

AC 2007-1943: PREPARING ENGINEERS FOR A GLOBAL INDUSTRY THROUGH LANGUAGE TRAINING

Daniel Korth, Brigham Young University

Daniel Korth spent several years living in Peru and speaks Spanish fluently. He graduated from Brigham Young University with a Bachelor of Science Degree in Mechanical Engineering in April 2007 and accepted a position with Raytheon Space and Airborne Systems in El Segundo, California.

Owen Carlson, Brigham Young University

Owen Carlson graduated with a Bachelor of Science Degree in Mechanical Engineering from Brigham Young University in April 2007. He speaks Cantonese fluently and lived in Hong Kong from 2001-2003. He worked for BD Medical in product design and manufacturing. Currently he is working for ATL technology as a Global Product Developer.

Mason Webster, Brigham Young University

Mason Webster is a graduate of Brigham Young University with a BS in Mechanical Engineering. He is fluent in Mandarin Chinese and has completed two internships in China at a Lithium-ion battery manufacturing plant. Next year, he plans on attending graduate school to pursue a Master of Business Administration degree.

C. Greg Jensen, Brigham Young University

Dr. C. Greg Jensen is an Associate Professor of Mechanical Engineering at Brigham Young University. He has also worked for Boeing, Lockheed, and United Technologies. His current research interests are in the area of integration, optimization and customization of CAx tools, with a second focus in the direct machining of CAD topology.

Preparing Engineers for a Global Industry Through Language Training

Abstract

Imagine a situation in which an engineering firm has had a catastrophic failure on one of its products. In order to assess what went wrong a design engineer in the United States is working with a component manufacturer in another country. However, because the designer cannot speak the manufacturer's language, the two are communicating through an interpreter. In this international version of "telephone" neither party is able to ensure that their instructions, questions, or solutions are communicated clearly. The engineer's ability to communicate directly with the manufacturer would greatly facilitate collaboration between the two parties. Unfortunately, undergraduate engineering programs today are not set up to prepare students to communicate in a global engineering environment.

As the industrial world evolves to survive in an ever more global market, a barrier to progress in technical collaboration efforts is the inability of most engineers to fluently speak a foreign language. Though language courses are included in the curricula of many schools throughout the United States, few students achieve any degree of fluency in the language they study. These meager lingual abilities are insufficient for the typical engineer to be able to discuss his/her work with others around the globe.

Simply taking a few language classes to learn vocabulary words or simple conversational techniques is wholly insufficient to produce engineers capable of actively participating in a global environment. A program is needed which will give students the opportunity to develop language skills as they are developing analytical and design skills. To make this possible, engineering students need opportunities to gain basic language skills and achieve fluency by studying under and working side-by-side with persons who natively speak the language being studied. In addition, time spent studying at a foreign university will help students gain an understanding of the culture and people they will be working with by immersing them in their language. In this paper we will propose a program to meet the goal of producing engineering graduates familiar with the global environment and capable of becoming active and effective participants within that environment.

Introduction

In 1980 Deputy Secretary of Commerce Luther H. Hodges Jr., spoke to a group of foreign language educators regarding the challenges facing the American economy in the new decade. During his remarks Hodges stated "In this new world communication is all-important.... One lesson that we ought to learn is that the whole world does not speak English; some of it speaks French and German, Chinese and Russian, Japanese and Arabic, Swahili and Spanish, and hundreds of other languages. We can probably survive, as we have in the past by expecting everyone else to do things our way, but that expectation is no longer feasible if we want to continue to lead. We must develop a better understanding of other cultures, a task that entails learning to speak the languages of other nations."¹ In the years since Hodges remarks were made the world has become an increasingly smaller place. A person can go almost anywhere in the

world within 24 hours. One can request information from someone in any corner of the globe and receive a reply in a matter of minutes using email. It is possible to hold a meeting with participants from every continent simultaneously by using video conferencing technology. In today's world, engineering along with virtually every type of business activity has become a global undertaking. In this modern market it is crucial that American engineers develop foreign language skills in order to communicate with potential clients, business partners, and other engineers in other parts of the world.

