
AC 2011-530: A NUCLEAR POWER INDUSTRY CAREER DEVELOPMENT WORKSHOP FOR HIGH SCHOOL TEACHERS IN A HISPANIC SERVING INSTITUTION

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A Nuclear Power Industry Career Development Workshop for High School Teachers in a Hispanic Serving Institution

Abstract

In recent years, Texas A&M University Corpus Christi entered into a partnership with the Nuclear Power Institute or NPI to attract students into careers in nuclear power and science. The partnership naturally involved both student recruitment and curriculum development efforts. As a part of this recruitment effort, a summer workshop was designed and implemented to train, prepare for research, and educate local area high school teachers for the careers in engineering, engineering technology and the nuclear power industry. First, an outreach effort to local area public, private high and junior high schools was organized to advertise and promote the workshop. After a considerable effort of visits and networking, a total of twenty teachers with a variety of science, math and technology specialties participated in this week-long program held in July of 2010.

During the workshop, a simple, portable curriculum, which can also be used by teachers in their institutions, was given to attract both teachers and students in the fundamental areas of Electrical Engineering Technology that is applicable to Nuclear Power Systems. The curriculum included both lecture and lab sessions which are suitable for beginners in Electric and Digital Systems. Additionally, a field trip to a nearby nuclear power plant and an oil refining facility was organized to introduce teachers to the industry.

Finally, a survey was conducted to evaluate the overall workshop and the staff/faculty performance as well as the sustainability of the established curriculum. The great majority of the feedback received from the teachers during and after the workshop indicated the success of this program. This paper describes this summer program in detail and presents its assessment and follow up results.

Introduction

Increasing energy demand in the 21st Century comes with important challenges such as environmental impacts, sustainability and cost effectiveness. One of the most useful forms of energy is unquestionably electrical energy. Therefore, recognizing our additional need for energy, cleaner electric energy generation through renewable sources (especially wind and solar) and nuclear power gained quite a momentum over the recent years. For instance, as of November 2010, U.S. Nuclear Regulatory Commission has received 18 combined license applications for a total of 30 new reactors¹. In addition, due to low variable operating costs, nuclear power plants in the U.S. historically have had very high utilization rates of around 90%, which is the highest among all energy sources².

With this growth in the energy industry to meet the increasing energy demands, the need for technical talent to support the energy workforce is obvious. To educate and prepare the skilled workers for the nuclear and power workforce, recruitment efforts are necessary, as students typically shy away from disciplines that are heavily dependent on math and sciences, due to the

rigor of such programs; therefore, it is important to expand recruitment efforts from colleges to high schools. Many of such recruitment efforts for engineering fields have typically been student-focused. At Texas A&M University Corpus Christi, such efforts are in progress in cooperation with Nuclear Power Institute, as detailed in the following sections at the college level. In addition, in this paper, a summer career development workshop for high school teachers is described to encourage high school teachers to cover engineering topics in their relevant courses, and equip them with the necessary tools to be successful as teachers in engaging students in meaningful activities in high school. This workshop is expected to play an important role in assisting the participating high school educators to support and encourage their students to prepare for the related engineering disciplines in college.

Recruitment Efforts into STEM Fields

With the obvious need for the engineering workforce in the near future, many educators at universities have taken on creative recruitment activities to help increase student enrollment in STEM fields. Recruitment efforts for engineering fields are definitely not restricted to the recent past. Bozynski and McCowen describe student initiated summer recruitment camp for engineering called Science Quest aimed at elementary school children in Kingston, Canada, through Queen's College, which started in 1988³. Each student carried out two projects every day for one week, in addition to one group project that lasted one week. The individual projects ranged from casting, to design related projects, with hands-on experiences. The authors explain the expansion of this summer program due to its success. More recently, Gleason *et al.* describe an Engineering Math Advancement Program (E-MAP) which is aimed to help students with calculus in preparation for engineering⁴; the program, in addition, offers "living-Lab" hands-on exercise, field trips and a service-oriented project that gets the students involved in the community. The authors report that the retention of students increased by 12% in three years after the implementation of the E-MAP. Describe the creation of student learning communities as a recruitment tool⁵. Tester *et al.* describe a Design4Practice (D4P) curriculum enhancement implementation to increase recruitment and retention of students in engineering fields⁶. Their study was aimed at identifying best practices in recruitment and retention of students in engineering fields that could be applied to their curriculum through the Multicultural Engineering Program (MEP). The authors note that "service learning" can be applied in the education protocol. With strong service-related activities, the college students can tackle not only environmental issues, such as renewable energy, but the practice can also be expanded to high school students. Finally, a study performed at University of Illinois at Urbana-Champaign⁷ revealed through student surveys that some of the factors that would assist with student recruitment and retention include providing more connections to the engineering workforce; providing more orientation for incoming students; increasing the quality of instruction; improving the process of selecting teaching assistants; and improving the engineering curriculum. As discussed earlier, most of these studies are student-focused. The teacher-focused training activities for student recruitment into engineering and related fields are described later in this paper. The next section is an account for justification for enhanced recruitment and retention efforts in power related fields.

