for private industry and free-markets.

Beginning in the 1980s, the privatization of state industries and activities and the opening of trade markets to international competition brought both the rise of private higher education and a more US-style approach to engineering education linked to industry (Valderrama et al., 2006; Torres Sanchez and Salazar Hurtado, 2002). In Mexico, for example, engineering programs at Universidad Nacional Autonoma de Mexico (UNAM) and Instituto Politecnico Nacional (IPN) played key roles from the 1940s onward in developing national infrastructure and import-substitution industries. But Monterrey Tech and the National System of Technical Institutes, which grew from 6 to nearly 200 since the 1960s, rose in the 1980s to occupy center stage in the development of private industry in Mexico (Lucena, 2007). A similar trend was evident in Colombia, where after more than a century of dominance in engineering education by state-funded Universidad Nacional de Colombia, the Universidad de los Andes, a private institution modeled after U.S. universities, rose to preeminence.

In the 1990s, challenged by the rise of private industry, the presence of foreign investment by multinational corporations, and international economic competition, engineering educators from different countries began connecting in ‘regional’ organizations, such as the Ibero-American Society for Engineering Education (ASIBEI) and Engineering for the Americas (EoA).

B. ASIBEI Links with Spain and Portugal

In 1997, a group of deans established ASIBEI during a meeting in Spain at the Universidad Politecnica de Madrid. The deans wanted to bring together engineering schools in Latin America, in part to protect the status of their graduates as priorities shifted from infrastructure to industry and as engineering programs expanded, particularly in private institutions and countries without accreditation processes. According to the founding document, ASIBEI's mission was to promote "cooperation and exchanges among engineering schools, development and quality of faculty and connections with private and social sectors, development of engineering programs … and study of systems of evaluation and processes of accreditation in member countries" (ASIBEI, 1997). Along with representatives from Spain and Portugal, the membership grew to include engineering education organizations from Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Mexico, Panama, Paraguay, Peru, Uruguay, and Venezuela.

Since its creation, ASIBEI has promoted the dissemination of knowledge about engineering curricula and accreditation in member countries with the goal of establishing common "Iberoamerican" criteria for evaluation and accreditation. At its 2002 General Assembly, ASIBEI even formally considered making itself an Iberoamerican accreditation agency for engineering education (ASIBEI, 2002). However, the enormous diversity in curricula, programs, institutions, and accreditation mechanisms, all shaped by distinctive histories, made it difficult to achieve such a high level of coordination. Over the next three years, this idea was abandoned, especially following a comprehensive survey documenting the existing complexity of engineering programs and institutions (ASIBEI, 2005, , 2005). In a 2005 report, ASIBEI concluded that

> "in spite of the existence of an Iberoamerican community brought together by strong cultural ties, the educational systems in each one of the member countries are different … differences are even greater in higher education … [where] academic autonomy of many institutions creates an inconvenience in establishing some degree of compatibility and convergence among majors and curricula … the marked diversity of engineering programs in the region are due to the difference in each profile of engineer [*perfil del ingeniero*] that each institution has chosen to define its program" (ASIBEI, 2005), pp. 282-83).

Earlier, in 2001, ASIBEI had also begun addressing the problem of defining competencies for an Iberoamerican engineer. The executive secretary, Mario Gomez Mejia, proposed that the Iberoamerican Engineer would have

> "knowledge of the social, political, economic, and cultural situation of Iberoamerican countries, the ability to actively participate with groups from cultures different than one's own, and the disposition to integrate in and participate with groups of different disciplines and social classes, without any ideological prejudices"(Mejia, 2001).

However, the challenge of regional competencies quickly became as elusive as the challenge of regional accreditation, given both the ongoing shift from infrastructure to industry and differences in each country's engineering education systems. In 2005 ASIBEI reported that "it is not easy then to synthesize the definitions of engineering provided by member countries … However all definitions have in common two elements: a previous knowledge of science and the goal of transforming nature for the service of humankind and society" (ASIBEI, 2005), pp. 282-83). No distinct set of regional competencies emerged from these general attributes. But ASIBEI's Executive Committee did agree on a broad set of criteria that invoked older responsibilities to civil life that had been exhibited under the earlier models of state institutions. Engineers should have (a) "knowledge of English and another foreign language such as German, French, Chinese or Japanese," (b) "the capacity to adapt to other countries," (c) "the ability to communicate, work in teams, be creative, entrepreneurial, and innovative," (d) "to have a global, regional, and national vision," and (e) "to have a vocation for service and a social conscience" (ASIBEI, 2006).