During the last few decades, people from countries throughout the world have studied English in order to increase their ability to do business internationally. This has made it possible for American, European and Asian companies to expand the markets for their products and reduce production and support expenses by moving labor and service jobs to areas with capable, low-cost work forces. The shift to a more global market has had profound effects on the way the world does business. Additionally, the opportunities that have been made available to people in less developed parts of the world are allowing professionals in those areas to increase their standard of living without the need to leave their homes, family, and way of life and relocate to other parts of the world in order to seek prosperity.²

As international collaboration in business becomes more widespread, Americans in all fields will be required to communicate and work with teams and individuals of other nationalities.⁶ This shift towards international cooperation in industry will require a change in the way the United States is preparing its engineers. If American engineers are to be successful in a global environment, they must be equipped to communicate and operate within that environment. As different nations distinguish themselves in specific areas such as business leadership, software development, manufacturing, design, etc. businesses and consumers throughout the world will turn to those nations to fulfill these varied needs. As this occurs it will become increasingly likely that engineers and other professionals in America will need some ability to communicate in the languages spoken in those nations. Over two decades ago Dr. J. Paul Hartman, an engineering professor at the University of Central Florida, wrote of the need to encourage American students at all levels to make the study of foreign languages a part of their education. He observed "Although English has spread throughout the world as an almost universal second language, at the same time the world role of U.S. business and technology has changed dramatically. Although still strong and large, it is no longer dominant.... We have a world of competition. And our mono-lingualism and narrow focus does not help us with inter-cultural dealings⁴."

More recently, Thomas Friedman, author of *The World is Flat: A Brief History of the Twenty-First Century* tells of a discussion he had with Xia Deren, mayor of Dalian, an industrial city in China which is home to many technical jobs outsourced from Japan. During the course of the conversation the mayor explained what he calls the "rule of the market economy". Mayor Xia said " '...if somewhere has the richest human resources and the cheapest labor, of course the enterprises and the businesses will naturally go there' In manufacturing... 'Chinese people first were the employees and working for the big foreign manufacturers, and after several years, after we have learned all the processes and steps, we can start our own firms. Software will go down the same road...First we will have our young people employed by the foreigners, and then we will start our own companies. It is like building a building. Today, the U.S., you are the

designers, the architects, and the developing countries are the bricklayers for the buildings. But one day I hope we will be the architects.’ ”⁵

As the mayor and Dr. Hartman explain, America is no longer the dominant economic power in the world and developing countries will not always be simply a source of cost effective labor for more developed countries. America cannot continue operating under the assumption that English will always be sufficient for working with those in other countries.¹ As workers in developing countries gain skills and learn the processes involved in the work they are doing for foreign companies, they will become competent enough to branch off and form their own companies. This changing role in developing nations will increase the need and opportunity for individuals and companies in the United States to do business with foreign companies as well as to develop markets for their own products and services in those nations. American companies will be able to operate much more effectively in international markets if they have employees who are capable of not only communicating with people in those markets but also of observing the local customs of those with whom they wish to do business.

Learning the language and customs of others is a great sign of respect. Demonstrating this respect will open many more doors to American businesses and help them to establish a good repertoire with foreign companies and customers. Many business travelers can tell stories of business deals lost to violations of local etiquette or involuntary displays of disrespect. These violations may be things as simple as writing on the back of a business card, patting someone on the back, or even a simple gesture which carries a positive connotation in the United States may be offensive or vulgar in other parts of the world. In order to limit the risk of these types of occurrences, professionals in all industries would benefit from the type of language and cultural training which will be discussed in this paper.

A particular challenge facing engineers who need to conduct work in a foreign language is that the technical and specific language spoken by engineers is not taught in traditional foreign language courses due to its limited usage in the world in general. Most students of foreign language, for example, will never have a need to discuss aerodynamic drag or convection heat transfer coefficients. However, a component design engineer might frequently discuss such topics as he/she explains a new turbine blade design with a coworker in another country. Unfortunately there are no large scale mechanisms currently in place to give engineers the technical language training needed to perform their normal job functions easily and proficiently in a second language. By beginning now to implement programs which allow engineering students at the undergraduate level to become proficient in a second language, American universities can ensure that the United States will have engineers prepared to compete and communicate both technically and practically in a global market.

