11. THE TRANSFORMATION OF ENGINEERING EDUCATION TO PRODUCE GLOBAL ENGINEERS: CASE STUDIES IN AFGHANISTAN, INDIA, KAZAKHSTAN AND NICARAGUA

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Abstract

This paper describes four case studies aimed at developing Global Engineers and Global Engineering Educators through faculty development, instructional development and service learning initiatives. Each case study is presented in the context of relevant background on the educational system, the current state of engineering and technology education in the country, and the pressing challenges and available resources. The four case studies involve faculty and instructional development initiatives in Afghanistan, India, and Kazakhstan, as well as, a global service learning project in Nicaragua. The success of each program was strongly dependent on face-to-face interaction and a community-driven approach.

Introduction

The International Federation of Engineering Education Societies in collaboration with the American Society of Engineering Education recently issued a list of essential attributes for the successful "global engineer". The attributes were determined from extensive feedback from educators, employers, students, and professional engineers throughout the global engineering community.[1] These attributes fall into the general categories of engineering science fundamentals; engineering; context of practice; communication; teamwork; leadership; flexibility; lifelong learning; commitment to quality, timeliness, and continuous improvement; and ethical standards and professionalism. Due to the importance of the Global Engineer in today's global economy, several universities have initiated Global Engineer Certification programs, curricula designed to prepare students with the essential attributes of the Global Engineer. Producing successful global engineer graduates generates new pedagogic challenges for engineering programs: teaching methods, curriculum structure and assessment must be modernized to address the need to produce Global Engineers, and Global Engineering Educators must have the training to create the next generation of Global Engineers. Industry

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and professional societies are calling for change, and some universities are responding with innovative curriculum changes, implementation of effective teaching strategies, and a reward system that supports these changes. For Example, IGIP (International Society of Engineering Education) has created an International Engineering Educator Registration Program, which provides certification of a high educational level for the educator.[2]

This paper describes four case studies aimed at developing Global Engineers and Global Engineering Educators, through faculty development, instructional development and service learning initiatives. Each case study is presented in the context of relevant background on the educational system, the current state of engineering and technology education in the country, the pressing challenges and available resources, the employment outlook for graduates, etc.

a. A comprehensive collaboration between the United States Military Academy (USMA), the United Stated Air Force Academy, and the National Military Academy of Afghanistan (NMAA), with the aim of developing the engineering curriculum and mentoring engineering faculty in their development as effective engineering educators.

b. Indo-US Collaboration for Engineering Education IUCEE is aiming to build a solid base for engineering education and research by strengthening the four pillars of education: learner-centric teaching; research excellence; outcomes based quality supported by accreditation; and innovation and entrepreneurship. This case study focuses on a workshop on effective teaching conducted at JNTU Kakinada (India), and provides insight into the change in knowledge and attitudes before and after the workshop.

c. The expansion of the highly successful IUCEE into Kazakhstan and Central Asia to form "K-IUCEE, which was officially launched in March, 2012. This case study describes the five-year plan for the K-IUCEE program and some of the initial faculty development and student training initiatives.

d. A global service-learning project through Engineers without Borders in which engineering students evaluated a water distribution system and redesigned a flooding control system for a village outside Grenada, Nicaragua. Students applied their technical engineering skills to solve open-ended, real-world problems. During the process they worked with local water board members, village and city leaders, lead engineers and local residents. This project provided important development opportunities and realistic professional challenges that allow students to acquire attributes which are essential for the Global Engineer.

1.0 Afghanistan - 2009

In 2009, a group of faculty members from the United States Military Academy (USMA) and the United States Air Force Academy traveled to Afghanistan for the sole purpose of helping to build that nation's fledgling university system. Their focus of effort was at the National Military Academy of Afghanistan (NMAA) located in the capital city of Kabul. They joined the core cadre of administrative advisors as rotating members of the academic development team for the months of June and July. Their mission was to assist the NMAA administration and faculty in the continuing development of the engineering curriculum and to mentor the engineering faculty in their development as effective engineering educators. To understand the challenges this group faced and the opportunities that drew them to these challenges, some background on the situation is necessary.

