Teaching Engineering Biomechanics in Vietnam

Benjamin S. Kelley, B. Rhett Rigby
School of Engineering and Computer Science
Baylor University

Hai Duy Vu
Department of Electronics Technology and Biomedical Engineering
Hanoi University of Technology

Abstract

The Vietnamese Ministry of Education and Technology (MOET) is investing in twelve technological disciplines to elevate them to international standards. The US government, through the Vietnam Education Foundation (VEF), also supports technology capacity building within Vietnamese universities through fellowships for graduate students and faculty to study and earn degrees from U.S. institutions. In 2008, VEF initiated the U.S. Faculty Scholars Program, and selected four participants to teach technology-related courses for Vietnamese universities. The proposed focus of one of these programs is biomedical engineering (BME) at the Hanoi University of Technology (HUT). The BME program at HUT historically produces graduates to administer and maintain biomedical instrumentation within Vietnamese hospitals. Because the expertise of the HUT BME faculty lies in the areas of electrical engineering, their most immediate need for course assistance is in non-electronics areas, for example, engineering biomechanics. Furthermore, studies sponsored in part by VEF have identified pedagogical practices within the Vietnamese higher education system that constrain the degree of higher-level learning for engineering and related students. The program described in this paper involves teaching in English a biomechanics course for HUT, through both on-site classroom instruction as well as and through distance learning. The technical topics of the course are centered on the design of an orthopedic implant, including specifications, a design report, and team presentations. A custom textbook for the course includes technical content targeted toward the design project, student assignments, and key PowerPoint slides. With obvious language challenges and cultural differences, the associated faculty and students establish a strong rapport including exposure to new learning approaches and engineering practices. Future efforts may include further expansion of the HUT BME curriculum and teaming with the HUT faculty to offer more of the curriculum using modern approaches to engineering design and education.

Introduction

The names of some cities, countries, and other geographic monikers may conjure up a definite impression. Sometimes these impressions are less than positive and associated with an unfortunate or controversial event of historical significance. Among the most famous of these with a Texas tie is “Remember the Alamo,” which Sam Houston shouted at the battle of San Jacinto nearly 175 years ago, and referring to the razing of the Alamo mission by Santa Anna’s troops. Even closer to home was the U.S. Bureau of Alcohol, Tobacco, and Firearms siege of

the Branch Davidians at Mount Caramel near Waco in 1993. Although local citizens had little advance influence or knowledge of the components of the compound, the term Waco is often associated as an adjective or noun and indelibly associated with those fateful events.

From the mid 1960s to the mid 1970s, America was engaged in military actions in Vietnam. This Southeast Asian country has a land mass around half of that of Texas, yet a current-day population more than three times as great.[1, 2] Americans were deeply divided over both the justification and means of fighting the Vietnam War, which had far-reaching political and cultural consequences. Even twenty-five years after the conclusion of the United States' military involvement, terms such as Vietnam-era-veterans, and recently as a presidential candidate was a prisoner-of-war in Vietnam, the Hanoi Hilton, invoke negative scenarios about the Southeast Asia country. Yet in spite of the oft negative connotations, Vietnam is the recipient of growing U.S. trade and investment.

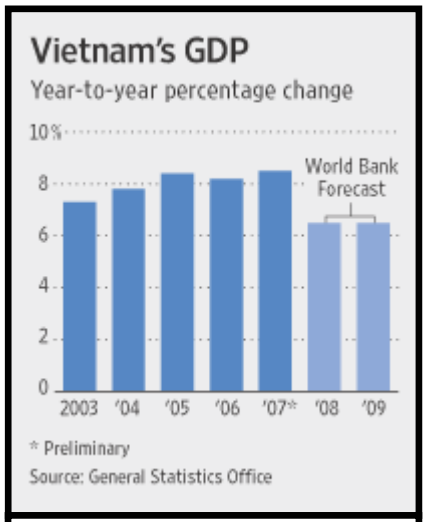

Figure 1: Past trend and forecast growth of Vietnam's GDP. [4]

