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## **AC 2011-1153: EDUCATING GLOBALLY COMPETENT ENGINEERS IN SEGOVIA, SPAIN**

### **James McConnell , North Carolina State University**

James McConnell was born in the city of Rome, New York. His father was in the military working as a combat photographer so the family moved around a lot before settling in Panama for 5 years until he was 10. Living in Panama and driving through Central America to return to the United States created a desire to continue being around the Spanish language and Hispanic culture. It also motivated him to receive an MA in Hispanic Literature from the University of Arizona where he taught from 1995-2000 before accepting a position as Caribbean Operations Director for an adventure travel company for teenagers called Broadreach. The years he taught for them afforded Mr. McConnell travel to Mexico, Ecuador, Fiji, The Solomon Islands and most of the Caribbean but it also renewed his desire to return to academia. He has been employed as a Lecturer at NC State since the fall of 2005. Among the courses he especially enjoys creating and teaching are conversation and introduction to culture and grammar through the use of film. He has recently taken over the role as the spring instructor for Beginning Spanish (FLS 101) and it has been exceptionally gratifying. This course is a new model, having moved from individual classes of 25 to large groups of over 250 each. As part of his course load, Mr. McConnell oversees four Graduate Teaching Assistants for FLS 101. In addition to the courses he teaches in a classroom setting, he is also the instructor of an online Spanish course that blends the elements of the Spanish language with the relationship among culture and technology. He meets regularly with department members to plan collaboratively and articulate content between courses. In addition to teaching, Mr. McConnell leads Engineering Students on a summer semester program to Spain. Although based out of the town of Segovia, students travel to several cities including Toledo, Barcelona, Madrid, Avila and Salamanca. The program is geared toward Engineering students and includes traditional language classes and various excursions such as kayaking, visits to glass factories, a daytrip to a winery and outings to visit several castles in the region to incorporate a historical and cultural perspective to the program. James is a current member of Sigma Iota Rho which is the Honor Society for International Studies and he is also currently a mentor for the Global Perspectives Certificate program through the Study Abroad Office. His most recent professional development involved conducting a three hour workshop for the Foreign Language Association of North Carolina titled: "Gmail and Beyond: Google applications and Foreign Language Teaching and Learning." Additional certifications he either holds or has held include being a Medic First Aid Instructor, a Master Scuba Diver Trainer and medical certifications in both Wilderness Medicine and CPR.

While his main focus continues to center around academia, James still likes to take the time to focus on activities not related to the university whenever he is free. He is a former scuba diver who also enjoys sailing, mountain biking, hiking, reading, cooking and any form of travel. His international travel has taken him to South and Central America, Europe, Africa, The South Pacific and parts of Canada.

### **Brian D. Koehler, North Carolina State University**

Brian D. Koehler is Director of International Engagement in the College of Engineering at NC State University. He leads NC State's Engineering Career Fair which has become one of the largest and highest-quality opportunities in the nation, mentors the NC State Engineering Ambassadors, and the Engineers' Council. He also serves corporations via the NC State Engineering Foundation, Inc. Teaching and research areas include: engineering education, international engineering, leadership, corporate recruiting, and supply chain management. Brian received degrees from the University of Wisconsin-Platteville (B.S.) and NC State University (M.A. & M.B.A.).

# **Educating Globally Competent Engineers in Segovia, Spain**

## **Abstract**

Upon designing an opportunity that offers engineering students an international experience, several questions need to be answered such as “What are the benefits to an engineering student?”; “Is it necessary to have an intensive language requirement?”; “How can excursions into the local community be geared toward engineers?” Removing the current economic situation of the United States from the equation, one can still make a strong case for the importance of time spent abroad due to the cultural understanding necessary to be marketable in a society that is truly affected by globalization. Technological advances have effectively shrunk our world which demands engineering fields to interact significantly more with other cultures. Upon leaving the university setting it is not that the students need some type of advantage to give them a leg up in the professional world but rather some type of international experience is necessary to merely compete in a global market.

An international experience is an excellent way to expand one’s horizons but that alone may not be enough. The Summer in Segovia, Spain offered by NC State University is specifically designed for engineering students who would like to address engineering problems around the world, in addition to learning vocabulary that is specific to the subject matter.