1.1 Formal Education in Afghanistan

The latest estimates place the population of Afghanistan at nearly 30 million, ranking it as the 40th most populous nation on earth. The life

expectancy of 45 years for both males and females, places it at 221st on the list; only Angola has a lower estimated life expectancy. The population is largely illiterate. Of those over the age of 15, only 28.1% can read and write; 43.1% of the male population and 12.6% of the female population. In Afghanistan, a young boy can expect eleven years of education and a young girl only five. This is based on the child's School Life Expectancy (SLE); the total number of years of schooling (primary to tertiary) that a child can expect to receive[3].

The history of formal education in Afghanistan is closely tied to the state's turbulent political history. Post secondary education degraded significantly beginning in 1978 with the establishment of the pro-Communist government. This decline occurred in spite of the new government's strong focus on education, which accounted for about 10% of Afghanistan's national budget during the 1980s[4]. This apparent contradiction was caused largely by a disconnect between nationally-imposed values and popular values: the focus on communist ideology and Russian as the primary language was rejected by people outside main population centers, so many Afghans opted out of formal education.

The establishment of the Islamic Republic of Afghanistan in 1992, prompted a renewed focus on education. The new government worked to replace Communist schools and establish basic education. Because of the complexity of this task, the government initially neglected higher education[4]. Progress was slowed by the rise to power of the Taliban in 1995. Taliban leaders closed girls' schools in areas they controlled[4]. In these areas and elsewhere, basic and higher education continued to decline as the country was torn by insurgency and ethnic fighting[5].

In many fields and at many universities, higher education curriculum was frozen in the 1970s and the curricula, textbooks, and laboratory techniques are now decades old. Technical and vocational education is largely theoretical, and many engineering and technology students progress all the way through an undergraduate program without a laboratory or design experience1 .

The cultural issues that hinder the re-establishment of an effective educational system in Afghanistan are many. The country is a mix of ethnic groups that live in a primarily tribal society outside of the primary cities. The breakdown is: Pashtun 42%, Tajik 27%, Hazara 9%, Uzbek 9%, Aimak 4%, Turkmen 3%, Baloch 2%, other 4% (Figure 1). Afghanistan is an Islamic Republic consisting of the following split: Sunni Muslim 80%, Shia Muslim 19%, other 1%. While Dari (50%) and Pashto (35%) are the official languages, 11% of the country speaks a Turkic language (primarily Uzbek and Turkmen), and 4% speak one or more of 30 minor languages (primarily Balochi and Pashai)[3].

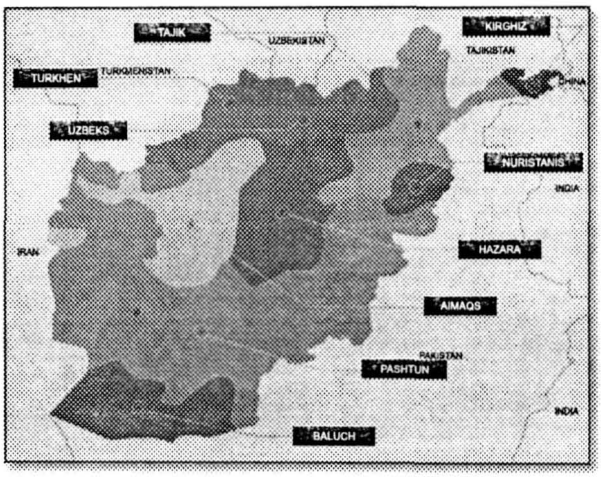

Figure 1: Ethnic Map of Afghanistan

1.2 Overview of NMAA

In the current post-war period, the NMAA has become the self-described 'Crown Jewel of Afghanistan' by the country's leadership. The mission of the NMAA is to produce officers for the Afghan National Army who also have a four-year bachelor's degree. Following a period of

assessment and evaluation, the Afghan government chose USMA at West Point as the model for its own academy. The academy brought in its first batch of 120 in 2005 and graduated 84 male officers in January of 2009. The second batch of 212 men graduated in March of 2010. This was the senior batch during our visit in the summer of 2009. The third batch of 299 men graduated in March of 2011. Current plans set future batch sizes at approximately 600 cadets of which 10% to 20% will be women. The first ten women were attending the academy as part of the medical program during the summer of our visit .