The Vietnam trade embargo affected at the end of the war was lifted in 1994. Normalization of diplomatic ties with Vietnam resumed in 1995. The economy of Vietnam has accelerated since then, and in contrast of the sometimes negative American perception, has easily outpaced the world's average. In 2007 Vietnam's gross domestic product (GDP) increased by 8.5%. Yet as the world's economy slowed in 2008, so did Vietnam's economy, as the GDP increased by only 6.2%. Furthermore, the national currency, the Vietnamese dong (VND), was devalued by 3% in December 2008[3] and a $6 billion stimulus packaged aims to keep growth above 6% in 2009, as forecasted in Figure 1.[4]

Higher Education in Vietnam

The economies of industrialized nations are largely characterized as knowledge-based economies. Yet some claim that Vietnam's higher education system is stuck in a time warp and years out of date.[5] For example, Vietnam does not have a single university considered to be of international quality, and its universities lag behind those of most other developing countries.[6] Noting that improving higher education is the key to economic-development efforts, the Vietnamese Ministry of Education and Training (MOET) has outlined an ambitious plan to overhaul Vietnam's outdated educational system. MOET seeks to improve Vietnam's education system to make it more competitive on an international basis. The goals of this strategic plan are "To bring our country out of an under-developed situation, to increase significantly the level of material, cultural and spiritual life of people, to lay down the foundation for our country to become basically an industrialized, modernized nation by 2020."[7]

To help achieve these goals, in 2005 MOET initiated a national plan that commits support for a comprehensive renovation of Vietnamese higher education. Included among these plans is the identification and selection of twelve advanced areas of technical study. With the exception of the Hanoi University of Technology (HUT), leading Vietnamese universities were awarded the responsibility for one advanced area. HUT was designated for both mechatronics and materials

science and engineering. The intent of these awards is to initiate the preparatory steps for building an academic environment of high quality that will lead to programs in line with "international standards." In 2007, an eleventh dedicated technical area, biomedical engineering, was identified and also assigned to HUT.[8] In 2008 HUT's forth program in Electric & Electronics Engineering was added.[9]

The U.S. federal government is also active in supporting technical higher education in Vietnam. In 2000 congress established the Vietnam Education Foundation (VEF) as an independent federal agency. The mission of VEF is to strengthen the U.S.-Vietnam bilateral relationship through educational exchanges in science and technology. Since 2003 VEF has sponsored 267 VEF Fellows to complete graduate engineering and science degrees at 68 American universities. In 2007 VEF initiated the Visiting Scholars Program for Vietnamese nationals who already hold a doctorate. In 2008 VEF launched the U.S. Faculty Scholars Program to enable faculty members at U.S. universities to teach a course in Vietnam, either completely onsite or through a combination of onsite and interactive video conferencing. It is this grant program, for which the lead author is the principal investigator, which is supporting the work reported in this paper. The three primary goals of the U.S. Faculty Scholar Program are:[10]

1. To help build capacity in Vietnam in science, mathematics, medicine, engineering and technology through teaching and related research activities.
2. To help Vietnamese institutions address specific educational needs, including curriculum developments, integration of research opportunities, identification of student learning outcomes, and evaluation.
3. To build positive relationships between U.S. and Vietnamese higher education institutions and faculty members that may lead to sustainable partnerships.

The first cohort of U.S. Faculty Scholars consists of four U.S. professors selected from a field of 120 applicants, each specializing in one of the following fields.