Proposal for an Engineering Language Program

Learning any language, including one's own language, is a lifelong pursuit. Accordingly no university program will be capable of preparing a student to enter the industry with all of the vocabulary and grammar necessary to work in any engineering environment. As with anything else, knowledge not gained in school will have to be acquired as an engineer begins working and has opportunities to learn the specific vocabulary associated with his/her assigned

responsibilities. A university program can, however, provide graduates with a sufficient level of foreign language fluency to allow them to be effective in an international setting in industry. Fluency in a given language is not to have a perfect knowledge of the grammar, mechanics, and vocabulary of a language, rather, as the word suggests it is the ability to communicate smoothly. For the purposes of this paper, a person fluent in a language is defined as someone who easily understands the language when hearing it and can respond quickly in a smooth, fluid-like manner. A person who is fluent does not need to translate things in their head before speaking or when listening to others. Fluency is essentially the ability to think in a given language.

In light of these facts, the goals of an engineering language program are to provide students with:

- The opportunity to achieve fluency in a given language.
- An adequate understanding of culture and customs which will allow them to work effectively within a foreign environment.
- A foundation of vocabulary which will allow them to perform necessary work, technical or otherwise, in a foreign language.

With these goals achieved, the task of learning additional vocabulary words to perform a specific job function will be a simple matter of referring to a dictionary as the need arises.

The most challenging part of any language training program is providing opportunities for students to achieve fluency in the language. For example, the average student who takes two years of typical language classes, will only spend 25% of the number of hours required to achieve a level of proficiency engaged in studying the language.³ This difficulty arises mainly due to the lack of opportunities that most students have to ever use the language skills they learn in the classroom in a real world setting. Typically a university student studying a second language part time will attend class several times a week. During class students will have opportunities to ask and answer questions and converse with the professor and other students using the language. Once outside the classroom, however, very few students will practice the mechanics, vocabulary, or conversational abilities they have learned in the classroom largely because they will not have occasion to do so. Without the need or opportunity to express oneself in the foreign language, students rarely develop a greater vocabulary than that presented in class work and assignments. Worst of all, most students never develop the critical abilities of speaking smoothly and understanding others. As previously noted, in addition to these challenges typically associated with learning a language, a traditional language program does not teach the technical vocabulary required in an engineering profession.

To accomplish the aforementioned goals and provide engineering students with the ability to communicate effectively using a foreign language, a special language program must be implemented by engineering departments. This program should tailor itself to the unique needs of engineering professionals. An engineering language program couples traditional language classes with discipline specific language training and give students opportunities to learn and use language skills throughout their education. Naturally not all engineering students will wish to participate in an intensive language program in addition to an already heavy technical course load. However, such an opportunity should be available to students who wish to better prepare themselves for today's global industry.

The balance of this paper will outline a program to allow engineering students the opportunity to learn both engineering and language skills simultaneously. The program presented in this paper is a proposal only and has not yet been implemented at any institution. Based on the authors' experiences in learning foreign languages, this program should meet the aforementioned goals for an engineering language program.

Program Outline

A key to a successful language program would involve American universities partnering with international universities where the languages being studied are natively spoken. Students and faculty from American universities would have the opportunity to work with faculty and students from the partnering institutions. Table 1 suggests how such a program could be coupled with a typical five year engineering program in a cost effective manner.

Table 1: Proposed engineering/language program layout.

Year 1	Year 2	Year 3	Year 4	Year 5
Traditional language and cultural courses.	Traditional language and cultural courses.	Engineering/General ed. courses taught via video conference by a foreign faculty member from a partner institution	Completed at partner institution. Classes and project.	Return to U.S. university. International capstone project.