As of 2009, the academy had 318 faculty and staff members; all Afghans. The faculty members all held a bachelor's degree, with a few holding post-graduate degrees. The academy is currently located at the former Soviet Union aviation school campus, adjacent to the international airport in the capital city of Kabul. Plans and construction are underway that will move the academy to its permanent location in Qargha on the western outskirts of Kabul in 2012-2013.

1.3 Appropriate Learning Theory

In mentoring the faculty at NMAA, the team used Bloom's Taxonomy for the cognitive domain1 . Depicted graphically in Fig. 2 Bloom's Taxonomy was particularly useful in mentoring the faculty through the process of scoping lesson objectives and lesson activities at the level appropriate for the course material, the stage of student development, and the overall objectives of the course.

The team also relied on Lowman's Model of College Teaching1 as a tool to council and mentor faculty members in their own development as engineering educators. The faculty members clearly understood the need to be at a high level in the Intellectual Excitement dimension. This was a particular concern for the junior faculty members. The team worked with the faculty in also stressingInterpersonal Rapport dimension of Lowman's model. Our goal, of course, was to help them move towards becoming the 'Complete Exemplar' described by Lowman.

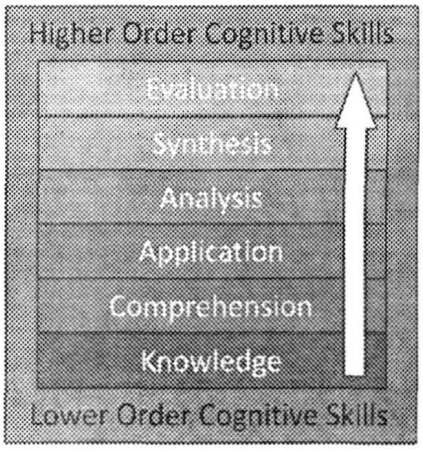

Figure 2: Bloom's Taxonomy Graphic

Our mission was broad and deliberately unstructured so that we could find the ways we could best help once we were in country and familiar with the people involved. The most important the ways we could best help once we were in country and familiar with the people involved. The most important motivation for sending people, rather than offering asistance via phone or internet, was the potential for mentoring made possible by face-to-face contact.

1.4 Civil Engineering Program Mentorship

The civil engineering program lacked a full hydrology course. An earlier faculty mentor had written a few lessons on open channel flow, but the larger course plan and most of the course lessons were still undeveloped. As an added challenge, the course was in session when we arrived: the instructors were teaching the established lessons without a larger strategic plan for the course and with only a short lead time before the prepared lessons were completed and new lesson plans were needed.

The first step in completing the hydrology course was to create an overall course plan. The scope of the course was patterned after a

similar class at the United States Military Academy, which covers both open channel flow and hydrology in a single junior-level class. Although the scopes of these classes were similar, the Afghan course also needed a unit on closed-conduit flow (which is covered in a different course at USMA). The semester at NMAA was 70 lessons long – nearly half again as long as the semester at USMA – but local custom dictated a slower pace of instruction. In many cases, the starting point of the lesson plan was the corresponding USMA plan, but the concepts were expanded over more lessons, and logical break points were established at different points.

Dr. Bristow delivered about six lesson plans to the instructional team without extensive collaboration, in order to increase the lead time between the lesson currently being taught and the lesson currently being developed. Once the time between development and presentation was increased, she encouraged the instructional team to take a key role in development of the lesson plans. Dr. Bristow asked for their help in writing lesson objectives, in designing presentations, and in structuring concepts. The instructors were reluctant at first, stating that their inexperience disqualified them from participating in course planning and citing a wish to defer to the mentoring team's greater experience, but with some encouragement and coaching they produced lesson plans which were far more complete and realistic than we could have given them without consultation. Once they had created a few lesson plans, their confidence and willingness to participate in planning increased considerably.