This paper describes that opportunity in addition to analyzing excursions that have been tailored specifically for engineering students. It takes into account the accomplishment of learning objectives pertinent for academic classes as well as real world applications intended to maintain engineering student interest. This paper will also discuss challenges in assessing and developing experiences, and the importance of international opportunities.

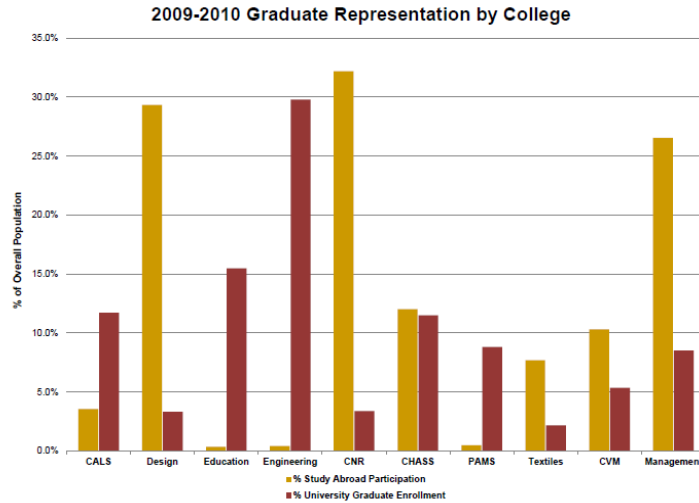
## **Introduction**

Historically, international study has been one of the primary means by which students, at institutions of higher education, have gained first-hand knowledge of other cultures and languages. Among the benefits are attaining a greater proficiency in a foreign language, gaining an appreciation for and understanding of other cultures, improving communication skills and the ability to live and work effectively in another culture.<sup>1</sup> The effects are felt long after return. Ninety-five percent of “alumni” report that their international experience had a lasting impact on their world view and a majority said that it influenced their career path. Although the number of students enrolled in international study has doubled over the past decade, only a small percent of undergraduates nation-wide take advantage of this opportunity.<sup>2</sup> At NC State University almost 30% of all enrolled international students are in the College of Engineering, however, a much smaller fraction of students participate in international study.

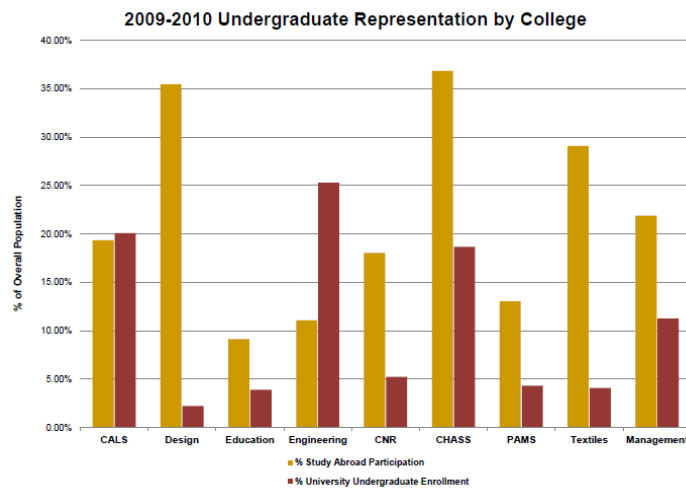
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<sup>1</sup> U.S. Committee for Economic Development (2006)

<sup>2</sup> Institute for International Education (IIE)



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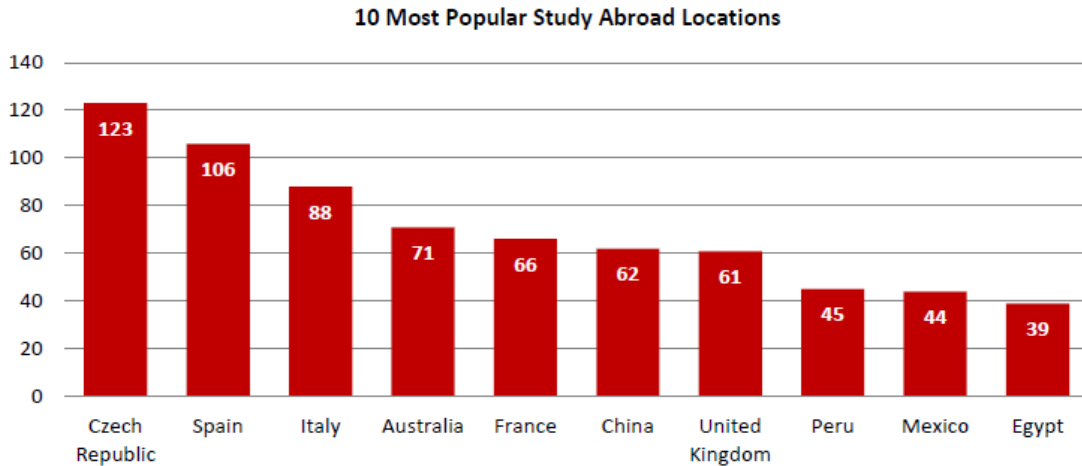