When participants tried to define problems around which to develop competencies, *poverty* was the only common issue, although members from Spain found this unusual and no agreement on how engineering would fight poverty emerged from the ensuing discussion. At this meeting the Executive Committee also modified one of its objectives to read "the promotion in engineering education institutions of linkages with the productive sector," thereby dropping the additional phrase "and wider complex of social sectors" (ASIBEI, 2005). And while ASIBEI members are watching closely developments in the U.S. and Europe, they have not yet followed suit by wholly adopting industrial employment and mobility as the definitive issues in formulating competencies.

In sum, ASIBEI's initial goal of enhancing collaboration among engineering schools, including by recreating former colonial relationships between Latin American countries and the Iberian peninsula, evolved to include solving the problems of accreditation and defining the competencies of an Iberoamerican engineer. However, the solution to these problems has proven elusive as ASIBEI continues to confront a tension between serving national governments and societies and serving multinational industry.

C. Engineer of the Americas Links with the U.S.

The Engineer of the Americas (EoA) initiative was born at the 2003 Iberoamerican Summit on Engineering Education (IASEE), held in San Jose dos Campos in Brazil. In contrast with ASIBEI , this international summit was built wholly around the idea of linking educational institutions to industry (INEER, 2003). The initial objective was to emulate in Latin America the organized efforts that were taking place in Europe. In July 2003, many Latin American delegates attended the annual conference of the International Network for Engineering Education and Research (INEER) in Valencia, Spain, and as one member of the EoA group commented, "Latin American groups here see developments in Europe [Bologna Declaration] as something they want to emulate." Another group of EoA organizers presented a paper on the initiative in EoA in which they reported, "[t]he example of Europe as a region was taken carefully since the very beginning of the conception of Iberoamerican Summit on Engineering Education" (Scavarda et al., 2003).

EoA advocates quickly built legitimacy for their initiative both within and between countries, conceptualizing its mission as capacity building for engineers. Russel Jones, a key architect of EoA is also President of the World Federation of Engineering Organizations Committee on Capacity Building. In a plenary session at the 2004 ICEE meeting in Gainsville, Florida, Jones defined capacity building as "a dedication to the strengthening of economies, governments, institutions and individuals through education, training, mentoring, and the infusion of resources." According to Jones, the desired outcomes of capacity building are "a solid base of technologically prepared people in developing countries to attract investments by multinational companies, to assist in making the most of foreign aid funds, [and] to provide a basis for business development by local entrepreneurs"(Jones, 2004). Jones also asserted the importance of ABET-like accreditation of engineering programs in relation to capacity building: "Quality assurance reviews lead to improvement of programs, leading to development of a base of well-qualified engineers. . . .Mutual recognition of accredited programs between countries allows student and graduate mobility. . . . Accreditation systems provide the basis for cross-border practice recognition systems, permitting the flow of [engineers] across national boundaries"(Ibid.).

The EoA initiative emphasizes identifying economic and social "asymmetries" between countries and then building "indigenous capacity for self growth" to reduce or eliminate those asymmetries. The result, in contrast with ASIBEI and LACCEI, is a more exclusive focus on private industry. For example, the competencies emphasized in the EoA initiative are designed to help "generate a local workforce that stimulates the economic development of each country through the presence of multinational industry" (Scavarda, Morell, and Jones, 2006). These competencies include (a) "a profound knowledge of the needs of the hemisphere and ability to take advantage of the rich aspect represented by its cultural diversity, (b) "the habit of generating local solutions to international problems," including "help[ing] or . . . participat[ing] in out-sourcing to the local small business and engineering consultant firms part of the responsibility of . . . new products design and manufacturing" and, hence "becoming members of the complex demand and supply chain of the attracted high-tech industry," (c) "knowledge of at least English and another hemisphere main language (Portuguese or Spanish)," and (d) "acceptance of the multicultural environment of the hemisphere and the recognition of the enriching aspect of this diversity" (Ibid.).