1.5 New Aeronautics Course

About six months prior to our trip, the NMAA Superintendent and Dean requested assistance in developing a 48-lesson course in aeronautics for senior cadets designated to be commissioned into the Afghan Air Corps. Unlike our country, all of the Afghan military aviation assets (fixed wing and rotary wing) are assigned to one organization. The young men who will become the pilots for these aircraft come from each of the academic majors at the academy. The leadership was adamant that the course would contain fundamental aeronautical engineering content and not be a flight training course. They wanted the students to understand the physical principles and design characteristics of the aircraft that they will someday fly.

The desire for an engineering course that contained both fixed wing and rotary wing content and that would be accessible to the non-engineering majors required a unique course design with a custom textbook. Preparations for developing the syllabus and writing the text (gathering references and resources) were completed prior to departure from the U.S. Actual work on the text could not be started until the team arrived at the NMAA and made an initial assessment of the knowledge and skills possessed by the prospective students and obtained detailed input from one of the primary constituents of the course, the Afghan Air Corps.

From the first week in country, it was obvious to both the mentor team and the NMAA administration that the involvement of this constituent would be cecessary for the course to fulfill its mandate. Dr. Crawfort and representatives of the NMAA faculty met each Saturday with various leaders of the Afghan Ari Corps; typically over several cups of chai (green tea). One of these meetings was with the commander of the Air Corps, Lieutenant General Dawran, a former Soviet-trained cosmonaut. With his full support, the NMAA team was able to obtain various aircraft parts, including an unserviceable gas turbine engine, to use as physical models in the class. Access to the Air Corps' various aircraft and technical information aided in the formulation of realistic aircraft performance models and example problems for use in the course.

The development of the aeronautics course consumed nearly all of two months in planning,

writing the textbook, translation, development of course problems, preparation of PowerPoint materials, acquisition of physical models for the course, and preparation of a new classroom (Figure 3).The text had to be presented in English and Dari and the Afghan instructor had to be prepared and ready to begin instruction in the fall. As the team left NMAA at the end of July, the course was ready for its initial offering.

2.0 India

2.1 Introduction

Engineering Education in India is undergoing rapid expansion in the past few decades. The growth is more pronounced in southern India in general and in the State of Andhra Pradesh. Jawaharlal Nehru Technological University Kakinada is a university with more than 200 engineering colleges affiliated to it spread over eight coastal districts of Andhra Pradesh. The University is responsible for curriculum design, monitoring of evaluation system and academic standards in these colleges. The University is also responsible for monitoring faculty development and has taken several initiatives with multipronged approach. One of the initiatives is coordinated through Indo US Collaboration for Engineering Education (IUCEE). Stephanie Farrell and Grant Crawford conducted two teaching workshops at the Jawaharlal Nehru Technological University Kakinada in Kakinada, India from 2 – 7 January 2012. Coordinated through the IUCEE, the Proven Strategies for Effective Teaching (PSET) seminars focused on student learning, teaching strategies, and assessment techniques.

2.2 IUCEE Background and Mission

Over 150 leaders of engineering education and business from the United States and India conceptualized the Indo US Collaboration for Engineering Education (IUCEE) in 2007. Its goal is to help create good quality engineering talent in order to find solutions to the global challenges facing humanity such as energy, environment, health and communications. IUCEE aims to build a solid base for engineering education and research by strengthening four pillars of education[1]:

- Learner-Centric Teaching
- Research Excellence
- Outcomes-Based Quality Supported by Accreditation
- Innovation and Entrepreneurship

Experts from the US travel to India to share global best practices in teaching and research with Indian faculty leaders from public & private colleges. This venue for this exchange is a one-half to one week Faculty Leadership Institutes (FLI) workshop. Indian faculty leaders then conduct regional workshops on the same topics to broaden the impact throughout India. In 2011, webinars and online short courses were also introduced.