- Biomedical Engineering- Baylor
- Medicine- Boston University
- Research and Statistics- Cal State Fullerton
- Watershed Science- Colorado State

Engineering Pedagogy in Vietnam

To better understand the current practices in engineering education in Vietnam, VEF, MOET, and the U.S. National Academies partnered to conduct a multiple case study quantitative research project. These efforts centered on four Vietnamese universities and were conducted by leading American experts in assessment and instructional design in the selected fields of computer science, electrical engineering, and physics. Follow-on studies also concentrated on undergraduate agricultural education.[11, 12] The results of the site visits identified five critical areas of Vietnam higher education in need of change.[13] They are:

1. Undergraduate teaching and learning: ineffective teaching methods and inadequate facilities and resources.
2. Undergraduate curriculum and courses: too many courses and requirements; out-of-date content; an imbalance between theoretical concepts and applied experiences; lack of professional skills; and absence of expected student learning outcomes.
3. Instructors: lack of qualified teachers, low level of academic preparation; lack of modern teaching practices; overworked and underpaid faculty.[14]
4. Graduate education and research: little opportunity to pursue research and apply modern

teaching methods; academic inbreeding, separation of teaching departments from research activities.

5. Assessment of student learning and institutional effectiveness: lack of articulated outcomes; institutional effectiveness and course quality not evaluated in terms of student learning; lack of institutional research infrastructure.

Biomedical Engineering in Vietnam

Healthcare generally in Vietnam remains in the fundamental stages of development, though there has been significant progress in modernizing and upgrading medical equipment facilities. Hospital bed utilization is low compared with other Asia nations. From 1997-2000 the Vietnamese government spent $30 million on importing new medical equipment. As part of the development of 57 new hospitals, that figure is expected to rise to over $1 billion during the 2005-2010 period. Outside sources account for around 80% of the total expenditures for Vietnam's purchases of medical equipment. The rapid growth in medical equipment expenditures has created business opportunities for foreign importers and the need for a larger and more highly qualified domestic biomedical engineering workforce. Included among the international medical equipment manufacturers with prominent distribution activities in Vietnam are GE, Phillips, Abbott, and Siemens.[15, 16]

Other growth areas of BME in Vietnam include biomaterials, rehabilitation engineering, biotechnology, and bioinformatics. Most of the BME activity is concentrated in universities and research institutes in the north in Hanoi, in the south in Ho Chi Minh City, and to a lesser extent in the Mekong Delta region and in Can Tho. Graduate BME education in Vietnam is virtually nonexistent. Most undergraduate BME curricula emphasize biomedical instrumentation because there are few domestic medical-device manufacturers, and so graduates must understand how to sell, use, and maintain biomedical instrumentation, principally for hospitals.[17, 18, 19, 20, 21, 22]

The interest and emphasis of the Vietnamese government in matters relating to BME can be seen in the expansion and improvement of the health care system,[16] the identification of an advanced BME program at HUT,[8] and in joint sponsorship of international BME conferences. The First International Conference on the Development of Biomedical Engineering in Vietnam was held at Ho Chi Minh University of Technology in August 2005, and drew more than 200 participants. Included among the more than 60 presentations were topics relating to scientific research, educational models, entrepreneurship, and models for Vietnam.[23] The Second International Conference on the Development of Biomedical Engineering in Vietnam was held at the Vietnam National University in Hanoi during July 2007.[24]

Biomedical Engineering at the Hanoi University of Technology

As an institution, HUT is one of two leading national polytechnic universities (Bách Khoa) in Vietnam. It was established in 1956. HUT's more than 40,000 students enroll in academic programs of study ranging from undergraduates to advanced graduate. Cumulatively, HUT has graduated 110,000 bachelor's-level engineers, 5,000 masters-level engineers, and 500 Ph.D. engineers. The more than 1,600 teaching staff serves 15 colleges and schools, 7 institutes, and 20 research centers.[25]

The modernization of the HUT BME program and curriculum, known as Advanced BME, includes several objectives. The first among these is to deliver the curriculum in English. This includes textbooks, teaching materials, laboratory facilities, and coursework experiments. The second objective is to develop the curriculum and pedagogical practices consistent with those of quality American programs. To meet this need, HUT developed a list of candidate partner universities, with the limiting criteria that the university must be ranked in the top 100 and the BME program must be ranked in the top 20.[8] Also envisioned in this approach is that HUT faculty will spend time at the U.S. partner university. Assistance in connecting with candidate American university partners developed from the teaching collaborations reported here. The Advanced BME program accepted its inaugural freshman class during fall 2008.

