Technical Core Competencies Assessment for the Global Construction Professional

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Abstract

The construction industry has become an international industry with firms vying for contracts across the globe. To support this globalized construction industry, university construction programs need to ensure their students have the core competencies necessary to compete in a diversified global construction environment. Future project managers are expected to adapt to a wide range of technical construction requirements, contracting methods, and managerial challenges. The focus of this research is to lay the foundation to determine the technical core competencies of a global construction professional versus focusing on the often emphasized cultural, language, and management issues. While all programs may share core competencies, there are different technical requirements in different places. Technical competencies required may vary from country to country, depending on the geological conditions, the building materials typically used, the kind of construction equipment available, and the economic development of the country, which affects the trade-off between labor and equipment.

In order to assess potential technical core competencies, a process was developed to analyze the technical requirements for design professionals in various regions throughout the world. The well-established civil engineering curricula at colleges and universities throughout the world were examined to assess regional differences and the required design competencies. Once these regional differences in design competencies are identified, then they are compared and compiled into a master list of global design competencies. Results from an initial study of regional differences are provided. In the future, this information can be used to determine the regional technical core competencies required for global construction professionals. The ultimate outcome of this research lead to a series of technical competencies required for the global construction professionals that can be included in a construction curriculum.

Keywords: Globalization, Construction Curriculum, Education

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1. Introduction

Recently, most sectors of the economy have become increasingly globalized, and this trend can be seen in all industries, including engineering and construction. One of the impacts of this globalization is that companies are becoming more global, and are undertaking projects not just in different parts of a country, but in different countries throughout the world. This globalization has an impact on the business of both civil engineering design and construction. Globalization has an impact on the skills that employees need, and subsequently on the skills that our universities must teach.

This paper examines different civil engineering curricula throughout the world in an attempt to identify common elements, as well as differences in civil engineering education. The concept and definition of global competence for students is still evolving (Deardorf 2006, Hunter 2006, Lohmann 2006), and this paper provides one framework in which to examine a process to identify technical global competence. It is important to recognize that just as scientific discovery and engineering practices evolves, so will the role of global engineering, and thus the definition of global competence in engineering.

The long standing profession of civil engineering will provide insight into the direction of technical competencies required by the construction professional. The civil engineering curricula from around the world have been well established over a much longer period than construction management programs. Many of these engineering curricula have required that students understand critical design issues important in that region. These unique technical challenges imbedded in the curriculum will shed light on what a construction professional will be required to know when working in a particular region of the world.

2. Background

Civil engineering education includes basic courses such as math, physics, statics, and dynamics as well as core competencies for civil engineering such as structural design, hydraulics, geotechnical, transportation, and materials. These core competencies are a part of most civil engineering education everywhere. In addition to these core competencies, students take classes that reflect the needs of the country or region, in this regard, engineering programs around the world are unique from country to country. The development of engineering programs has been based on many factors that include the historical educational system for the country and political influences (Lucena 2008, Kavar 1995). Even with increased standardization of engineering programs through Accreditation Board for Engineering and Technology (ABET) and other organizations, countries have maintained unique aspects of engineering curriculum that have significant value for the practicing engineer in the country. Often engineering curricula are shaped by the needs of the industry through the industry advisory boards in the U.S.A. (Warnick 2011). The participation of industry advisory boards and the resulting influence on curriculum assures that graduates have the skills necessary for employment, and are capable of addressing the needs of the region. Civil engineering curricula need to be especially focused on meeting specialized needs of the country; in some cases, these needs may be driven by geography, climate, natural resources or even politics. For example, the country of Turkey is in a very highly active seismic region; as a result, the engineers have to be well educated in seismology and structural dynamics. One of the oldest universities in Turkey is the Istanbul Technical University and their civil engineering program has graduate degree programs focused on earthquake engineering, which is a necessity for the region.

The concept of global competence in engineering is still evolving. This is illustrated by the fact that there is little concurrence regarding what exactly this implies. One definition, as noted in Parkinson (2009), states that for engineers to be globally competent, they must “emphasize skills such as cultural empathy, foreign language ability, or the ability to practice one’s profession in an international setting”. While this is certainly one perspective, it does not address technical considerations. As an analogy, an attorney who practices international law certainly benefits from understanding the culture and language, however, he or she must know more than just the culture and the language. To practice internationally as an attorney requires an understanding of the local law. Similarly, to practice internationally as an engineer or constructor it takes more than an understanding of the culture and language, it requires an understanding of the technical design and construction issues of the country.

