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**Service-Learning Project for Engineering PhD Students:
International Higher Education Development**

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Educational Challenge: PhD-level graduate students in engineering most often seek careers in academics as faculty members or in research groups in industry or government laboratories. National-level studies have identified a need to educate such PhD students on broader aspects to better prepare them for their careers (e.g., team work, project management, economics, globalization, communication skills, languages, culture). Some topics needing attention in PhD-level educational programs for academically-directed careers are: (i) communication skills, both written and oral, and effective teaching strategies; (ii) learning how to develop classroom-based courses/curricula; (iii) learning how to develop experiments and laboratories to compliment classroom-based treatments of theory; (iv) team work and project management; (v) an understanding of the university system and sources of recruitment for their future graduate students; and (vi) cross-cultural challenges and world-wide development of higher education in engineering.

Service-Learning Approach: To provide a hands-on approach to educating PhD students seeking academic careers on the topics (i)-(vi), it is proposed that a service-learning based approach be used. The basic idea is to have faculty lead a group of graduate students to develop and deliver short courses and an associated laboratory to international institutions of higher education. This would include course development, laboratory development, delivery and set-up of a laboratory, delivery of the course, in addition to related activities.

Current Program Under Development: A sample 5-6 day program (for delivery during Spring Break or summer) that is under development for the control systems and/or systems biology areas is:

1. Course development: (i) Develop a graduate-level introductory course on systems and control. Prioritize topics, consider state of background of target audience, time constraints, software resources, and need to exploit laboratory experience to teach about the application of the theory. Topics under consideration: (a) state feedback methods (LQR, observer), (b) system identification (BLS/RLS), (c) nonlinear analysis and control, (d) optimization theory and algorithms, etc.; and

- (ii) Develop a graduate-level introductory course on systems biology, as for (i). Topics under consideration: Matlab, basic probability, differential equations, stability theory, optimization, and game theory.
2. Laboratory development: Develop laboratories to complement the courses in 1: (i) allow the students to test the theory given in the course, (ii) be low-cost enough to donate to the target institution (including used computers), (iii) be robust and easy to maintain, (iv) have several developed sets of laboratory procedures (possibly field experiments) and exercises, and (v) be relatively easy to extend/expand for additional experiments and research.
 3. Thesis/research projects: Develop a set of candidate undergraduate thesis projects that could be conducted in the course topics and laboratory. Identify the potential to do graduate-level research in the area. This is a critical need in countries where higher education is still under development.
 4. Background Reading: In the process of developing the course and laboratory, the graduate student should learn about the history, culture, and current state of development of the higher education system in the target country or at least the region surrounding the country.

Benefits: There are a number of clear benefits to the foreign site in terms of:

1. Developing their engineering/biology programs and research infrastructure.
2. Establishment of long-term research collaborations.
3. Educational experiences that help graduate students get admitted and succeed at top research institutions.

However, there are likewise significant benefits to the team that engages in such service-learning for higher education development, including:

1. Giving hands-on experiences in (i)-(vi) above.
2. Attractive for record of a PhD student seeking employment as a faculty member in the U.S.
3. Help the faculty member recruit graduate students to come to the U.S.