Years 1 and 2: Basic Language Classes

The first two years of the program students will enroll in traditional language and cultural courses in addition to normal preliminary technical courses such as math, chemistry, and physics. Enrollment in these language classes will allow students to gain the fundamentals of the language such as grammar, mechanics, and conversational vocabulary. Additionally these classes will begin familiarizing students with the culture and history of the people students will be working with. At least one of these classes should specifically address items that should or should not be done (gestures, gifts, customs, etc.) in order to avoid offending persons in the countries in question. Familiarizing students with these customs and other practical information is far more important in preparing engineers to build effective relationships than a detailed understanding of a culture's history and art.

Year 3: Participation in Classes Taught at Foreign Institutions

By the time students are in the third year of the program they will have a decent understanding of the fundamentals of their language. In order to continue progressing students will need opportunities to exercise skills gained in the classroom in real world settings. Therefore during this third year, students will enroll in engineering and general education classes taught by faculty members from a partner institution using video conferencing technology. Although the ideal situation would allow faculty from the partner institution to come to the American university to teach, the logistics and cost of such an effort would severely limit the number of language programs that could be accommodated by a single university. Using video conferencing equipment will make attending classes taught by a foreign professor much more feasible and cost effective because a single teacher in Mexico City or Shanghai for example will be able to

simultaneously teach students from institutions throughout the United States. By employing these modern communication methods universities will be able to support many more students and language programs by limiting the costs associated with any one program.

General education classes, such as biology, history, or the humanities, presented in the second language will be an excellent opportunity for students to begin acquiring the necessary skill of understanding the language when hearing it spoken by a native of the language. Although these classes will be more challenging to American students than GE courses taught in English, the courses will cover material that is likely familiar to the students and will facilitate keeping pace with the other students. In order to allow students to gain the desired language skills and cultural understanding without extending the time required to earn their degrees, language and cultural classes taught by both the American and international universities will be used to replace other courses normally used to fulfill general education requirements. For example a student learning Mandarin would be allowed to use a class in Chinese history to fulfill a requirement normally fulfilled by a world history class. Figure 1 shows a flow chart to graduation for the Mechanical Engineering Department at Brigham Young University and indicates classes that could likely be taken from a foreign institution. The classes highlighted in blue are general education classes that would likely be available at a foreign institution. Boxes highlighted in green are core mechanical engineering classes that should be available from any mechanical engineering program in the world and are typically taken by students in at least their third year. These are the types of classes that could be taken via video conference at a student's home school during this third year.

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8
First-Year English Requirement 3	Letters Elective 3		Biology Requirement 3	Engl 316 Technical Writing 3	Social Science Elective 3	Civilization 1 X201 3	Civilization 2 (Arts) X202 3
American Heritage Requirement 3		Wellness Requirement 2					
2	2	2		2	2	2	2
Math 112 4 Calculus 1*[AM] Math 110, 111	Math 113 4 Calculus 2 Math 112	Math 302 4 Engr Math 1 Math 113	Math 303 4 Engr Math 2 Math 302	MeEn 321 3 Thermo	MeEn 312 3 Fluid Mech	Technical Elective 3	
MeEn 191 0.5 New Student Seminar	Phscs 123# 3 Physics 2 *[NS] Math 113 p or c CEEn 103 p or c	Phscs 220 3 Physics 3 *[NS] Math 113 Phscs 121 or CeEn 103	MeEn 282 3 Mfg Process CEEn 203, MeEn 250	MeEn 363 3 Instrumentation	MeEn 340 3 Heat Transfer	MeEn 475 3 Capstone 1 Fall Semester See note at bottom	MeEn 476 3 Capstone 2 Winter Semester See note at bottom
	MeEn 172 3 Graphics Engr & Tech Majors	MeEn 250 3 Materials Sci Chem 105	ECEn 301 3 Elem Elec En Phscs 220, Math 303 p or c	MeEn 372 3 Mech Sys Des	MeEn 335 3 Dyn Systems	Technical Elective 3	Technical Elective 3
Chem 105 4 Chemistry*[PS] Math 110	CEEn 103 2 Statics Math 113 p or c	CEEn 203 3 Mech of Mat'ls CEEn 103	CEEn 204 3 Dynamics CEEn 103	MeEn 373 3 Computing	Stat 361 3 Statistics	Technical Elective 3	Technical Elective 3

Figure 1: Flow chart for the undergraduate mechanical engineering program at Brigham Young University. Courses marked in blue are general education classes and those in green are core mechanical engineering classes.