Like the previous traditional BME curriculum, the Advanced BME curriculum will emphasize biomedical electronics, owing to the demand for graduates to be employed in positions that select, sell, recommend, and service hospital instrumentation. And also like the traditional curriculum, the Advanced BME program requires 5 years to complete. Students who are admitted to the Advanced BME program will typically be ranked in the top half of all HUT applicants and be English proficient.

As the Advanced BME curriculum is modeled after those in the U.S., it will contain BME courses outside of the bioinstrumentation area. The previous traditional BME curriculum only allowed for BME courses relating to bioinstrumentation, for example, medical image processing, biomedical signals processing, bioelectricity, and biomedical electronics equipment. Although the traditional curriculum included customary non-electrical topics, i.e., mechanics and thermodynamics, those courses did not emphasize biomedical applications. Therefore, among the current HUT BME faculty, there is little expertise in some new courses required in the Advanced BME curriculum like orthopedic biomechanics and biomedical materials.

HUT Engineering Biomechanics Course

With the release of the VEF Request for Proposals for the U.S. Faculty Scholars Program, the first and third authors initiated a dialog concerning the possibility of working together to teach a BME course in English for HUT. Prior to this time there had been no communications between these two individuals or between HUT and Baylor. The lead author has a close family tie to Vietnam but had never before traveled there. It was fortunate that the Advanced BME curriculum was in its infancy and thus had no internal HUT expertise in that area, as that is the academic specialty of the lead author. The second author is a second year Baylor graduate student and is assisting in the preparation of course materials.[26]

The VEF U.S. Faculty Scholars Program funding permits courses to be offered either on site, or a combination of onsite and real-time video conferencing. The format for this course will be that the first two weeks in February 2009 will be offered onsite, followed by 11 weeks of distance-offered video conferencing, and then concluding with the final two weeks onsite. Historically Vietnam observes the lunar calendar, as opposed to the solar calendar as in the U.S. Therefore, the semester break occurs in late January when the Lunar New Year, Tet, is celebrated. Thus the semester begins around a month later than is common in the U.S.

In preparation for confirming course details and construct, and to become better acquainted with cultural, physical, and language differences, the lead author visited HUT for a week early during the semester before the course was to be offered. During this time finer course particulars were determined as well as completing a guest lecturing assignment. As shown in Figure 2, classroom facilities often include a projection system for PowerPoint presentations. However, they often do not include climate control, besides curtains hanging over open-air breezeways lining opposite sides of the classroom. This situation makes for warm and perspiring experiences during the hot and muggy summers and chilly ones during the cooler and breezy winters.

Figure 2: Professor Kelley presenting guest lecture to HUT BME students.

The course topics for the biomechanics course are customized and paced for the needs of the HUT students. This includes a text-book style course packet prepared for each student that includes PowerPoint slides, topical readings, and homework assignments.[27]

The structure and presentation of the course is designed to address many of the pedagogical shortcomings identified in the National Academies/VEF report.[13] The course topics and organization are built around the assignment of a project to design an orthopedic appliance. The students will use engineering analysis techniques to design a bone place to stabilize a femoral fracture, whereby the neutral axis of the construct is at the plate-bone interface. The deliverables for this project include a team design report and a design presentation near the end of the course.

While onsite, the course will be taught for two hours per day, three days each week. From a classroom-time perspective, this is roughly twice the pace of a normal three-credit course. However, because of language and pedagogical challenges, it is anticipated that this pace will actually be considerably slower than a typical course.

During the 11 weeks the course is offered using video conferencing, it will meet once each week for two hours. It was a challenge to identify and agree upon the time of day the distance learning portion of the course will be offered. During the portion of the year when standard time is in effect, the local time in Hanoi is 13 hours ahead of Central Standard Time. When Day Light Savings Time goes into effect, Hanoi will be 12 hours ahead. During the first part of the distance-education segment, the HUT students will begin class at 7:00 a.m., which will be 6:00 p.m. the evening before in Texas. During the later part of the semester, the HUT students will continue to have class at 7:00 a.m., when it will be 7:00 p.m. in Texas. While onsite, the course will be offered at 8:00 a.m. It has been surprising at the flexibility HUT has in setting the schedule for this course.

