Engineering Ph.D. Program Assessment and Outcomes

The Mission of the College of Engineering at Tennessee Technological University states, "Through education, research, and service we will prepare graduates to integrate their experience as engineers and technologists with cultural understanding to improve life in the region and the world."

The doctoral program in engineering strives to accomplish the mission in whole, more particularly, in research. The degree is research based which requires that the graduate demonstrate his/her capability to perform scientifically valid engineering research to find solutions to appropriate problems faced by industry and society in general. The educational aspect of the program delves into preparing the student to gain the knowledge and confidence to perform such research work. The Ph.D. Program is reviewed every five years by external evaluators as per the requirements of the Tennessee Board of Regents. The most recent review was done in the spring of 2010. **The Program earned the maximum points in quantitative and top grade in qualitative evaluation.**

Program Outcomes and Assessment

1. Increase the enrollment to 50 students to maintain a critical mass of students needed to support the Program without overstressing the faculty resources.

   The enrollment in Fall 2011 was 49 students compared to 48 students in 2006. The highest enrollment during the current review period was 59 students in the spring of 2010. (**See Table 1 – Ph.D. Enrollments and Graduations Summer 2005 – Fall 2011**) Historically the vast majority of doctoral students were from Electrical and Computer (ECE) and Mechanical Engineering (ME) departments. In recent years, Civil and Environmental (CEE) and Chemical Engineering (ChE) departments have also increased their Ph.D. enrollment. Further, the Computer Science (CSC) department has become a part of the College of Engineering and is getting ready to admit Ph.D. students.

2. Graduate 8 students per year.

Table 1 shows the number of graduates by semester since Summer 2005 which varied from 8 to 13 (average 10.2 per year). Considering the faculty and financial resources available, we expect the graduation numbers to be in this range for the next few years.

3. Graduates are employed in positions of responsibility in teaching and/or research.

   Table 2 shows the last known employment position of recent graduates. Our graduates are working at academic institutions, industry and/or government with responsibility for research and teaching. The students' research publications showing their continued professional activity are also shown in Table 2.

Learning Outcomes and Assessment

1. The student should gain breadth of knowledge in the discipline and depth in the specific area of his/her research topic.

   The student's Advisory Committee is responsible for the development of a program of study including advanced level courses in the discipline and verification that the student takes the courses prescribed. The comprehensive exam is taken at the end of the course work part of the program and is administered by the Committee. It is designed to examine the student's breadth of knowledge, depth of knowledge, and readiness to undertake independent research. A student performing successfully on the comprehensive examination has demonstrated the learning of the subject matters and the capability to perform research in the chosen area. The original paper copies of the comprehensive examination are kept in the departmental office for at least 10 years.

2. The student should learn and gain experience in doing independent academic work.

   The student is required to take at least 12 hours of course and research work at the 7000 level which requires significant independent work (laboratory, library, or industry) in addition to the regular course work. This is verified by the Committee and the College office before the student is permitted to take the comprehensive examination.

3. The student should demonstrate his/her ability to identify and define the engineering research problem.

The student meets this expected outcome by developing his/her research proposal and by obtaining the Committee's approval.

4. The research work performed by the student should be of such a level to contribute to the existing knowledge in the engineering field.

   First, the student defends his/her research work to the advisory committee and other professionals in an open meeting by describing the work and answering questions to their satisfaction. Secondly, the students are encouraged to present papers at professional meetings and also publish in journals. **Table 3** lists the presentations made by students at professional meetings during 2010-2011.

Use of Assessment Results to Improve the Program

The ChE and the CEE departments are being encouraged to increase their participation in the Ph.D. Program. Recent new faculty hires in these departments have been more research oriented and interested in participating in the Program. Enrollment has already increased in the Ph.D. Program as a result. Since the CSC Department also became a part of the College of Engineering in Fall 2010, it will start enrolling Ph.D. students soon. It is expected that the Program will experience further growth in the next three to five years.

The student learning assessment is a continuous process and is less formal because of the relatively small number of students enrolled. Based on the assessments, the following have been implemented.

1. Every student will undergo a preliminary assessment of his/her knowledge in the chosen field. This will be performed by the respective department prior to finalizing the program of study, and the student performance will be readjusted to the College of Engineering.

2. The comprehensive examination will be prepared and administered by the Advisory Committee when the student has completed most of the required course work. All parts of the examination will be given over a two week period instead of over a semester as was done in previous years. The student is also required to present a proposal for dissertation research within 4 weeks of taking the comprehensive examination.