From 2008-2011, 249 Faculty Leadership Institutes have been conducted across India by US academic and industrial experts. In the first three years alone, over 3,000 Indian faculty attended IUCEE FLIs, resulting in significant positive outcomes with over 100 colleges all over India[2].

This paper describes one of the Faculty Leadership Institute initiatives: The Proven Strategies of Effective Teaching (PSET) teaching workshops at the Jawaharlal Nehru Technological University Kakinada in Kakinada, India in January 2012. Coordinated through IUCEE, the Proven Strategies for Effective Teaching (PSET) seminars focused on student learning, teaching strategies, and assessment techniques.

2.3 PSET Content

The PSET workshop was conducted twice during the week of January 2-6, 2012 at JNTUK. The first workshop (Jan 2-4) was attended by 43 participants, and the second workshop (Jan 5-6) was attended by 102 participants. While

sponsored by the University College of Engineering, faculty attendees for the workshop included members from 17 diverse disciplines including fifteen in Computer Science, eight in English, and even one in Medicine (Figure 4). The workshop was a hands on experience in which participants were instructed to bring several lessons from a course they were currently teaching and would like to re-design. The workshop consisted of seminars with embedded breakout sessions that allowed for presentation of theory, demonstration of application, and opportunities for the attendees to apply and share their own insights. Specific workshop content included:

- Felder and Silverman's Model of Learning Styles
- Lowman's Model of Teaching
- Bloom's Taxonomy for the Cognitive Domain
- Writing Learning Objectives
- Active Learning Techniques
- Cooperative Learning
- Problem-Based Learning
- Inquiry Based Learning
- Inductive Teaching Methods
- Classroom Assessment Techniques
- Teaching Assessment Techniques

Dr. Farrell and Dr. Crawford conducted the workshop as a series of seminars that included mixture of presentation, free exchange, embedded activities, and breakout sessions. Some concepts were modeled using 'skits' by the presenters or video clips from popular movies. Assessment instruments were embedded into the seminars. Feedback was collected, assessed, and quickly shared with the participants to model the feasibility of using these same techniques in the classroom.

As recommended by Felder and Brent and Felder et al.[2], strategies were suggested rather than prescribed. Participants were encouraged to try strategies with which they felt comfortable and that fit best into their course structure and presentation style. It was also recommended that instructors try new strategies gradually rather than all at once, which would be overwhelming for both the instructors and students.

2.4 PSET Feedback

Pre and post workshop surveys were planned and conducted for the purpose of measuring the effectiveness of the workshop and with the aim of providing IUCEE with input for use in improving future workshops. Workshop attendees were surveyed prior to the initial seminar and after the final seminar had been concluded. Feedback from workshop participants was exceptionally positive. A copy of selected questions from the post-workshop assessment tool, as they were presented to the participants, is located in Appendix A at the end of this paper. The results for these questions are presented in Figure 3 through Figure 5.

Both workshops had a significant impact on the majority of the participants with regard to their intent to use specific teaching strategies and techniques in the future and with regard to their increased enthusiasm for teaching. One area for improvement that is shown in Figure 6 and was born out in the open-ended comments of the respondents was in visual content of the sessions. The participants loved the visual content of the seminars: cartoons, photos, videos, and skits incorporated to highlight points of emphasis and provide examples (both good and bad). Figure 12 indicates high ratings for the workshop contents, presentation and the presenters. Open-ended comments were heavily weighted towards the desire for even more movie clips and visual content across the sessions.

3.0 Kazakhstan

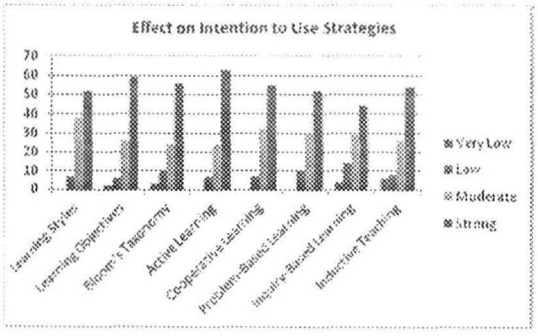

Figure 3: Effect of the PSET Workshop on the Intent of the Participants to Use Selected Teaching Strategies in the Future