The grading scale for the course is different than the customary A, B, C, or the 100%-basis grading in the U.S. Generally in the U.S. a grade below 60% is considered failure. In Vietnam

the equivalent failure score is 40%. But still, the distribution of grades, such as the expectation of the percentage of students finishing near the top of the class, is roughly equivalent to that in the U.S. Although grading has not yet commenced, it is expected that degree of harsh penalties (number of points deducted for errors) will be increased, in effect lowing percentage scores, so that the failure cutoff between Vietnamese and U.S. expectations will be roughly equivalent.

The first offering of the HUT biomechanics course will be delivered as an elective to students enrolled in the traditional BME curriculum. The first cohort of Advanced BME students are currently freshman and not yet prepared to take courses offered at the upper level. This feature is actually a positive as it permits fine tuning of the biomechanics course and expectations before it is offered as a required course to the Advanced BME students. This will also allow the HUT BME faculty exposure to the course content as well as American teaching styles. It is envisioned that the next few offerings of the course will be conducted in a concentrated and intense mode over a period of three-four weeks during the summer. This collapsed timeframe will permit sustained involvement of the principal investigator, with MOET support, until HUT can acquire mechanics expertise within its BME faculty.

The topical course outline is shown in Table 1. The customized course materials are also presented in this arrangement. Each "chapter," or "session," has a title page, bibliographic references, PowerPoint slides, and topical readings. The course materials were taken exclusively from open source and readily available materials so there would be no concerns with copyright or intellectual property issues. Each slide and reading contains a reference to its source.[27]

Both the onsite and online portions of the course involve two academic hours of instruction each day. During the initial sessions of the course, each of the instructional sessions covers different topics. This approach was selected so that the design project and expectations are introduced over several class sessions, while also covering technical topics later during the class session. As was reported in the VEF/National Academies report,[13] Vietnamese engineering education traditionally includes more theoretical content than practical applications, and so the HUT students have little experience with the engineering design process. Likewise, reviews of fundamental applications of statics, kinematics, and mechanics permit the students and instructor to develop a common set of nomenclature and terms used in engineering analysis. During the online portion of the course, the entire class session is generally devoted to a single biomechanics topic.

The Elluminate® real-time online learning system/software was chosen as the platform for delivering the distance-learning portion of the course. Baylor is a user of this system that allows for video and audio feeds, PowerPoint slide presentation, and even digital/tablet writings that simulate a chalk board. During the online portion of the course the HUT students will use a computer laboratory where each student has access to an individual computer and headphones. The last class session offered onsite will actually be taught using Elluminate® so that the students become familiar with the system. The Baylor graduate assistant will be at HUT during the first online session offered from Baylor to identify and solve problems that may arise.