Since the engineering classes taught this third year will be the first experience students have with the technical aspect of the language, these classes will ideally be conducted by a foreign faculty member in English. Students will be taught the terms and vocabulary used in the class in both English and the new language thus helping them to begin building their technical vocabulary. These engineering classes should be core classes in the students selected field of study so that the courses taken will be among those offered by any similar program in the world. For example any mechanical engineering program throughout the world will teach stress analysis, fluid mechanics, and thermal science. Therefore students may enroll in these courses in lieu of the classes offered by their own home departments. At the discretion of the professor, students in these engineering courses may be required to complete some assignments or other practices in the second language. These assignments will provide students further opportunities to employ the new technical vocabulary being presented during lectures.

Attending classes in this manner will allow students to begin training themselves to understand the accent of those who speak the language they are learning. Additionally students will begin developing the vocabulary necessary to function in an engineering environment. Teaching assistants for these classes will ideally be chosen from fifth year students at the U.S. institution who have returned from their time studying abroad and will have a proficiency in both the language and the technical areas being covered in the class.

Year 4: Travel to Foreign University

Fourth year students will spend two semesters studying at a partner institution. This institution will ideally be the same which conducted the student's third year video conference classes. During these two semesters, students will take engineering courses which may be either core or elective credits. Additionally students will enroll in general education classes which will allow them to further master the language and come to better understand the native culture. During the second semester, visiting students will be required to complete an engineering project working with students who are not part of the language program. This will allow students to work closely with a team of engineers who don't speak English in order to achieve a common technical goal. This project will familiarize students with some of the challenges associated with multinational design efforts and to exercise the language skills they have developed during the previous three and a half years.

The travel and activities of the fourth year are in many ways the culmination of the language training offered by this program. These two semesters spent immersed in a foreign language will finally allow a student to begin to achieve fluency in that language. When students first arrive they will likely find that when they are spoken to they must consciously think about the words they heard and mentally translate them into English before comprehending what was said. However, as students spend each day listening to those around them, they will find that translation not only becomes easier but will eventually be unnecessary. One day each student will stop and realize that while listening to someone speak the second language they simply understand what is being said without any need to stop and think about the conversation. Students will have a similar experience as they try to express themselves, at first it will be necessary to mentally translate thoughts into the second language before attempting to express

them. As a student practices they will find that the tongue becomes accustomed to speaking the new language and in time will be able to express him or herself without consciously translating or even thinking about the words they wish to say before saying them. When students have achieved this, the ability to think in their second language and to express themselves smoothly without mentally translating before speaking, they will have begun to achieve a basic fluency in their language. With this level of proficiency students will truly be prepared to begin mastering their language. The difficulty will no longer be to understand or be understood; rather students will be challenged to continue mastering the vocabulary and mechanics of the language in order to adequately express themselves in any situation.

Year 5: International Capstone Project

Students will return to their home campus to finish the fifth year of their education. During this final year participants will continue to hone their language and technical skills by participating in several important activities. First, fifth year students will again enroll in classes to be taught via video conference by a partner institution. These classes should be conducted completely in the second language in order to allow students to continue developing their technical language abilities. Second, as previously noted, fifth year students may also be engaged as teaching assistants for third year students taking preliminary courses from an international university. Interacting with younger students in a teaching role will provide valuable opportunities for senior students to better understand the basics of the language they have studied.

As a conclusion to their engineering studies, seniors should be given the opportunity to participate in an international capstone project. This project would ideally allow students to work with classmates who have studied other languages and engineering disciplines. For example, a team of electrical engineering students at an American institution that have studied German and Mandarin Chinese could partner with a group of mechanical engineering students in China and another group of aerospace engineers in Germany. This expanded international team can not only handle a project requiring skills in all three engineering disciplines but can also draw on the knowledge, talents and resources available from all three universities. The combination of the international capstone project and teaching assistantships will give students extensive experience using both their language and engineering skills before moving on to industry employment or graduate education.