3. Students are actively encouraged to present papers in professional meetings in front of peers and defend their work.

4. Students now have an option to enroll and work on research courses prior to embarking on their dissertation research.

Table 1. Ph.D. Enrollments and Graduations Summer 2005 - Fall 2011

Term	Enrollment	Graduated	No. each Time of Work	Time of Work
			1	2 yrs. + 2 sems.
Summer 2005	38	2	1	4 yrs. + 2 sems.
			1	3 yrs. + 2 sems.
Fall 2005	52	3	2	4 yrs.
			1	2 yrs. + 2 sems.
Spring 2006	52	2	1	8 yrs. + 1 sem.
			1	1 yr. + 2 sems.
			1	2 yrs. + 1 sem.
Summer 2006	31	3	1	4 yrs. + 1 sem.
			1	2 yrs.
			1	2 yrs. + 2 sems.
			1	3 yrs.
Fall 2006	44	5	2	3 yrs. + 2 sems.
Spring 2007	44	2	2	3 yrs. + 2 sems.
			1	3 yrs. + 1 sem.
			1	3 yrs. + 2 sems.
			3	4 yrs.
Summer 2007	24	6	1	4 yrs. + 1 sem.
			1	3 yrs.
			2	4 yrs.
Fall 2007	44	4	1	5 yrs. + 2 sems.
			2	3 yrs. + 1 sem.
Spring 2008	41	3	1	4 yrs.
			1	3 yrs. + 2 sems.

Summer 2008	17	2	1	4 yrs. + 2 sems.
			1	2 yrs. + 2 sems.
			2	3 yrs.
Fall 2008	44	4	1	8 yrs.
			1	2 yrs. + 1 sem.
			2	3 yrs. + 1 sem.
			1	4 yrs.
			1	4 yrs. + 2 sems.
Spring 2009	43	6	1	5 yrs. + 1 sem.
			2	2 yrs. + 2 sems.
Summer 2009	15	3	1	3 yrs. + 2 sems.
Fall 2009	50	1	1	4 yrs.
			1	3 yrs.
			1	3 yrs. + 1 sem.
Spring 2010	59	5	3	5 yrs.
			3	2 yrs. + 1 sem.
			1	3 yrs.
Summer 2010	6	5	1	9 yrs. + 2 sem.
			2	3 yrs. + 1 sem.
Fall 2010	54	3	1	4 yrs. + 1 sem.
			1	3 yrs.
Spring 2011	54	2	1	4 yrs.
			1	2 yrs. + 1 sem.
			1	3 yrs.
Summer 2011	6	3	1	4 yrs. + 2 sem.
			1	3 yrs.
			1	3 yrs. + 1 sem.
			2	2 yrs. + 1 sem.
			1	2 yrs. + 2 sems.
Fall 2011	49	6	1	4 yrs.

Spring 2012 est.	49	7	
Average			3 yrs. + 2 sems.

Table 2. Employment and Publications Summer 2005 - Spring 2012

ID No.	Term Graduated	Recent Known Employment	Publication(s)
1	Summer 2005	Texas A & M University	
2	Summer 2005	unknown	
3	Fall 2005	Siemens Energy & Automation, Inc.	
4	Fall 2005	Praxair Inc.	
5	Fall 2005	GMR Energy	
6	Spring 2006	unknown	
7	Spring 2006	CEC, Nashville, TN	
8	Summer 2006	Burns & McDonnell	
9	Summer 2006	EnerNex LLC	
10	Summer 2006	AEDC	
11	Fall 2006	unknown	
12	Fall 2006	unknown	
13	Fall 2006	unknown	
14	Fall 2006	Chromalloy	
15	Fall 2006	Johnson Controls, Inc.	
16	Spring 2007	ISO-NE	
17	Spring 2007	Rolls Royce USA	
18	Summer 2007	Alstom Power	
19	Summer 2007	Cummins College of Engineering, India	
20	Summer 2007	Lipscomb University	
21	Summer 2007	California ISO	
22	Summer 2007	US Pharacopeia	
23	Summer 2007	Doosan Badcock	
24	Fall 2007	McQuay International	