The Segovia program is sponsored by the College of Humanities and Social Sciences (CHASS) and the College of Engineering (COE) at NC State University and is designed for engineering majors. During this experience, students utilize the city and surrounding area to explore language, technology, and culture.<sup>4</sup> The classes and excursions encourage the ability to use the language in authentic settings and allow the student to study and experience the rich culture of Spain. The classes teach the structures inherent in a beginning / intermediate language class by integrating vocabulary, issues, and projects that are of special interest to engineering students. During the excursions, students visit the famous aqueduct, textile factories and other unique locations to experience technology past and present. There are excursions to various cities and sites to experience medieval, renaissance, baroque and modern Spain. In order to assist in the language retention, authentic home stays with families, instead of dormitories, are arranged. This avoids the possibility of speaking English at home -- a true highlight of the experience where students gain an understanding and appreciation of the Spanish lifestyle.

<sup>3</sup> <http://www.ncsu.edu/>

<sup>4</sup> Ollis (1999)

During the 1995-96 academic year a total of 13 students from NC State University chose to take advantage of an international experience in Spain. By the 2000-01, when NC State University designed this opportunity, a total of 27 students gained an international experience in Spain. Today, Spain is the 2<sup>nd</sup> most popular international opportunity:<sup>5</sup>



### **Segovia, Spain**

Segovia, a small city 55 miles northwest of Madrid, boasts a Roman aqueduct, a Gothic cathedral, and a castle. It is a perfect introduction to the richness of Spanish artifacts and also introduces students to the life and schedule of the Spanish people. The history, urban layout, historic sites and scenery of Segovia have been awarded a place on the UNESCO World Heritage list. Segovia, because of its unique historical mixing of Christian, Jewish and Muslim cultures, is an ideal focus for students who are considering questions of the relationship between technology and culture and in finding their place in our global society.

### **Curriculum Integration**

At NC State University, international study is increasingly integrated into the curriculum. It is essential for a students' international experience to be integrated into their plan of study<sup>6</sup> whereby differentiating themselves from the more than 1,000 that will graduate from just this College of Engineering, not to mention the 70,000 plus graduating with an engineering degree nationwide and the over 1/3 million engineering graduates worldwide – just in one year alone.

<sup>5</sup> <http://studyabroad.ncsu.edu/>

<sup>6</sup> Reed-Rhoads, T. (2007)

**NC STATE UNIVERSITY**

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*"It is an experience that I will never forget and was one of the best times of my life."*

-Justin Lee, Semester in Wales, Aerospace Engineering



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**NC STATE UNIVERSITY**

## Study Abroad Programs for Engineering Students

**Featured Semester Programs**

**BRAZIL**  
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Students can earn an NCSU International Certificate in Engineering while studying in the Faculty of Engineering at one of three Brazilian universities. Completing coursework in Portuguese, students travel to Brazil for a two month language immersion program prior to the start of the classes. Additional financial support is available.

**MEXICO**  
**Tecnologico de Monterrey (ITESM)**  
ITESM offers English & Spanish-taught courses in the Faculty of Engineering. Students can participate in research projects, community service-learning programs, & engineering internship placements. ITESM also offers certificates in manufacturing systems, construction systems, & software engineering.

**SWEDEN**  
**Lund University**  
Lund offers English-taught courses in one of the leading engineering universities in Europe. Students can take courses in the following departments: chemical, electrical, industrial, mechanical, computer, construction, design sciences, environmental building, electrical information, and immune technology. Lund is home to Sweden's largest science park.

