AC 2012-5132: IEEE REAL WORLD ENGINEERING PROJECTS (RWEP)

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IEEE Real World Engineering Projects (RWEP)

ABSTRACT

As part of IEEE's mission to further engineering education and support faculty and student development, the IEEE Educational Activities Board (EAB) along with the IEEE Women in Engineering (WIE) Committee created the Real-World Engineering Projects (RWEP) program. The goal of the RWEP program is to provide university educators of electrical engineering (EE), computer engineering (CE), computer science (CS), biomedical engineering (BE) and electrical engineering technology (EET) with a library of high-quality, tested, hands-on, team-based, and society-focused projects for first-year students.

These projects are designed to increase the recruitment, persistence to degree, and satisfaction of all students, in baccalaureate EE, CE, CS, BE and EET degree programs. In many EE/CE/CS/BE/EET programs, current first-year curricula focus on the theoretical and mathematical components of engineering. The vehicle for change is a series of IEEE-approved hands-on projects that educators are able to use in the first-year classroom in order to acquaint their students to the practice of these disciplines.

The projects clearly demonstrate a benefit to society in general and also involve the students at a more intimate level than a typical lecture. Research has shown the recruitment of women gains significantly from the illustration of how electrical and computer engineers and computer scientists benefit society. The persistent under-participation of women in engineering and computer science is an area of continued concern to governments, industry leaders, policy making bodies, and professional associations.

I. RWEP INTENT

Recent studies have shown that the graduation rates for engineering students entered in 4-year degree programs have hovered below 60%. The graduation rates for women and under-represented minority students are even lower. Recruitment of students into engineering programs remains a challenge and therefore retaining students already enrolled is a critical concern to educators and professional associations. The majority of these losses occur in the first year of an engineering program where students are acquainted with the mathematical and theoretical underpinnings of engineering. The problem is that in the early part of the program students don't see any demonstration of what the practice of engineering is all about; that engineers create the solutions that serve humanity and improve the quality of life. So they are left with the impression that, "this is not what I signed up for" and they move to another major. The RWEP is intended to address this 'first-year' gap.

It is widely known that we will need many more science, technology, engineering, and mathematics graduates in the coming years and there will be many job openings in these fields. As reported in the US News & World Report [1], there will be approximately 8M jobs in these high technology disciplines within next 8 years. The shortage of scientists and engineers, especially in certain disciplines, will hinder economic growth and endanger further research and development in key electro information technology fields. Therefore projects such as IEEE

RWEP can be useful in attracting more students to study in these promising (but also highly demanding) fields.

RWEP projects allow first-year ECE and other engineering, science and technology students to discover the importance of various engineering and computer related fields of study. Using 'real-life' examples, students solve contemporary problems that elicits excitement about creative problem solving and the impact they can have as engineers. The RWEP provides faculty with fully developed curriculum modules that include specially designed first-year projects.

These projects, showcase how engineers impact society, illustrate real-world problems, allow students to experience trade-offs in the design process, giving them teamwork experience, as well as providing discovery-based activities in the Science, Technology, Engineering and Mathematics (STEM) fields which have attracted considerable amount of attention during the last few years in the US and throughout the world. The importance of attracting university students to study in the STEM fields is highlighted in several recent reports; examples include a study ("STEM: Good Jobs Now and for the Future") by the U.S. Department of Commerce, Economics and Statistics Administration July 2011; Engineering and Technology Labour Market Study Final Report, Engineers Canada and Canadian Council of Technicians and Technologists, May 2009.

II. IEEE AND EDUCATIONAL ACTIVITIES MISSION

Tracing its origins back to 1884, IEEE is the world's largest professional association with more than 400,000 members in more than 160 countries. IEEE members are engineers, scientists and allied professionals whose technical interests are rooted in electrical and computer sciences, engineering and related disciplines. IEEE and its global community of members are dedicated to advancing technological innovation and excellence for the benefit of humanity.

IEEE's purposes are scientific, educational and professional. Through its more than 1300 standards, 150 transactions, journals and magazines, more than 1200 technical conferences and hundreds of continuing education programs, IEEE furthers the advancement of the theory and practice of engineering and computer science in its fields of interest, the professional development of the members it serves and the understanding of the influence of technology on the public welfare.

All of IEEE's programs and activities are made possible through the collaborative efforts of thousands of volunteers and a professional staff. IEEE is led by a diverse body of elected and appointed volunteer members who serve on boards and committees for operational areas as well as representing members in geographic regions. The IEEE Educational Activities Board (EAB) is one such board and is focused on developing, implementing and overseeing programs in the pre-university, university and continuing education areas.

Pre-university Programs are intended to provide young people, and their teachers and parents, with opportunities to understand career paths in engineering and technology and to increase the propensity of young people to select engineering as a profession. University Programs monitors

IEEE's engineering education accreditation activities and develops programs intended for faculty and students in the areas of curricula and professional development. Continuing Education Programs are intended to provide members and others involved in IEEE's technical fields of interest with high quality opportunities for professional development linked to their career and educational needs.