Demands of Nuclear Power Industry in Texas

For several years it has been projected that the current nuclear power industry will soon be facing a manpower crisis due to attrition within its “soon-to-be-retiring” workforce. Estimates for the number of nuclear power industry workers that will be needed in the near future have shown that we must recruit many more individuals than we have recruited in recent years, and that imperative, in turn, demands that a concerted effort must be placed on recruiting individuals from non-traditional student populations. Our university is designated as a Hispanic Serving Institution (HSI) which means that our Hispanic student population is at least 25% (over 39% in Fall 2010⁸). Underrepresented students have historically not entered careers in nuclear power fields and are, therefore, exactly the students who should be targeted today. Consequently, our university entered into a partnership with the Nuclear Power Institute or NPI (which is a Texas-wide partnership led by the Texas Engineering Experiment Station (TEES) and headquartered at Texas A&M University to attract students, especially traditionally underrepresented students, into careers in nuclear power and science.

With eight new nuclear reactors approved to be built in Texas along with the aging workforce, the need for skilled workers is growing rapidly. Each of these reactors requires hundreds of permanent full time employees with undergraduate degrees in engineering, engineering technology and engineering physics, with an understanding of nuclear power plant technology, as well as skilled workforce with associate degrees in nuclear power plant systems, radiation protection and digital instrumentation and control. More specifically, around 450 skilled workers will be required for each of the eight nuclear plants planned for Texas, among the thirty-one plants planned for the U.S.A. This number translates to a need for 3600 skilled workers in Texas, two-thirds of whom are expected to hold plant technician positions with a two-year degree, and one-third holding a four-year degree in engineering disciplines, including nuclear engineering, mechanical engineering, electrical engineering and engineering technology⁹.

Texas A&M University Corpus Christi and NPI Partnership

The activities associated with this partnership include both nuclear power certificate development and student recruiting efforts in The Department of Computing Sciences, Mechanical Engineering and Engineering Technology Program. The program has an undergraduate enrollment over 180 students at Texas A&M University Corpus Christi includes total of three majors of specialty as listed below:

- Mechanical Engineering
- Mechanical Engineering Technology
- Electrical Engineering Technology

While Mechanical Engineering (ME) is a recently established major, both Mechanical Engineering Technology (MET) and Electrical Engineering Technology (EET) are well established and ABET accredited majors serving the region since 2002. Bachelor of Science degrees are offered in all the three majors.

Through the NPI partnership, the nuclear power certificate that has been developed is adapted to support the power industry in Texas. Specifically, the electrical engineering technology curriculum was selected to comprise three on-site common fundamental power systems courses¹⁰ in order to address major power education components including generation, transmission and distribution, and protection systems. The on-site courses that have been added to the curriculum are:

- Energy Conversion
- Power Transmission and Distribution
- Power Protection Systems

All three on-site courses are senior elective level courses to define “power emphasis” in the program, particularly, in Electrical Engineering Technology.

The certificate courses also include additional two on-line courses that are offered by NPI. These courses are selected with advising faculty’s guidance from the online course offerings provided by NPI which include:

1. Nuclear Power Plant Fundamentals
2. Nuclear Power Plant Systems – PWR (Pressurized Water Reactors)
3. Nuclear Power Plant Systems – BWR (Boiling Water Reactors)
4. Nuclear Power Plant Operations
5. Human Performance for Nuclear Power Plant Engineers

These certificate courses can be taken as electives by mechanical engineering and engineering technology (mechanical engineering technology and electrical engineering technology) students who meet the prerequisites of these courses.

In conjunction with the curriculum development efforts, the recruiting activities have been planned to include visits to local secondary educational institutions and having promotional presentations about engineering and engineering technology programs at Texas A&M University Corpus Christi, organizing educational summer training and support programs with high/middle school students and math/science teachers, attending local conferences, workshops, panels or platforms.