**FINLAND**  
**Aalto University - School of Science & Technology (TKK)**  
TKK offers English-taught courses in the Faculty of Engineering and Architecture, Faculty of Chemistry and Materials Science, Faculty of Electronics, Communications, and Automation, and Faculty of Information and Natural Sciences. Located in Helsinki, the headquarters to Nokia, Kone, and Neste Oil, the university has several research centers and students have the opportunity to conduct independent research.

**SOUTH AFRICA**  
**University of Cape Town**  
Cape Town offers English-taught courses in the Faculty of Engineering and the Built Environment. Departments include: architecture/planning/geomatics, civil engineering, construction economics and management, chemical engineering, electrical engineering, mechanical engineering, and computer science. Opportunities also exist to volunteer in local township communities in need.

**AUSTRALIA**  
**University of Wollongong**  
One of the best engineering schools in Australia, Wollongong offers academic coursework in the following engineering departments: civil, computer, electrical, environmental, materials, mechanical, mining, and telecommunications.

**MONASH UNIVERSITY**  
With an international reputation in teaching and research, Monash has academic departments in the following engineering areas: biological, chemical, civil, electrical/computer systems, materials, and mechanical/aerospace.

**UNITED KINGDOM**  
**Swansea offers English-taught courses in the School of Engineering with concentrations in the following departments: aerospace, chemical/biological, civil, electrical/electronic, information, communications/computer technology, materials, mechanical, medical, nanotechnology, and product design engineering. Students can participate in a fall 3 credit internship prior to the start of the semester.**

**HONG KONG**  
**Hong Kong Polytechnic University**  
HKPU offers English-taught courses in these areas of the Faculty of Engineering: computing, electrical, electronic/information, industrial systems, mechanical, building service, civil/structural, land surveying/geo-informatics engineering. HKPU also has engineering-based research centers.

**Featured Summer Programs**

**London: ENG 331**  
Explore London while studying written communication in industrial & technical organizations in ENG 331. Students use London as their classroom by participating in engineering-related company site visits, conducting research, & choosing excursions.

**South Africa Civil Engineering**  
Conducting classes at University of Stellenbosch, students fulfill NCSU degree requirements through CE 401, CE 305, and CE 527. Day trips and cultural excursions are included. Note, this program rotates to a different country each year.

**Segovia, Spain**  
Students earn 6 credit hours of coursework in Spanish, fulfilling the Humanities/Social Sciences requirement for the College of Engineering. Students also visit the famous aqueduct, textile factories and other places to experience technology past and present.

**TU Braunschweig, Germany: Non-NCSU Research**  
Students engage in a 7 week summer program in Mechanical Engineering, Electronics and Chemical Engineering, Physics, Computer Sciences or Bioscience. Includes scientific work and practical training on active research projects and German language training (no language pre-requisite).

\*\*\* While these are featured programs for the College of Engineering, students are not limited to these opportunities. Please visit our website, <http://studyabroad.ncsu.edu>, for all available programs.

## Content-based Instruction

The successful execution of content-based instruction in foreign languages provides a model for many forms of more vibrant and effective foreign language instruction. The development and refinement of this approach is broadly applicable to other disciplines. These are not simply conventional language courses with a specialized vocabulary grafted onto them. They represent a new way of teaching, an interdisciplinary approach, utilizing materials from both engineering and foreign languages which provides an enhanced and exciting educational and cultural experience.

Students demonstrate an awareness and appreciation of the culture; they understand guides to cultural and engineering sites; appreciate cultural and historic importance of artifacts in the Hispanic world such as Roman aqueducts, cathedrals, castles, paintings, and basic principles of architecture. Modern Spanish culture is a fascinating product of Romano-Hispanic, Moorish, and Jewish traditions. For example, the great mosque in Cordoba, the Mesquita, is a dramatic example of the way that culture shapes technology. The mosque is a beautiful example of the richness of the Moorish approach to creating a place of worship. After the Moors were expelled from Cordoba, Carlos V built a Catholic church in the center of the mosque. Its elaborate appearance presents a stark and riveting contrast to the elegant simplicity of the mosque. Both buildings serve the same function as a place of worship, but they could hardly be more different. The student who passes from one to the other cannot help but ponder the way in which culture informs the application of technology to the design and construction of functional objects.

## **Academics**

Although English continues to grow as the primary international language, corporations have started to face the problem that international business cannot be done in English alone. In a survey of leading executives, only 31 percent reported using English for professional purposes.<sup>7</sup> Corporations have clearly communicated the need for foreign languages and the increasing importance into the future.