Table 1: HUT Engineering Biomechanics Course- Spring 2009			
Session	**2009 Date**	**Topic**	**Environment**
1	Tues	Course Expectations - Homework, Syllabus, Grading, Objectives	On-site
2	2/10	Introduction- History	On-site
3	Wed	Introduction to Design - The Process	On-site
4	2/11	Kinetics - Forces (Linear Velocities, Accelerations)	On-site
5	Fri	Introduction to Design - The Report	On-site
6	2/13	Kinematics	On-site
7	Mon	Introduction to Design - The Presentation	On-site
8	2/16	Statics – Basics	On-site
9	Wed	Human Anatomy - Musculoskeletal System	On-site
10	2/18	Statics – Bioapplications	On-site
11	Fri	Human Anatomy - Simple and Articulating Joints	On-site
12	2/20	Mechanics and materials – Stress and Strain	On-site
13	Mon	Getting acquainted with Elluminate	On-site
14	2/23	Mechanics and Materials – Material Properties	On-site
15	Wed	Introduction to Stress/Bending	Online
16	2/25	Advanced Stress/Bending - Neutral Axis, Parallel Axis Theorem	Online
17	Wed	Structure of Bones	Online
18	3/4	Mechanical Properties of Bone	Online
19	Wed	Fracture Mechanics and Breaks	Online
20	3/11	Fracture Mechanics and Healing	Online
21	Wed	Ligaments/Tendons- Structure and Properties	Online
22	3/18	Tendons/Ligaments- Mechanical and Viscoelastic Properties	Online
23	Wed	Articular Cartilage- Structure and Function	Online
24	3/25	Articular Cartilage- Mechanical Properties	Online
25	Wed	Introduction to Joints- Structure and Function	Online
26	4/1	Introduction to Joints- Types and Movement	Online
27	Wed	Implants- Devices and Materials	Online
28	4/8	Implants- Bone Plate Analysis and Design	Online
29	Wed	Knee Biomechanics- Structure and Function	Online
30	4/15	Knee Biomechanics- Movement and Forces	Online
31	Wed	Midterm exam	Online
32	4/22	Midterm exam	Online
33	Wed	Hip- Structural Components	Online
34	4/29	Hip- Biomechanical Properties	Online
35	Wed	Spine- Structural Components	Online
36	5/6	Spine- Biomechanical Properties	Online
37	Mon	Review Midterm Exam	On-site
38	5/11	Introduction to Muscle- Anatomy	On-site
39	Wed	Introduction to Muscle- Micro- and Macro-Structure	On-site
40	5/13	Introduction to Muscle- Mechanics	On-site
41	Fri	Built in Flexible Time	On-site
42	5/15	Built in Flexible Time	On-site
43	Mon	Design Presentations	On-site
44	5/18	Design Presentations	On-site
45	Wed	Design Presentations	On-site
46	5/20	Design Presentations	On-site
47	Fri	Final Exam	On-site
48	5/22	Final Exam	On-site

Summary and Future Work

As Vietnam's economy and relationship with the United States continues to grow and improve, there is an increasing need and expectation for enhancements in the Vietnamese health care and higher education systems. The Vietnam Ministry of Education and Training has identified and supported twelve technical specialties at leading universities to raise them to international standards. With support from the Vietnam Education Foundation, a course in engineering biomechanics was developed for students in the Advanced BME program at the Hanoi University of Technology. The course will be offered through a combination of onsite and interactive video conferencing instruction. Student materials prepared for the course center around the design of an orthopedic appliance and student assignments include a design report and presentation. Future course offerings will be refined to best match the needs of the student and university.

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BENJAMIN S. KELLEY
Dr. Kelley serves a professor and dean of the School of Engineering and Computer Science at Baylor University in Waco, Texas. His area of academic expertise is orthopedic biomechanics and cardiovascular dynamics. As well as his work in Vietnam, Dr. Kelley has also completed projects in Iraq, Kazakhstan, China, Kenya, Scandinavia and South America. In addition to his interest in international engineering education, Dr. Kelley focuses his efforts on student success, student life, and retention.

B. RHETT RIGBY
Mr. Rigby is a second year graduate student at Baylor University, studying mechanical engineering with a concentration in biomedical engineering. His master's thesis centers around the design of a therapeutic hippotherapy mechanical horse that simulates real-time motions, as well as investigating and comparing trunk kinematics of healthy subjects when walking and riding a horse.

HAI DUY VU
Mr. Vu is an associate professor of Biomedical Engineering at the Hanoi University of Technology. He serves as Vice Chair of the BME Department that is housed in the Faculty of Electronic Technology and Biomedical Engineering. He is the author of the biomedical digital signals processing text book used at HUT. Mr. Vu has been involved in research projects ranging from galvanic drug delivery systems to cardiovascular monitors. He served as the secretariat for the Second International Conference on the Development of Biomedical Engineering in Vietnam.