The following section describes the summer workshop activity in detail that is designed as part of these student recruiting efforts.

The Summer Workshop

It is clear that student recruitment efforts into STEM fields should not be limited to college and college-bound students. By assisting teachers to gain the right tools and learn about engaging exercises that not only develop student skills but also encourage them into these technical fields, it is expected that students will be exposed to engineering and related fields earlier than they would otherwise, and preferably gain enough interest in these fields to pursue them as a major in college and then a career in their work life.

The summer workshops introduced participating teachers to Texas A&M University Corpus Christi Engineering programs specifically its Electrical Engineering Technology program and its emphasis in Nuclear Power Systems. Considerable time and effort was also put on the workshop planning activities. Local area teachers were made aware of the week-long workshop via email, program flyers and website advertisement. In addition, the faculty and staff spent many hours in curriculum and lab development activities (Figure 1). Here, the details of the Summer Workshop for High School Teachers are presented, and the success of the workshop evaluated.

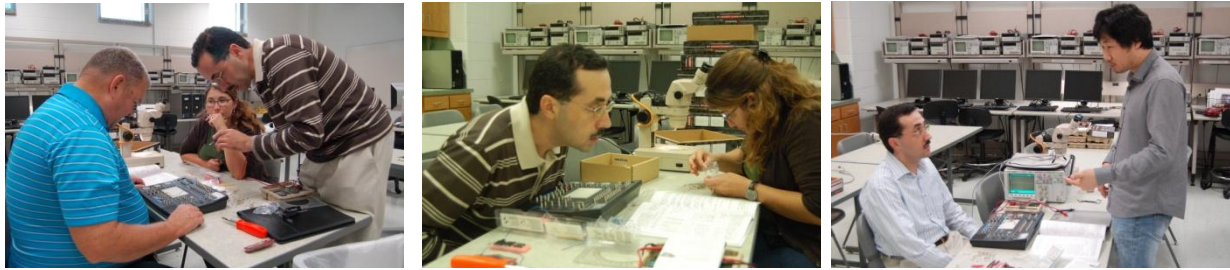


Figure 1: Faculty and staff in summer workshop laboratory planning and development activities

Attendees

Participants were chosen from regional high school teacher applicants first then from junior high school applicants. There were a total of 20 teachers, 15 high school teachers and 5 junior high school teachers. One high school teacher traveled over 350 miles to attend the workshop. Represented schools include: Advantage Academy Waxahachie, Annapolis Christian Academy, Flour Bluff Junior High, Flour Bluff High School, Foy H. Moody High School, Gregory-Portland High School, Harmony Science Academy Brownsville, Harmony Science Academy Laredo, Memorial Middle School, Richard King High School, Sinton High School, and the School of Science and Technology Corpus Christi.

Schedule

The week-long workshop provided participants with hands-on educational activities, guest speakers from local industry partners and a curriculum that can be implemented within each of their institutions. Participants were given tours of the university laboratories, the Conoco Phillips Sweeney refinery and the South Texas Project Nuclear Power Plant. At the end of the workshop each participant was awarded a stipend of \$500 to purchase materials for their institutions and a certificate of completion of 40 continuing professional education credit hours. The schedule for the summer workshop is listed below in Table 1.

Table 1: Workshop Schedule

	July 12	July 13	July 14	July 15	July 16
Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:30am	Welcome to University Introduction to Engineering Technology Circuit Analysis I • DC Fundamentals	Circuit Analysis II • AC Fundamentals • Transformers • Motors • Generators	Field Trip Day (leave @6:15am) Conoco Phillips Sweeny Refinery Tour and Training	Digital Circuits • Combinational • Sequential Logic Circuits	Digital Circuits Labs II Informative Sessions • Admission • Scholarships • Advisor
12:00 noon	Lunch Guest Speaker (Associate Dean of Engineering)	Lunch Guest Speaker (AEP Principal Engineer)	Lunch at Conoco Phillips Sweeny Refinery	Lunch Guest Speaker (VP of a Local Engineering Firm)	11:30am – 12:30pm Guest Speaker from the NPI
1:30pm	Circuit Analysis I Labs	Circuit Analysis II Labs	South Texas Project Nuclear Power Plant Tour and Training	Digital Circuits Labs I	12:30pm Lunch and Graduation
4:00pm	Dismissed	Dismissed	Return @ 7:45	Dismissed	

Activities and Exercises

Throughout the program, the activities and exercises implemented can be listed as follows:

- Informative and Introductory Sessions about Engineering and Engineering Technology Program, University, Admissions, Scholarships, etc.
- Lectures of Circuit Analysis DC/AC and Digital Circuit Fundamentals
- Associated Laboratory Sessions
- Lunch Guest Speakers
- Field Trip Day

Each of these activities is described in detail below:

1. Informative and Introductory Sessions : Total of two sessions were organized to inform teachers about:
 - a. *The Department of Computing Sciences and Mechanical Engineering and Engineering Technology Program* - The Department Chair addressed and welcomed the teachers and gave a brief introduction about the program and its objectives. Later, the teachers were given a tour of the facilities by faculty and support staff.
 - b. *University and Admissions* – The College of Science and Technology (which houses the department and the program) staff advisor had an interactive presentation to give details of University admission procedures and scholarships in the final day of the workshop.

2. Lectures : The following lecture topics were covered throughout the workshop to train and educate the teachers. The teachers were provided with the lecture material (presentations, lesson plans, etc.) to be able to assist with implementing the curriculum:
- a. *DC and AC Circuit Analysis* – The basics of Circuit Analysis were briefed in two morning sessions:
 - i. *DC Circuit Analysis* – included the following items:
 - The definitions of charge, voltage, current and battery.
 - Resistance, I-V characteristics, wattage ratings and resistor color coding.
 - Ohms Law and basic circuit diagrams.
 - Diode and I-V characteristics.
 - Series resistance and Kirchhoff’s voltage law.
 - Series DC circuits and Voltage Divide Rule.
 - Parallel resistance and Kirchhoff’s current law.
 - Parallel DC circuits and Current divider rule.
 - ii. *AC Circuit Analysis* – included the following items:
 - Capacitors and Inductors
 - Sinusoidal waveform and characteristics
 - Angular frequency, phase, average and RMS values.
 - Resistor vs. Impedance
 - Concepts of magnetism, permeability, induced voltage and Faraday’s law
 - Reluctance and Ohm’s Law for magnetic circuits
 - Hysteresis
 - Transformers and mutual inductance
 - DC Machines
 - AC Synchronous and Induction Machines.
 - b. *Digital Circuit Fundamentals* – The following topics were briefed in a single morning session:
 - Introduction to Digital Circuits (digital vs. analog, logic levels, digital waveforms, serial and parallel data)
 - Numbers (decimal, binary, hexadecimal)
 - Logic Gates (NOT, AND, OR, etc.)
 - Boolean Algebra
 - Combinational Logic Circuits
 - Sequential Logic Circuits (Latches, flip-flops, counters)
3. Laboratory Exercises : To be able to implement all purpose, easily portable lab practices, “Electronics Learning Lab” sets and a 29-range digital multimeters by RadioShack (as seen in Figure 2) were utilized throughout the workshop. This low cost and reasonably small form factor “Electronics Learning Lab” set comes with two well designed workbooks (by Forest M. Mims III) for both electrical/electronic and digital logic project exercises along with step by step implementation procedures. Some snapshots from workshop lab activities can be seen Figure 3.

For most of the lecture items listed above, a corresponding lab exercise was easily located in the workbooks and implemented in the workshop lab activity. Only DC and

AC machine lab practices were skipped due to the factors of associated cost burden with lab equipment and time constraints.

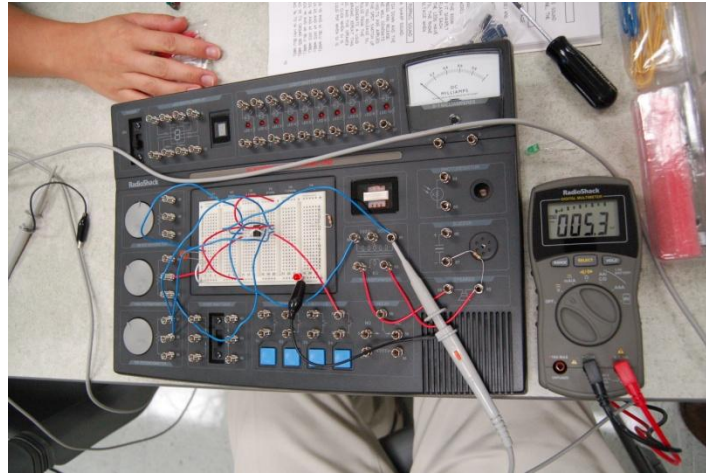


Figure 2: Workshop Lab Materials; “Electronics Learning Lab” set and a 29-range digital multimeter by RadioShack



Figure 3: Snapshots from Laboratory Sessions

4. Lunch Guest Speakers : The workshop program as can be seen in Table 1 hosted four quality guest speakers to inform and educate teachers about our university, the needs of industry and career opportunities in engineering, engineering technology and the nuclear power industry. These speakers specifically were:
- Associate Dean of Engineering for College of Science and Technology
 - A Principle Engineer from Local Utility Company
 - Vice President of a Local Engineering Firm
 - NPI Director of Outreach and Development

These interactive sessions provided clear and concise picture of the practical and existing needs of the industry in Texas.