The Segovia experience focuses on developing the ability to use Spanish in a real life context, to experience and gain an appreciation for the culture, technology, and society. It is designed for engineering students,<sup>8</sup> but the experience is applicable for any student with an open mind and an interest in engineering topics as it relates to the rich culture of Medieval, Renaissance, and Baroque Spain.

Students must have at least beginning, intermediate foreign language ability prior to the start of this program. Both courses are taught in Spanish and meet the General Education Program requirement in the College of Engineering.

### ***FLS 212 - Spanish: Language, Technology, Culture***

*This course teaches the structures inherent in a beginning/intermediate language class by integrating vocabulary, issues, and projects of unique interest to engineering students.*

### ***FLS 395 - Spain: History, Art, Culture***<sup>9</sup>

*This course provides an historical and aesthetic focus necessary to understand the virtual museum in which students live in Segovia and will study the culture.*

The student will learn and demonstrate vocabulary commonly used in technology contexts and will develop the ability to comprehend and use Spanish in professional settings. They will also demonstrate an awareness and appreciation of Hispanic culture, including the cultural and historical importance of artifacts in the Hispanic world. As a result, in addition to demonstrable mastery of the intermediate language curriculum with emphasis on speaking, reading, and writing in Spanish, students will learn to appreciate cultural awareness as a practical tool in the application of their technical training to specific projects in their professional careers.

In the College of Engineering at NC State University, “we support unique efforts to provide opportunities for our students. The FLS 212 course encourages students with some Spanish language skills to continue developing those skills in the context of studying the culture and technology in Spanish-speaking communities. Courses such as FLS 212 provide the basis for a broadening of perspective and experience, thus creating a greater awareness of the social and global implications of engineering design and problem solving. This is a major goal for the undergraduate engineering programs at NC State.”<sup>10</sup>

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<sup>7</sup> Panetta, L. (1999)

<sup>8</sup> 18 Undergraduate Engineering Degrees; <http://www.engr.ncsu.edu/>

<sup>9</sup> This course is also approved to complete a course requirement in the Spanish minor.

<sup>10</sup> Lavelle, J. (Associate Dean)

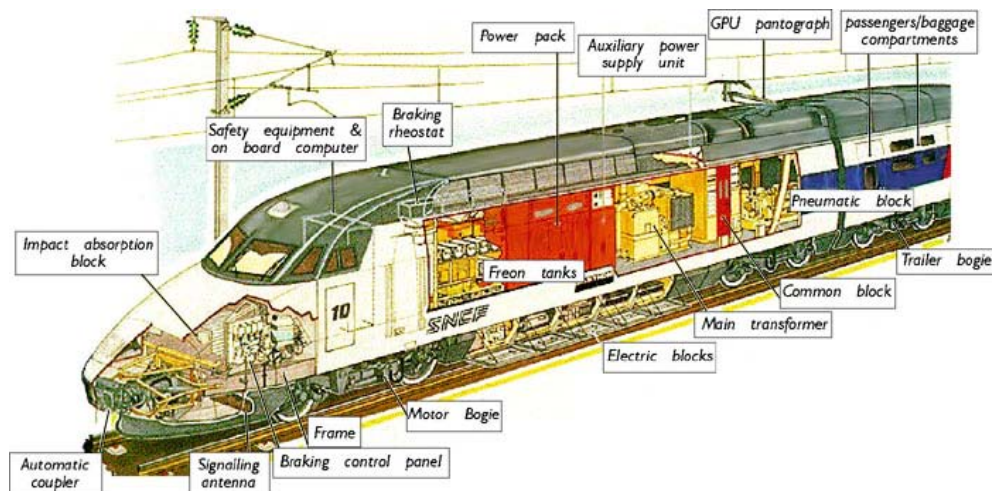
The course objectives:

- ✓ communicate in the foreign language in a real world setting;
  - master grammatical structures required in intermediate Spanish;
  - communicate in written and oral form;
  - learn vocabulary commonly used in engineering and technology;
  - comprehend and use Spanish in our technological society;
- ✓ demonstrate an awareness and appreciation for the culture, history, and technology;
- ✓ develop an understanding of our place in global society.

In addition to two academic classes, one based on grammar and technology and the other on culture and history, students are required to complete a final project (e.g., involving a paper and a visual presentation). Research is to exhibit culture and technology working together, and how this form of technology has influenced the Hispanic culture.