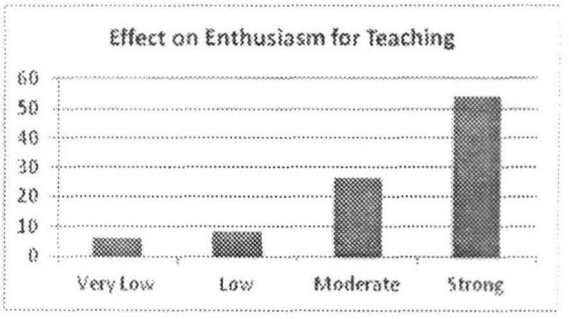

Figure 4: Effect of the PSET Workshop on the Participants Enthusiasm for Teaching

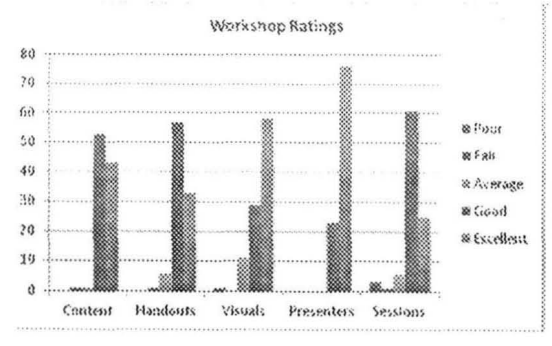

Figure 5: Participant Ratings for Various Workshop Components

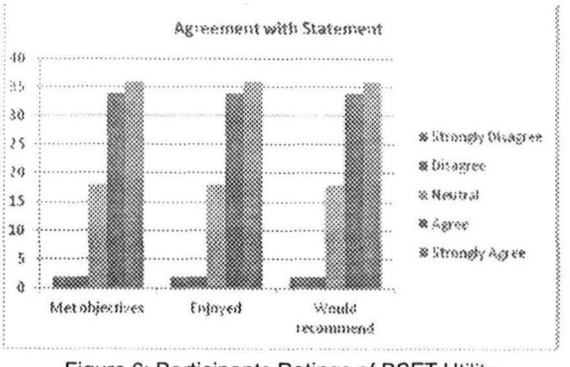

Figure 6: Participants Ratings of PSET Utility

The Republic of Kazakhstan is recognized as having made significant progress in the establishment and development of a market economy during the short time since its independence in 1991. Education has been identified as a top priority in increasing the economic competitiveness of the country. In 2011 the Ministry of Education and Science of the Republic of Kazakhstan launched a major initiative with a goal of increasing its competitiveness in education and human capital by ensuring access to quality education for sustainable economic growth1 . Among the many objectives of this program include national accreditation of universities according to international standards, training of faculty for undergraduate and post-graduate degrees, and modernization of technological facilities and information technologies at educational institutions.xiv.

As one of the leading universities in Kazakhstan, Al-Farabi Kazakh National University (KazNU) is committed to advancing its international reputation and to obtaining institutional and specialized accreditation, especially in engineering disciplines. KazNU rector G. Mutanovich is leading a joint international project with the American Committee for Global Education (ACGE) which clearly demonstrates the role of KazNU in developing engineering education in the country. The project commenced with an international forum on the exchange of international experience and scientific and technical cooperation in engineering at KazNU in October, 2012. Over 100 scientists from 30 countries attended the forum which resulted in the establishment of student exchanges, faculty training initiatives, and infrastructure development projects. This paper describes two outcomes of the forum that are now major initiatives of the joint international KazNU-ACGE

project.

The first major initiative is the creation of the "Kazakh-Indo-American Project for Training and Retraining of the Faculty Staff on Natural Sciences and Technical Disciplines". KazNU, is the host and lead institution and will serve as a hub for dissemination throughout Central Asia. A second major initiative is the Laboratory for New Knowledge and Technology Transfer at KazNU, which represents state-of-the art computer infrastructure. The synergism between these two initiatives isoutlined in the following sections.