5. Field Trip : The field trip was intended to expose the workshop participants into the industry. Throughout the trip, the teachers had a great opportunity to explore multiple segments of the energy world and interact with various industry representatives and leadership. The facilities visited were:
- Conoco Phillips Sweeny Refinery
 - South Texas Project Nuclear Power Plant

In both facilities, plant's chief engineers and representatives provided a nice tour and educational/training sessions for the basics of electrical and mechanical engineering, nuclear power and science that are applicable to the industry.

The trip was overall a very informative, educational and rewarding experience for the attendees, university representatives and the program's industry partners.



Figure 4: Workshop participants, faculty and staff at Conoco Phillips Sweeny Refinery

Program Results & Impact

At the end of the program participants were asked to complete a survey regarding the workshop experience and its potential impact in their institutions. As can be seen in Table 2, it was determined that 85% of the participants strongly agreed that the workshops were useful in improving their overall knowledge and skills in electrical engineering applications as well as in Electrical Engineering Technology. When asked if the overall quality of instruction was appropriate and useful 95% strongly agreed that it was in fact useful.

Table 2. Teacher Survey Results

		Strongly Agree	Somewhat Agree	Somewhat Disagree	Disagree	Not Applicable	Total	Strongly Agree Percentage
1	Have you found workshop useful to improve your knowledge and skills on Electrical Engineering Technology?	17	3	0	0	0	20	85.0%
2	Are Mathematical relationships and calculations selected in this workshop appropriate for secondary school students?	8	11	1	0	0	20	40.0%
3	Do you think electrical, magnetic and digital circuits' applications will help students to better understand electrical engineering technology?	18	2	0	0	0	20	90.0%
4	Are you interested in implementing this applied electrical engineering technology curriculum to promote Engineering Technology Education in your school?	15	3	1	1	0	20	75.0%
5	Facilities such as parking, classroom, demonstrations, and lab activities were selected well for this workshop.	19	1	0	0	0	20	95.0%
6	Overall quality of instruction was appropriate and useful for this class.	19	1	0	0	0	20	95.0%
7	Field Trip, refreshments and lunch arrangements were done very well for this week-long workshop.	19	1	0	0	0	20	95.0%
8	I am interested in future workshops of these or similar subject matters.	18	1	0	1	0	20	90.0%

The area that will need to be improved upon was in mathematical relationships. Participants were asked if the relationships and calculations were appropriate for secondary school and only 40% strongly agreed that it was appropriate and 55% felt somewhat agreed that it was appropriate.

The return investment for this workshop was verified when 90% of the participants strongly agreed to pursue our future workshops in similar subject matters.

In a recent follow up with the participant teachers showed that two schools currently incorporated the full workshop curriculum into their extracurricular activities. Another school also incorporated only the lecture materials into their class curriculum. The university faculty in charge with the workshop and an undergraduate student assistant currently contribute to one of these extracurricular activities.

Conclusions

It is clear that there will be a need for skilled workers in the renewable energy and nuclear power fields. The universities are responsible for preparing students for positions in these fields; however, more and more, the role of universities and educators are shifting from just education to recruitment and retention efforts as well. This paper presented a multi-faceted recruitment and retention related activities taken on at (University Name) through the support of NPI in an effort to avoid shortages in the workforce in these fields. (University Name) has adopted a power emphasis in its Engineering Technology program, and offers energy related courses in its mechanical engineering program. In addition, through partnership with NPI, the University offers certificates in nuclear power to support the foreseen needs of the nuclear and power industry. As part of recruitment efforts, the Summer Workshop aimed at high school teachers demonstrated the success of this endeavor. The survey results and follow ups conducted through participants after the workshop revealed that a number of educators have already incorporated the exercises and tools learned during the workshop in their schools. The effect of these activities on recruitment will most likely take some time to reveal; however, the preliminary information is quite promising, and the repetition of such workshops is encouraged.

Acknowledgements

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