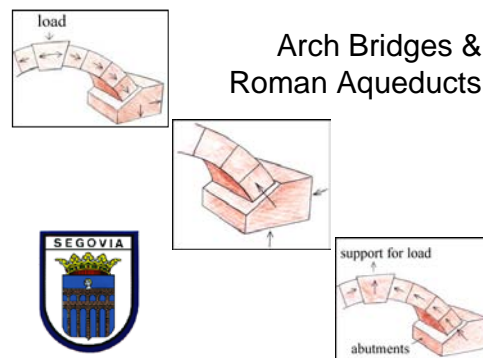
- What is its function and purpose?
- Who in society uses it?
- What societal needs guided its creation?
- What does it reveal about its culture?
- How does it work technologically?
- What engineering innovations were used?
- What fields of engineering were involved?
- What engineering principles were used?

For instance, a student rode the AVE<sup>11</sup>, the Spanish high-speed train, and researched how the energy created, in the form of heat by braking the train, is fed into the electrical system and used as energy.



<sup>11</sup> Alta Velocidad Espanola; <http://www.railway-technology.com>

Students are given tremendous latitude with this final project. A popular project is about the roman aqueduct, but other examples include:



- anti-counterfeiting methods used in the Euro and societal response to the change from the Peseta to the Euro,
- the application of Bernoulli's principle with regard to the gravity fed fountains at the gardens of the Royal Palace in La Granja;
- the tunnel boring used to create paths for the rails supporting the AVE and the cultural influence on small towns previously without efficient public transportation.

Final projects are the synthesis of the experience, as it relates to the technology, society, and culture of Spain. They are in Spanish to reinforce the foreign language and delivered using innovative modes of communication.<sup>12</sup>

### Excursions

In addition to the intermediate language classes,<sup>13</sup> the students gain cultural awareness via the excursions. This development of cultural awareness becomes a practical tool during throughout their technical training and into their professional careers. There is no better way to experience the intersection of culture, technology, society and history.

Toledo, a well preserved medieval city, features Moorish, Jewish, and Christian culture and architecture. Salamanca, an open and expansive city, is contrasted to the walled and protected city of Avila. Other excursions:

- ✓ Whisky DYC (e.g, grain selection, toasting, distillation)
- ✓ Palacio Real (e.g., construction, armory)
- ✓ El Prado and Reina Sofia (e.g., restoration and preservation processes)
- ✓ Tapestry Museum (e.g., textiles, quality of materials)
- ✓ Cathedrals (e.g., architecture, cultural significance)
- ✓ Toledo (e.g., metallurgy, contrasting medieval and renaissance styles)

<sup>12</sup> Prezi, PowerPoint, Movie Maker, Picasa Web, and Adobe

<sup>13</sup> Reinforced by home stay



## “The Castle Route”

In close proximity to Segovia are the castles of Turegano, Pedraza, and Coca. The castles are markedly different from each other due to the age of their construction, location and historical circumstances. The castle found at Turegano dates from Celtiberian times, at Pedraza it is found inside a walled in city with the rear of the castle supported by a sheer cliff, and the one at Coca, constructed in 1473, is the best preserved. Students learn about the history of the region, the engineering behind the construction and the cultural importance to the area.

The castle at Coca not only served as a noble household, but also as a fortress and a refuge for the local township during defensive times. The design and construction, strongly influenced by Moorish culture and workmanship, was to maximize defensive capabilities rather than create comforts. The castle contains a moat, a drawbridge, and a large gate to impede entrance as well as other structures to enhance defensive capabilities. One such structure is the narrow spiral staircases. The ceilings are low and the spiral is very tight which impedes the progress of those attacking. The spiral staircase did not allow attackers to swing a sword, or even stand erect, making it difficult to engage in combat. It also allowed the inhabitants to pour hot oil or large boulders down the stairway for defense. The upper façade of the castle contains crenellations along the top of the parapet<sup>14</sup> which allowed soldiers to shoot arrows while making themselves difficult targets for advancing troops. Another interesting feature is the use of grating in many walkways directly above entryways. As an enemy would enter, hot oil was poured through the grate. One last structure, the jail, is an inverted 20 foot high cone shaped room was built with the only entrance being a two foot trap door at the very top where prisoners would be lowered in by a rope.<sup>15</sup>

## Wine Production

Spain is a leading producer of wine world-wide. The entire process of producing wine is highlighted during an excursion beginning with the type of grape chosen for the wine, location selected for the vineyard, collection of the grapes, separation of the grapes from stems and leaves, crushing of the grapes to produce must, distribution into stainless steel vats for fermenting and finally the bottling. One such process is from separation to fermentation. The feed auger moves grape clusters into a crusher-destemmer where the portion that will be used for wine is piped in to be crushed before being transferred to stainless steel, temperature controlled vats where the fermentation process begins.