25	Fall 2007	Assistant Professor, Department of Civil Engineering, West Virginia University Institute of Technology	
26	Fall 2007	unknown	
27	Fall 2007	Freed Hardiman University	1) *Predicting the In-plane Stiffness of Masonry Infilled Frames*, The Masonry Society Journal, Accepted for publication.
28	Spring 2008	Bechtel/TVA	
29	Spring 2008	Electrolux Home Products	1) "Effect of Skewness on the Distribution of Live Load Reaction at Piers of Continuous Skewed Bridges," *ASCE Journal of Bridge Engineering*, Vol. 13, No. 1, pp. 110-114. (2008) 2) "Live Load Distribution for Reactions at Piers of Continuous Prestressed Concrete Skewed Bridges," *Proceedings of the 2007 Structures Congress*, May 16-19, 2007, Long Beach, California (doi http://dx.doi.org/10.1061/40946(248)67
30	Spring 2008	Disney Research Lab	
31	Summer 2008	unknown	
32	Summer 2008	Pacific Northwest National Lab	
33	Fall 2008	Tennessee Technological University	
34	Fall 2008	Cummins Power Generation	
35	Fall 2008	American Bureau of Shipping, Houston, Texas	
36	Fall 2008	Ammann & Whitney, New York City, NY	1) " Experimental Investigation on Dynamic Properties of Rubberized Concrete," *Construction and Building Materials* , Vol. 22, No. 5, pp 939-947. (2008) 2) "Strength, Modulus of Elasticity, and Brittleness Index of Rubberized Concrete," *ASCE Journal of Materials in Civil Engineering*, Vol. 20, No. 11, pp. 692-699. (2008)

			3) “Comparison of Load Factor Rating (LFR) to Load and Resistance Factor Rating (LRFR) of Prestressed Concrete I-Beam Bridges,” *Proceedings of the 2007 Structures Congress,* May 16-19, 2007, Long Beach, California. (doi http://dx.doi.org/10.1061/40946(248)71)
			4) “Comparison of Load Factor Rating (LFR) to Load and Resistance Factor Rating (LRFR) of Prestressed Concrete I-Beam Bridges,” *Proceedings of the 2007 Structures Congress,* May 16-19, 2007, Long Beach, California. (doi http://dx.doi.org/10.1061/40946(248)71)
			5) “Effects of State Legal Loads on Bridge Rating Results Using the LRFR Procedure,” ASCE Journal of Bridge Engineering, Vol. 13, No. 6, November/December 2008, pp. 565-572.
37	Spring 2009	Magna E-Car Systems, USA	
38	Spring 2009	Georgia Institute of Technology	
39	Spring 2009	Mahindra Reva Electric Vehicles Pvt	
40	Spring 2009	The Petroleum Institute, UAE	
41	Spring 2009	Johnson Controls	
42	Spring 2009	CD-adapco	
43	Summer 2009	Cadence Corp.	
44	Summer 2009	MEGGER	
45	Summer 2009	unknown	
46	Fall 2009	University of Alberta	
47	Spring 2010	unknown	
48	Spring 2010	unknown	
49	Spring 2010	Assistant Professor, Civil and Mechanical Engineering Department at South Carolina State University	1) **Estimating Household Trip-rates for Cross-Classification Cells with No Data: Alternative Methods and their Performance in Prediction of Travel,** *ASCE Journal of Urban Planning and Development* Vol. 137, No. 3, September 2011, pp. 262-271

			2) **Trip Generation Modeling Using Data Collected in Single and Repeated Cross-Sectional Surveys**. Proceedings of the *90th Annual Transportation Research Board Conference (On CD-ROM)*, Washington D.C., 2011 3) **Comparison of Forecast Performance of Alternative Methods for Estimating Missing Cell Values of Cross-classification Matrix.** Proceedings of the *89th Annual Transportation Research Board Conference (On CD-ROM)*, Washington D.C., 2010
50	Spring 2010	NSF Posdoctoral Fellow/Australia	1) The Origins and Evolution of Cement Hydration Models, Comp. Concr., 8(6), 647-675 (2011).
51	Spring 2010	Air Liquide (China) Holding Co., Ltd	
52	Summer 2010	unknown	1) "Towards Affordable Home Health Care Devices Using Reconfigurable System-on-Chip Technology," Book chapter 7,Applied Biomedical Engineering, INTECHWEB.ORG Publisher, ISBN 978-953-307-256-2, pp. 141-166, 2011. 2) "A Multi-channel Frequency Detection and Monitoring System," In proceedings of The 23 rd IEEE International SOC Conference (SOCC'10), 2010. 3) "A Multi-channel Frequency Detection and Monitoring System," In proceedings of The 23 rd IEEE International SOC Conference (SOCC'10), 2010. 4) "A Low-Cost Stand-Alone Real-Time Multi-Channel Frequency Monitoring System." In proceedings of The IEEE SoutheastCon Conference (SECON'10), 2010. 5) "Standalone Simultaneous Multi-channel Instrument to Measure, Monitor and Record Analog Signals using SoC-FPGA Technology." IEEE Transaction on Instrumentation and Measurement, vol. 59 (4), pp. 1-15, 2009.