Program Initiation and Associated Challenges

Program Requirements

There will be three principal requirements for a university that wishes to implement the proposed program. First, availability of basic foreign language classes where students will learn the vocabulary, grammar, and mechanics of the language they wish to study. These courses should be rigorous to prepare students with adequate vocabulary and conversational skills so that they will be successful during their study at the foreign university. Ideally these courses will be organized and offered by an organization other than the engineering department to minimize program start up costs.

The second requirement will be to establish partnerships with international universities that will work with the American university from year to year. These partners will conduct the video conference classes and will host fourth year students in their international study. Having an established network of foreign universities will make this program more successful by allowing students to take classes from teachers at the same university they will travel to during their fourth year. This will help participants form relationships with the students and faculty they will study with during their fourth year and provide a network of people who can help them to be successful during their study abroad. Additionally, sending fourth year students to the same international schools each year means officials at the American university can ensure that the living conditions and academic preparation available to their students will meet the standards required by their institution.

A final requirement will be that students participating in the program have ready access to video conferencing equipment. The number of video conferencing units required at any one school will depend primarily on the number of language programs offered by the university and the number of students participating in those programs.

Challenges

Although it is not the purpose of this paper to investigate the details of implementing this type of program at a given university, the authors feel it is necessary to identify some of the associated challenges that will arise for any university wishing to implement this type of program. These issues are items that will need to be analyzed and solved on a case by case basis as the requirements, curriculum, and circumstances will vary for each institution. Some of these challenges are:

- Funding the initiation and operation of the program.
- Identifying classes taught at international universities which will be acceptable for substitution in a university's general education core.
- Identifying the number of programs that can be offered at a university and selecting which languages will be offered.
- Identifying requirements for admittance into the language program, advancement from one phase of the program to the next and graduation from the program.
- Determining whether graduates of the program will receive an additional degree, certification, etc. for their participation in the language program.
- Helping graduates identify employment opportunities where they will be able to utilize the language skills they have developed.

Conclusion

Although many engineers do not often interact directly with customers, there will be an increasing number of opportunities in the coming years to work with engineers and other professionals from foreign companies. By participating in a joint language/engineering program such as the one proposed, engineering students can prepare themselves to be at the forefront of establishing effective, international relationships with companies, universities and individuals in all parts of the world. These relationships will increase opportunities to share and expand

technology, advertise products and services to potential customers, and to break down walls and prejudices between countries and peoples throughout the world. By beginning now to offer undergraduate engineering students the opportunity to become proficient at operating in both technical and non-technical situations in a foreign language, America will be able to remain competitive in the global market and be capable of taking advantage of business opportunities wherever they may arise.

Bibliography

1. Hodges, Luther H., Jr., "On Commerce and Language Study," Association of Departments of Foreign Languages Bulletin, Vol. 11, No. 4, May 1980, pp 36-37
2. Friedman, Thomas L., "The World is Flat: A Brief History of the Twenty-First Century," Farrar, Straus and Giroux, New York, 2006, p 28
3. Malone, Margaret E., Benjamin Rifkin, Donna Christian, Dora E. Johnson, "Attaining High Levels of Proficiency: Challenges for Foreign Language Education in the United States," CAL Digest, Center For Applied Linguistics, 2005
4. Hartman, J. Paul, "Modern Foreign Languages: A Needed Requirement in Undergraduate Engineering Education," 1982 Frontiers in Education Conference Proceedings, 18-20 October 1982
5. Friedman, Thomas L., "The World is Flat: A Brief History of the Twenty-First Century," Farrar, Straus and Giroux, New York, 2006, p 36
6. Sigsbee, David L., "Why Americans Don't Study Foreign languages and What We Can Do About That," New directions for Higher Education, Vol. 2002, Issue 117 pp 45-52, 2002