## Glass Factories

Located 10 kilometers from Segovia is the city of San Ildefonso de La Granja. A commercial, and an artisanal, glass factory is here and are excellent examples of how culture and technology have worked together to create a sustainable enterprise. The commercial glass factory, VICASA, is of particular interest due to the assembly

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<sup>14</sup> Typically in the shape of a cross

<sup>15</sup> <http://www.castillodecoca.com/>

workstations and automation of the process. Students see how silica is mixed with sodium oxide and calcium oxide, heated to approximately 1500° Celsius and then manipulated with both steel and air to produce a particular shape. Technology is used to test for imperfections whereby a vibration is sent through each piece of glass produced to check for fractures and imperfections.

### Royal Fountains

Also found in the city of La Granja is the Royal Palace that was a summer home for the King and Queen of Spain. Home to 1500 acres of gardens that contain 18<sup>th</sup> century fountains based on classic Greek mythology. What makes this excursion extraordinary to engineers? The fountains project up to 40 meters high yet they are purely gravity fed. There are 26 fountains and a reservoir found at the highest point of the gardens supplying the water for all of them. Large pipes divert water toward a specific area while the diameter of the pipe is reduced further downhill. Pressure increases, a valve is opened and with a smaller aperture they are able to control the flow.<sup>16</sup>

### Roman Aqueduct

One of the best preserved roman aqueducts is in Segovia. The Romans, needing a constant water source, constructed a solution to transport water from the Sierra Guadarrama Mountains nearby to Segovia. The hydraulic engineers who tapped the waters of the Río Frío to bring them 18km to Segovia via a canal with an average gradient of 1% ran into many challenges along the way. In order to reach the city, an enormous construction of masonry 813 m in length, consisting of four straight segments and two superimposed arcades borne by 128 pillars was needed. At the lowest point of the valley, the aqueduct stands at a height of 28.5 m above ground.<sup>17</sup> No mortar was used in construction and a keystone, in all of the arches, holds the aqueduct together. In addition, a historical engineering innovation to clean and remove sediment was designed. The water is naturally decanted and sand settles out before continuing the route.<sup>18</sup>

An excursion to these areas, and others, reinforce the classes and final project. For instance, one year a student took special interest in the engineering of the fountains at the Royal Palace in La Granja. Utilizing empty 2 liter soda bottles, straws and tubing of different diameters to demonstrate the principle, as a visual aid in the final project, water was released from the top bottle through ½ inch tubing to ¼ inch tubing and then to straws that allowed the water to propel several feet.<sup>19</sup> Another checked for engineering failure by stress, column buckling, and fracture to prove that the Roman Aqueduct in Segovia is more than 20 times over engineered and, in theory, should not fail barring some type of natural disaster or intentional sabotage.

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<sup>16</sup> The piping used is original from the late 1700's and still functions properly.

<sup>17</sup> Aqueduct of Segovia

<sup>18</sup> UNESCO

<sup>19</sup> Demonstrating this principle reinforced the value of a global education.

## **Conclusion**

Students must develop global competence and be able to function as global citizens. All engineering students should “have the broad education to understand the impact of engineering solutions in a global and societal context.”<sup>20</sup> To do so, students must increase their international knowledge and skills through, for example, international study and experiences. The United States, to remain a leader, must continue to emphasize internationalization in higher education. Our counterparts around the world are certainly doing so – often times at a faster rate. If this continues, we will lose our competitive edge in the international marketplace. Therefore, it is vital that we embrace this global economy and reinforce the experiencing of other societies and cultures as both valuable and necessary to remain competitive.<sup>21</sup> Investing in international education is the key to educating globally competent engineers.

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<sup>20</sup> ABET, Inc.

<sup>21</sup> Continental AG (2006)