3.1 Kazkh-Indo-US Project

The approach for the development of the Kazakh-Indo-American project was to take the successful IUCEE model and extend it to Kazakhstan, thus creating K-IUCEE. Target areas for improvement and growth were identified by faculty and administration at KazNU as: Education, R&D, Services, Entrepreneurship (social and business), Internationalization and the Culture of Quality. In March, 2012 KazNU administrators met with the ACGEto outline several specific opportunities for quality improvement and international cooperation listed in Table 1. This Table also shows the corresponding synergistic activities of the Laboratory for New Knowledge and Technology Transfer which is described in the following section.

A five-year plan was developed with the goals of training of 75% of KazNU faculty of natural sciences and technical disciplines and expanding this training to other Kazakhstani universities and academic institutions throughout Central Asia.

At least 15% of the faculty will have training access each year beginning with the first international K-IUCEE workshop that was launched in March, 2012. The five year plan includes opportunities for training of KazNU faculty via video conferencing, webinars, and onsite workshops, with duration of training between one week and one month. The faculty of four departments (Mechanics and Mathematics, Chemistry and Chemical Technology, Biology and Biotechnology, and Physics) have developed a comprehensive list of training topics for the first set of workshops this year which will enhance faculty expertise in specific research areas. The training sessions will be conducted experts from both the United States and India who will share their experiences with colleagues from Kazakhstan and Central Asia, and certification of training according to international standards will enhance the academic mobility of the faculty trainees.

3.2 Laboratory for New Knowledge and Technology Transfer

In 2011 IUCEE launched its Virtual Academy to serve as a platform for transfer of knowledge of technology from the USA to India. Since its inception, the Virtual Academy has offered 84 webinars viewed by 20,000 faculty and students in India. In January 2012 the IUCEE Virtual Academy piloted 11 mini-courses reaching 4487 students and 133 faculty, demonstrating tremendous potential for broad impact[x]. The Virtual Laboratory for Transfer of Knowledge and

Technology at KazNUis modeled on the IUCEE Virtual Academy, and it launched its first virtual seminar in March, 2012, attended by approximately 50 faculty of KazNU who gained certification in disruptive microelectronics. The main activities of the Laboratory fall into three general categories: (1) professional development courses in engineering education; (2) participation in large-scale joint research projects with world top universities and involvement of scientists and PhD students of KazNU and other universities; and (3) online resource consolidation for professional accreditation of programs in engineering education. The Laboratory utilizes the state-of-the-art computer infrastructure and technology of the laboratory for New Knowledge and Technology Transfer. These facilitiesare provided by the material and technical base of KazNU with the services of

the InterOperability Laboratory of the University of New Hampshire. The Laboratory will provide the technology for K-IUCEE webinars and online training, and trainees will receive certification and be included in the database of experts for further participation in accreditation of programs in engineering. The planned activities of the Laboratory and their synergism with KIUCEE activities are listed in Table 1.

4.0 Nicaragua - 2011

Non-governmental organizations provide ample opportunities for faculty and students alike to undertake service learning domestically and internationally. One well-established organization which provides opportunities for engineering faculty to volunteer their time or make monetary contributions is Engineers Without Borders (EWB). EWB "supports community-driven development programs worldwide by collaborating with local partners to design and implement sustainable engineering projects, while creating transformative experiences and responsible leaders"[1]. EWB-USA members participate in professional or student chapters on a wide variety of projects in locations around the world. Members have the opportunity to travel but need not do so in order to make valuable contributions to their chapter's project. For those who do travel, EWB-USA provides extensive informational resources on its website to help members prepare for their journeys.