EoA organizers have also built a network of governmental and nongovernmental organizations to support this initiative, including the Inter-American Agency for Cooperation and Development (IACD), Organization of American States (OAS), World Federation of Engineering Organizations (WFEO), U.S. Department of State, and a significant number of universities and government agencies from interested Latin American countries, with the goal to "encourage . . . the strengthening of national and regional infrastructure, policies, and dissemination of science, technology, engineering, innovation, and science education." In the so-called Lima Declaration, Ministers of Science and Technology of OAS members included a specific "commitment to support concrete hemispheric initiatives … including … 'Engineering for the Americas' [to] build local engineering capacity to create knowledge that ensures the solution of local needs and opens the chance to compete for global opportunities"(Organization of American States, 2004). The Lima Declaration signaled that 'Engineer of the Americas' had become 'Engineering for the Americas,' thereby recognizing that regional variations in educational systems meant that the near-term goal had to shift from establishing a particular type of engineer with certain competencies to building a regional network and establishing mechanisms for formal educational collaborations.

In 2005, the EoA Task Force organized the "Engineering for the Americas Symposium" to highlight the growth of a diverse network of educational institutions, national governments, and international organization dedicated to its three objectives: "the needs of the productive sector for engineering graduates and capacity building; quality assurance in engineering education; and country planning for financing of upgrades to engineering education" (Organization of American States, 2005).

As Scavarda, Jones, and Morell explain in 2006, the EoA project had become part of a larger process to extend the idea of the region to the hemisphere, the “Hemisphere of the Americas,” by advocating for “a more homogeneous economic and social growth.” This focus on economic homogeneity across the Hemisphere points toward greater integration with the United States. Making the EoA case, Scavarda et al. assert that “Latin America and the Caribbean does not have the internal energy to become a region by itself, although several initiatives of regionalization like Mercosur [a common market including Brazil, Argentina, Uruguay, Paraguay and Venezuela] have shown very positive economic results.” They maintain that economic integration with the United States will occur “sooner or later” because of “cultural roots, economic practices and industrial integration” (Scavarda, Morell, and Jones, 2006).

In sum, the examples of ASIBEI and EoA reveal contrasts in how to define and organize the region. The images of Iberoamerica, Latin America, the Americas, and Western Hemisphere all imply distinct relations with the U.S. and Europe, and even different connections among countries within the continent. Since each organizational model has a distinct vision of the responsibilities of engineers to national infrastructures, private industry, and shared problems such as poverty, the result is contrasting definitions of appropriate engineering competencies.

VI. CONCLUSION

Organizations advocating for engineering education are now moving beyond countries to both regions and the world, motivated by the increased mobility of engineers and a model of competition among countries in terms of economic competitiveness. The U.S. offers a case of country-based developments extended to the globe in which competencies have been defined primarily in terms of the needs of private industry and agreement on competencies has grounded the efforts of engineering educators to establish engineering education research as a disciplinary field. Europe provides a case in which the challenge is to supplement country-based identities with an emergent regional identity, creating a circumstance in which European engineering educators maintain a delicate balance between, on the one hand, national and institutional autonomy over competencies and accreditation, and, on the other, a commitment to European mobility. In Latin America, contrasting definitions of the region are vying for prominence, and, hence, the question of regional competencies remains unclear. This situation poses a difficult challenge to engineering educators as they work to define the future agendas of regional organizations.

This comparative analysis of engineering education organizations has several implications for engineering education and engineering education research. First, it suggests that the contemporary re-definition of competencies in engineering education is not a uniform global phenomenon but depends upon prior success within countries in defining identities that extend beyond their boundaries. In particular, the competencies that graduating engineers will be required to have will vary depending upon (a) whether regulating bodies understand the goals of engineering work as linked to multinational corporations, international humanitarian organizations, governments, or some combination of the above, and (b) whether the mobility of engineers involves movement within a given country, from the country to a neighbor region, from the country to distant regions, or from the country to the globe as a whole.