6) “Multi-channel Multiplexed Stand-alone Audio Data Acquisition System: The effect of settling time on acquisition accuracy,” In proceedings of The ISCA 22nd International Conference on Computer Applications in Industry and Engineering, 2009.

7) “A Novel Dynamic Scheduling for Simultaneous Multi-channel DAQ,” In proceedings of The International Conference on High Performance Computing, Networking and Communication Systems HPCNCS, accepted 2009, Not published.

8) “Multi-channel Multiplexed Stand-alone Audio Data Acquisition System,” In proceedings of The International Conference on High Performance Computing, Networking and Communication Systems , HPCNCS, accepted 2009, Not published.

9) ”Simultaneous Multi-channel Data Acquisition and Storing System,” In proceedings of The International Conference on Computing, Engineering and Information Systems, ICC, 2009.

10) ”A Survey on Data Acquisition systems DAQ,” In proceedings of The International Conference on Computing, Engineering and Information Systems ICC, 2009.

11) "Stand-alone Portable Digital Body Sound Data Acquisition Device," International Journal of Embedded Systems, (IJES), vol. 4(3), 2009.

12) “A Conceptual Design of a Compact Multi-channel real-time Analog Signal Acquisition and Processing System,” In proceedings of *The IEEE 41st Southeast Symposium on System Theory (SSST’09),* 2009.

13)"Reconfigurable wireless Stand-alone Platform for Electrical Capacitance Tomography," In proceedings of *The IEEE Symposium on Computational Intelligence in Control and Automation (CICA'09),* 2009.

14) "Simultaneous Multi-channel Data Acquisition with Variable Sampling Frequencies using a Scalable Adaptive Synchronous Controller," In proceedings of *The ACM/SIGDA International Symposium on Field-Programmable Gate Arrays (FPGA)*, 2009.

15) "An Efficient Hardware Reconfigurable Multi-channel Audio Data Acquisition, Storing and Monitoring System," In proceedings of *The IEEE International Conference on Consumer Electronics*, 2008.

16) "System-On-Chip Technology-based On-the-fly Audio Data Acquisition, Monitoring and Displaying System using FPGA", In proceedings of *The International System on Chip conference*, Korea, 2008.

17) "Stand-alone Data Acquisition System with Graphical Monitoring of Analog Data in Embedded System Applications," In proceedings of *The IEEE Southeast Conference*, pp. 252-256, 2008.

18) "A Novel Design and Development of a Single Channel Integrated Digital Body Sound Data Acquisition Device", In proceedings of *The International Conference on Biomedical Electronics and Devices*, Portugal, vol. 2, pp. 244-249, 2008.

19) "An Efficient Embedded System Design for Capturing and Storing Analog Data," Journal of Engineering and Applied Sciences, Medwell Journals, vol. 2(8), pp. 1290-1296, 2007.

20) "An Efficient Embedded System Design for Capturing and Storing Analog Data," In the proceedings of *The Parallel and Distributed Computing Systems Conference*, pp. 302-307, 2007.

53	Summer 2010	EnerNex LLC
54	Summer 2010	unknown
55	Summer 2010	unknown
56	Summer 2010	Michelin, Shenyang, China
57	Fall 2010	unknown
58	Fall 2010	unknown

59	Fall 2010	Indo Kordsa	
60	Spring 2011	PostDoc Research Associate Kansas State University	
61	Spring 2011	Research Engineer, China	
62	Summer 2011	unknown	
63	Summer 2011	Goddard Space Flight Center	1) Investigating the similarity of satellite rainfall error metrics as a function of Koppen climate classification, *Atmospheric Research*, (doi:10.1016/j.atmosres.2011.10.006). 2) Understanding the dynamics of transfer of satellite rainfall error metrics from gauged to ungauged grid boxes using interpolation methods, *IEEE Journal of Selected Topics in Applied Remote Sensing,* pp. 1939-140 (doi:10.1109/JSTARS.2011.2135840). 3) Forensic Analysis of two contrasting satellite rainfall products for detection of the July 2002 flooding in South-central Texas, *Environmental Forensics*, vol. 12, pp. 19–225,(doi:10.1080/15275922.2011.595045). 4) Transfer of Satellite Rainfall Error from Gauged to Ungauged Regions at Regional and Seasonal Timescales, *Journal of Hydrometeorology* , (doi:10.1175/2010JHM1296.1). 5) Transfer of Satellite Rainfall Error from Gauged to Ungauged Locations: How realistic will it be for the Global Precipitation Mission? *Geophysical Research Letters*, vol. 36, (doi:10.1029/2009GL037965). 6) Investigating Spatial Downscaling of Satellite Rainfall Data for Flood Prediction, *Journal of Hydrometeorology*, vol. 10: 1063-1079 (doi:10.1175/2009JHM1072.1).