3. Research Methodology

The methodology of this research was to assess and compare the engineering curricula for a bachelor’s degree in civil engineering at schools around the world. The baseline curriculum in the United States is an ABET accredited civil engineering program; Purdue University’s civil engineering program was used as a typical school in the United States. The Purdue University program is among the top ten programs at a land grant university. The curriculum at Purdue is considered typical of the many civil engineering schools in the United States. Variance between civil engineering schools in the United States is reduced by the ABET criteria sponsored by the American Society of Civil Engineers (ASCE), which assure a common framework for civil engineering education.

Civil engineering curricula for other schools across the world were also assessed based on published information available on the internet. Schools in Germany, England, Hong Kong, Mexico, India, Egypt, Russia, Turkey, and Afghanistan were found that were a very close match to a bachelor’s of science in civil engineering. While not all programs were an exact match on title of degree, they offered courses that would prepare an engineering professional to structurally design facilities. While this sample is not exhaustive, it does provide an indication of the range of engineering curricula around the world. The published curriculum at each school was evaluated and coverage of each topic was assessed. Comparisons were then made between the schools in different countries to evaluate the common elements and the disparities due to local considerations.

4. Results

The results of the curriculum assessment are shown in Table 1 and 2 with the name of the school and the degree title noted. The elements in Table 1 represent the subjects that were generally common to most of the engineering schools included. The common elements included an emphasis on basic engineering topics, including materials, statics and dynamics, structural mechanics, introductory hydraulics and geotechnical (soils) engineering, concrete and steel design. Virtually all civil engineering programs had the common elements of basic civil engineering subjects as shown in Table 1. These subjects may be considered part of a global core of courses for all civil engineering curricula.

Additional required courses for degrees in civil engineering are presented in Table 2. These subjects are required for a civil engineering degree and are not considered elective courses. These topics are outside the core curriculum or they may represent advanced topics for which the basic or introductory information is part of the core curriculum included in Table 1. An example of a course that may not typically be offered at the undergraduate level is computational finite element analysis. An example of a unique course is advanced irrigation systems, which are an outgrowth of the basic hydraulics courses included in Table 1. It is likely that some of these subjects are covered to some extent in other classes, even if an entire course is not devoted to them.

As can be seen by examining Table 2, the specialty subjects vary widely, from energy and infrastructure, to computationally intensive topics such as computational finite element analysis, numerical methods, and computer aided structural design. In some cases the difference reflect differences in academic emphasis, such as a mathematically based curriculum, in other cases the differences may reflect local design practices, available resources, traditional construction methods, or environmental conditions, such as arid climate or propensity for earthquakes.

5. Discussions

Based on the results of this study into civil engineering curricula, the programs in general were very similar; however, there were some programs that had unique required coursework. These courses were sometimes related to the specific needs or characteristics of the country, such as geography, climate, natural resources or even politics. A brief review of some of the unique courses that were required is provided below.

5.1 Country Specific Coursework

5.1.1 Computational Methods and Finite Element Analysis

The curricula in Germany, Hong Kong and England included an emphasis in computational methods. The German program had a significant emphasis with three courses devoted to computational methods, numerical methods, and finite element analysis. While many civil engineering curricula have courses that include computational methods, these programs had separate courses focused on the topics. The study of advanced computational modelling at the undergraduate level puts these programs on the forefront of advanced civil engineering design using computer modelling and analysis.

5.1.2 Advanced Water and Biosciences

The civil programs in India and Egypt had advanced courses for water and biosciences, beyond the introductory civil engineering hydraulics course. This required coursework signals an emphasis on the design of water and wastewater systems. In both of these countries, potable water is a precious commodity and there is a heavy emphasis on the construction of water and wastewater systems. It is logical that the engineering curricula in these countries reflect this need.

5.1.3 Prefabrication

One of the more unique courses was in the Russian program, which included coursework in prefabrication. Prefabrication is currently a topic of increasing interest as noted by a recent corporate study by FMI (Bowman 2013). The Russian construction industry has long embraced prefabrication for large housing complexes and other structures. The centralized government system has relied heavily on the efficiencies of housing with standard design of buildings and the manufacturing of housing components. With this in mind, it is logical that their civil engineering program includes coursework to support this design and construction technique.

5.2 Case Study of Adopting Established Curriculum into the Global Environment

As international communication and travel have increased, the activities and events at one university can have a significant impact on other universities. For example, the educational methods of Europe and later, those of the United States, had a significant impact on the educational framework for engineering in Afghanistan.

The higher education system in Afghanistan started in 1932 by opening the first Medical school in the country. Other schools such as Science, Letters, Law, Islamic studies were added later. Each of these schools was located in different part of the City of Kabul. In the early 1960s, with the help of a USAID project, a central campus was initiated at the present Kabul University site.

Initially, all the colleges followed the European system of education, in which students had a yearly evaluation, and those who failed one course were required to repeat the entire year. Student evaluations were not frequent during the academic year, starting around March 20th and ending around the end of December of each year. However, there was some variation on frequency of evaluations among the schools.