Second, the examples of the United States, Europe, and Latin America help reveal the types of issues that engineering education organizations in other territories of the world are facing. For example, organizations in China and India are likely to parallel the United States because of their size. At present, engineering organizations in both countries have not yet fully established their jurisdictions over engineering education. For better or worse, they likely will not have the luxury of emulating countries such as the U.S. that initially developed and defined competencies for work solely at home. Rather, they will probably rely on rapidly increasing international influence to help motivate, conceptualize, and justify domestic efforts. Experiences in Latin America may provide some insight into what will likely emerge across the regions of East Asia, South Asia, Africa, Southwest Asia, and the Middle East, namely conflicting definitions of the region, and, hence, of engineering competencies. The example of Europe may serve as a model for other regional initiatives to emulate, but less so if formal unions prove difficult to accomplish. Overall, advocates for reform among engineering educators and researchers in engineering education may find that the specific character of regional differences and conflicts can help shed light on the kinds of initiatives that are most likely to succeed.

A third implication is that this comparative account calls attention to shifts toward private industry. Historically, engineering societies and education programs in many countries emerged around the development of national infrastructures. But as multinational firms scale up the size of global design and supply chains, engineering education is following suit. In the United States, the shift to private industry is not new, for a national commitment to low-cost production for mass consumption has influenced patterns in engineering education since the late nineteenth century(Downey, 2007). This long history may help explain the apparent ease with which engineering educators in the United States have come to agreement about the key issues at stake as they follow the expansion of U.S.-based corporations from the country to the globe. It also explains the lengthier description of U.S. developments in this paper. The significant shifts taking place in Europe vary from country to country and range from significantly elevating the status of private industry in the first place, as in France, to increasing attention to low-cost production for mass consumption, as in Germany and the United Kingdom. In Latin America, the ongoing shift from infrastructure to industry is both new and dramatic.

A fourth implication of this work is that it calls attention to unique issues facing the emergence of engineering education as a distinct field of research and scholarship. One issue is that the achievement of disciplinary status in a given country or region may depend upon the extent to which agreement has been forged about competencies, the contents of engineers' knowledge, and national or regional identity. Another is that relationships among academic fields vary significantly from country to country. Researchers in engineering education are extending their boundaries to link to such fields as psychology, education, statistics, science and technology studies, and women's studies. The successful emergence of engineering education as a discipline spanning multiple regions of the world will likely depend upon participants becoming informed about and taking into account the contrasting constraints and opportunities facing researchers in different countries.

Lastly, this analysis of the relationship between competencies and identities suggests that epistemological studies of engineering education must pay attention to the question of who engineers are and who they would like to be in order to deliberate what they must know. The 2006 report of the Engineering Education Research Colloquies (EERC) includes engineering epistemology as one of the field's five main research strands, defining it as "[r]esearch on what constitutes engineering thinking and knowledge within societal contexts now and into the future." (Steering Committee of the National Engineering Education Research Colloquies, 2006),

p. 259). This definition reflects a tendency to treat the question of knowledge as isolated from questions of identity. But if what engineers must know depends, at least in part, upon who they are in national, regional, and/or global senses, then analysis of the changing competencies demanded of engineers must take account of changes in identity. The EERC report comes closest to recognizing the need for such a connection when it proposes that research on engineering epistemology include the question, "Is engineering best characterized by the people it serves, the problems it addresses, the knowledge used to address problems, the methods by which knowledge is applied, or its social relevancy or impact?" (Ibid., p. 260). The analysis above requires adding the phrase: "or who engineers are in a national, regional, and/or global sense?"

In sum, as countries of the world re-organize themselves into regional economic blocs or act as regions themselves, engineering educators will likely continue to follow by redefining key competencies in engineering formation. To the extent that the trajectories of countries and regions continue to differ in important ways, the prospects for a unified field of engineering education around the world remain uncertain. Indeed, the field of engineering education may be most likely to persist and succeed if it is built with the expectation that it will be a highly diverse field, with contrasts not only in theories and methods but also in what counts as significant problems to address in the first place. Engineering educators might find, in general, that the relative success of international initiatives of all sorts may depend greatly on the specific identities of the target populations in question.

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