During the spring and summer of 2011, Dr. Bristow and the USMA student chapter of Engineers Without Borders-USA planned and completed its first survey trip to a village outside Granada, Nicaragua to assess the condition of its water distribution system and the main road

Kazakh-Indo-American Project Activity	Laboratory for New Knowledge and Technology Transfer Activity
Training (Qualification advancement) of Al-FarabiKazNU staff	W ebinars; support of K-IUCEE Virtual Academy
The academic mobility of the faculty staff and students	Consolidation of academic and scientific mobility resources in one place; faculty training certification according to international standards
Create Gradu ate and Undergraduate Double Degree Programs	Online courses
Joint curricula development and certificate programs	Online courses
Conduction of international seminars and conferences on innovative learning technologies, exchange of experiences	Virtual seminars; support of K-IUCEE Virtual Academy
Joint R&D basic and applied	Joint work with international partnerson behalf of the single laboratory
Infrastructure enhancement/creation (laboratories, IT, libraries, other)	Development of information and commun ication network of the university at the state and world levels
Expansion of its activities within the Kazakhstani universities	Webinars; online courses; Virtual Academy;
Expansion of its activities within the universities of Central Asia	Webinars; online courses; Virtual Academy accessible to universities throughout the region; positioning of KazNU as a leader in the integration of science of Kazakhstan into the global scientific environment

Table 1. Synergism between Kazakh-Indo-Americal Project and Laboratory for New Knowledge and Technology Transfer

connecting the village to the city of Granada. This trip, which was largely student-planned, included eight students and two professors. It gave students important development opportunities and realistic professional challenges, allowing them to struggle with the challenge of planning an assessment mission without a clear idea of the area's layout, key challenges, or resources available on the ground. Personal development was also a significant benefit of the experience; students saw firsthand the consequences of extreme poverty and inadequate infrastructure, and they gained firsthand knowledge of a culture different from their own.

Upon arrival in Nicaragua, students spent their initial time on location conducting topographic surveys of the area's main roads (Figure 7). Exposure to the area allowed them to fill in many of their knowledge gaps on the social structure, infrastructure status, and quality of life concerns. The students met with local water board members, village and city leadership, and local engineers to inquire about the status of the water system. They also visited each household to ask local residents about their chief concerns with the infrastructure (Figure 8).

When they returned, the students built on their data and understanding of the community to focus further their design goals. Having discovered that the water system was adequate to meet the community's needs, they turned their attention to brainstorming ways to control the frequent severe flooding which troubled the area. The process of designing a replacement for a culvert which was undersized and caused significant backwater flooding allowed them to exercise their growing engineering skills as well. This experience enabled the students to develop many of the attributes of the Global Engineer. In addition to applying science and engineering knowledge to a design project, the students gained experience with context of practice; communication; teamwork; leadership; flexibility; commitment to quality, timeliness, and continuous improvement; and ethical standards and professionalism

5.0 Summary

We have presented four case studies aimed at developing Global Engineers and Global Engineering Educators through faculty development, instructional development and service learning initiatives. Each case study was presented in the context of relevant background on the educational system, such as the current state of engineering and technology education in the country, the pressing challenges and available resources, and the employment outlook for graduates. We believe that two key factors to the success of these initiatives is the (1) face-to-face interaction between the primary stakeholders and the international consultants and (2) "community-driven" approach in which the primary stakeholders (i.e., colleagues in Afghanistan, India, and Kazakhstan; community members in Nicaragua) identify their needs and work together with academic experts to establish and implement a plan for improvement. For this reason the specific goals and outcomes were different for each case study. In the case of Afghanistan, the government had chosen USMA as the model for its own NMAA. USMA faculty provided guidance in course development by providing example lecture plans and working with the faculty who were responsible for the full course development. At the PSET workshop, a variety of learning strategies were proposed, and the workshop presenters worked with participants to adapt them for use within the different Indian university systems. In addition, participants were encouraged to try the techniques that they felt were most suitable to their courses and their own teaching styles. In Kazakhstan, the needs of the KazNU community and academia in Central Asia were identified by academics at KazNU; the ACGE worked with KazNU academics to develop a working plan to adapt the IUCEE model and implement it to meet the needs of higher education in Kazakhstan and Central Asia. Finally, EWB-USA supported

a community-driven development program in Nicaragua by partnering with local community members to design and implement a culvert to prevent backwater flooding. This created the opportunity for the students working on the project to use their engineering skills in the culvert design, while developing many of the attributes of the Global Engineer.

6.0 Acknowledgments

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