In 1956, with the help of a USAID project, a joint school of Agriculture and Engineering was initiated; this introduced the U.S. system of higher education at Kabul University. In the two new schools, the semester system was introduced and the schools used the credit system whereby a student can retake a failed course instead of repeating the whole academic year. This was a big change and the two schools were given permission to follow the U.S. system without formal recognition as an accepted university alternative system.

At the College of Engineering, the curriculum of a typical U.S. university engineering curriculum was used. It started as general engineering program which included civil, electrical, and mechanical engineering courses. Later, the electrical and mechanical separated as a unit and civil engineering became a separate unit. Also, a new department of architecture was added to the school. Finally, the electrical and mechanical engineering disciplines split into different departments and thus the school became four departments, architecture, civil, electrical, and mechanical engineering. The medium of instruction was English and typical U.S. text books were used in the classes, (Baha 1976).

One of the authors was involved first hand at the Kabul program, and is able to offer the following observations regarding the U.S. adopted curriculum in the school of engineering at Kabul University.

The School of Engineering at Kabul University played a role model of excellence and accomplishments and here are a few examples that may explain the success of this adopted curriculum.

1. Those graduates who came to the U.S. for graduate work were practically all able to successfully complete graduate programs.

2. The graduates were not only very successful in technical areas, but also successful in administrative roles. Graduates reached the cabinet positions in the government system within 20 years of the establishment of the school.

3. When the five year development plan was initiated by the government of Afghanistan in 1977, the government had asked the school to expand to provide the professionals needed for the implementation of the five year development plan of the country. The normal intake of about 250 students each year was raised to about 1,100 students in 1977, an increase of more than four fold. Although there were other institutions of higher learning to train technical personnel in the country, the popularity and success of the graduates of the faculty of engineering at Kabul University made this school an obvious choice for expansion.

4. The School of Engineering at Kabul University was one of the successful programs to provide competent professionals. It could be compared with the two other very successful programs in the region. One of these programs was the American University of Beirut (AUB), Lebanon, and the other was the Asian Institute of Technology (AIT) in Bangkok, Thailand. One of the authors has been familiar with these institutions of higher learning and is acquainted with some of their graduates.

5. Using the English language as the media of instruction could have been one of the elements of success for the Kabul program. Graduates were able to access international reference resources to further develop their professional expertise throughout their careers.

6. Conclusions

This paper provides an initial study of regional differences in civil engineering curricula from various countries from around the world. These differences can arise from differences in geography, climate, natural resources, and politics. An in-depth study is provided on how an engineering program has evolved in Afghanistan. The process of examining civil engineering design curriculum from universities around the world can be further extended to review other engineering programs with a more comprehensive analysis of the programs. In the future, this information can be used to determine the technical core competencies required for global construction professionals. An outcome of this research will be a series of technical competencies that can be included in a single course for those students focused on a global construction career or can be spread through many courses in a construction curriculum. These competencies could also serve as a basis for developing a core curriculum for construction that could be implemented globally.

Table 1: Civil Engineering Curriculum Common Subjects

	Geomatics/Surveying	Materials	Structural Mechanics	Statics/Dynamics	Computer Graphics	Hydraulics	System Design	Concrete Design	Steel Design	Geotechnical	Structural Analysis
Kabul, Afghanistan	X		X	X		X		X	X	X	X
Cairo, Egypt	X	X	X	X	X	X	X	X	X	X	X
Hong Kong Univeristy of Science and Technology (Hong Kong)	X	X	X	X	X	X	X	X	X	X	X
Imperical College London (England)	X	X	X	X	X	X	X	X	X	X	X
Indian Institute of Technology, Kharagpur (India)	X	X	X	X	X	X	X	X	X	X	X
Moscow State University of Civil Engineering (Russia)	X	X	X	X	X	X		X	X	X	X
Purdue University (U.S.)	X	X	X	X	X	X	X	X	X	X	X
Technology De Monterrey (Mexico)	X	X	X	X	X	X	X	X	X	X	X
Technical University Munich (Germany)	X	X	X	X	X	X	X	X	X	X	X

Table 2: Civil Engineering Curriculum Unique Required Courses

	Computational	Finite Element Analysis	Numerical Methods	Energy	Modeling Systems	Computer Aided Structural Design	Water/Bio Sciences Courses	Plastics Engineering	Prefabrication (Concrete)
Kabul, Afghanistan							X		
Cairo, Egypt							X		
Hong Kong Univeristy of Science and Technology (Hong Kong)			X		X				
Imperical College London (England)	X			X					
Indian Institute of Technology, Kharagpur (India)							X		
Moscow State University of Civil Engineering (Russia)								X	X
Technology De Monterrey (Mexico)						X			
Technical University Munich (Germany)	X	X	X			X			

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