			7) A Practical Guide to a Space-Time Stochastic Error Model for Simulation of High Resolution Satellite Rainfall Data. *Book Chapter on Satellite Applications of Hydrology*, Springer Publications, (doi:10.1007/978-90-481-2915-7_9).
			8) Predicting the In-plane Stiffness of Masonry Infilled
			1) "V2G Electric Power Capacity Estimation and Ancillary Service Market Evaluation;" 2011 IEEE PES General Meeting, pp. 1-8.
64	Fall 2011	EnerNex LLC	
65	Fall 2011	TCE	
66	Fall 2011	Comefri USA, Inc.	1) "Laboratory Testing of Converging Flow Flat Oval Tees and Laterals to Determine Loss Coefficients," HVAC&R Research, Vol. 15, No. 5, pp. 710-725. 2) "Laboratory Testing of Flexible Duct," Final Report, Thermaflex Corp. 3) "Laboratory Testing of a Fabric Air Dispersion System," Final Report, DuctSox Corp
			4)"Measurement of Loss Coefficients in Divided Flow Fittings, and CFD Studies of Developing Turbulent Flows for Various Entrance Geometries," 2011
67	Fall 2011	ASERT-IRACDA Post Doctoral Fellow at University of New Mexico	
68	Fall 2011	Ixia Communications	
69	Fall 2011	Federal University of Technology	

Table 3. Ph.D. Student Presentation: Professional Meetings 2010-2011

Ph.D. Student	Sponsoring Dept.	Conference Name	Conference Date	Presentation Title
1	ECE	2010 Military Communications Conference San Jose, CA	Oct 31-Nov 2,2010	Wideband Waveform Optimization for Multiple Input Single Output Cognitive Radio with Practical Considerations
2	ECE	MILCOM 2010 San Jose, CA	Oct 31-Nov 3,2010	Demonstration of Real-time Spectrum Sensing for Cognitive Radio
3	ChE	National AIChE Conference Salt Lake City, UT	Nov 7-10, 2010	1) Polyacrylamide-MMT Nanocomposite Hydrogels: Effect of Nanoparticle Loading on Protein Electrophoretic Mobility 2) Electro-Poiseuille Flow Modeling in Annular Geometry
4	ChE	National AIChE Conference Salt Lake City, UT	Nov 7-11,2010	1) The "Single Pellet Reactor": A "Cool" Multiscale Problem, or a Useful Chemical Engineering POK for Learning of Mass Transfer? 2) Dynamics of Separation in an Electrical Field Flow Fractionation Separator with Couette Flow: Effect of Wall Velocities 3) Eight Other Papers

5	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	Modeling TCP/IP Stack in a Single Custom Processor, with Secure Data Transmission to an Altera-based Web Server
6	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	Calculation of Weight Vectors for Wideband Beam forming Using Graphics Processing Units
7	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	1) Q-Learning Based Bidding Algorithm for Spectrum Auction in Cognitive Radio 2) Cooperative Spectrum Sensing Using Q-Learning with Experimental Validation 3) Three other Papers
8	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	MATLAB - Based Fault Analysis of Power Systems with Graphical User Interface as an Educational Tool
9	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	PV Output Power Smoothing Using Energy Capacitor System
10	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	FACTS Devices Ownership in Restructured Electricity Markets
11	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	Towards a Real-time UWB MIMO Testbed for Sensing and Communications

12	ECE	IEEE Southeast Conference 2011 Nashville, TN	March 17-20, 2011	Evaluation of First Swing Stability of Power System with Doubly Fed Induction Generator Wind Farms
13	ECE	37th International Photovoltaics Specialists Conference Seattle, WA	June 19 - 23, 2011	Improved Efficiencies of Multi-Sized Quantum Dot Doped Solar Cells