The RWEP is an example of how IEEE furthers its mission. Developed under University Programs to address the specific need of 1st year engineering student retention, it provides faculty members with tools to complement their course work with "real-world hands-on" projects. Each year, thousands of IEEE programs just like the RWEP engage hundreds of thousands of students, members and other technical practitioners in advancing the profession and in serving humanity.

III. RWEP PROGRAM DESCRIPTION

The IEEE RWEP program's ongoing goal is to develop an on-line, open-access library of high quality, hands-on, team-based curriculum modules for use in first-year college courses in electrical engineering (EE), computer engineering (CE), biomedical engineering (BE), electrical engineering technology (EET), and computer science (CS).

To be eligible to apply for this program, a person must be a faculty member who teaches Electrical Engineering, Computer Engineering, Computer Science, Biomedical Engineering and/or Electrical Engineering Technology at a university that grants degrees in accredited EE, CE, CS, BE and/or EET programs.

These curriculum modules are designed to be used by faculty members around the world who teach first-year students in introductory laboratory courses. The modules are stand-alone units each covering about two weeks of instruction, so that faculty can pick and choose the modules they like to build a course that meets their needs. The curriculum modules are specifically designed to be discovery-based, and to illustrate real-world contemporary problems whose engineering solutions benefit society. The projects are planned by faculty experts in such a way that the underlying complex principles and concepts are made tractable for first-year students.

IV. HOW ARE THE PROJECTS CREATED AND VETTED?

Project submission is a three-stage process. First, the proposer submits a one-page summary abstract. If accepted after a double-blind peer review, the proposer is invited to submit a more detailed project proposal. If the detailed project proposal is accepted after another double-blind peer review, the proposer is invited to submit a full project for inclusion in the RWEP project library. After editing and review approval of the full project submittal, the full project is made available to the public through IEEE's University Programs Portal [2]. The rigorous review process ensures that the RWEP is comprised of high quality curricular materials.

At each submittal stage, materials are reviewed based on four criteria: relevance, quality, achievability, and discovery:

- ***Relevance***: Does the proposed project address a problem whose solution benefits society? Is the project presented in the context of a real-world, contemporary application? Are these connections made explicit in the proposed project?

- ***Quality***: Is the proposed project described in a straightforward, organized, and complete manner? Are the proposed project description and methods accurate, clear, and concise? Is the project appropriate for an international audience, and can it be easily replicated at other institutions?

- ***Achievability***: Is the proposed project tractable for first-year EE, CE, CS, EET and BE students? Is the project of an appropriate scope to be done within two weeks of instruction?

- ***Discovery***: Does the proposed project result in student discovery of an underlying principle or concept in EE, CE, CS, EET and BE? Does the proposed project illustrate strategies and design trade-offs that are important in the engineering problem-solving process?

V. WHAT COURSE/INSTRUCTIONAL MATERIALS DOES AN INDIVIDUAL PROJECT CONTAIN?

The set of curricular materials for approved projects posted on the portal consist of:

- ***Background lecture*** (30-40 PowerPoint slides) that motivates and introduces the problem and provides the necessary technical background (for presentation to the students). The impact of the problem's solution on society must be demonstrated and illustrated in the context of a real-world, contemporary application.

- ***Student project assignment*** (2-3 page PDF document) that recaps the problem and details the hands-on project to be conducted (for distribution to the students who would conduct the project). This assignment must detail what the students will do and what they will discover.

- ***Faculty project description*** (3-5 page PDF document) that details the hands-on project (for distribution to the EE, CE, CS, EET and BE faculty who would use the project in class). This description must include a description of the resources needed to conduct the project and explicit directions on how to build/assemble the system (if applicable). This description must also include the necessary data, code, or other methods for executing the project. Finally, this description must explicitly describe the expected problems, strategies, design trade-offs, and results.

- ***Project report solution*** (3 page PDF document) that provides an example to the EE, CE, CS, EET and BE faculty of a successful, complete, student project report. The sections of the project report include: problem definition, methods, results, and conclusions. The report should include graphs and data (as appropriate), the observed trade-offs, the employed strategies, and what was discovered.

- ***Summary lecture*** (20-30 PowerPoint slides) that reviews the problem, the methods for solving the problem, the trade-offs and strategies involved in the solution, and what was discovered (principles, concepts, etc.; this is for presentation to the students). The summary lecture should conclude with the reconsideration of the real-world application and its benefit to society.

VI. IEEE EDUCATIONAL ACTIVITIES AND ASEE FIRST-YEAR PROGRAMS WORKSHOPS

In the 2011 ASEE conference, the ASEE First-Year Programs Division sponsored Sunday workshop on the RWEP program. At the conference, attendees worked on aspects of two related IEEE hands-on Real World Engineering Projects (RWEP). This served as an example of how the freely-available RWEP curricular materials may be used in the participant institutions' first year courses. During the workshop participants discovered first-hand how students design and build project materials and what they learn about engineered solutions to societal challenges and the engineering design cycle.

The workshop activities were based upon two RWEP modules associated with Electrical Engineering: *Pico Power Generation for the Developing World* and *Solid State Lighting for the Developing World*. These collectively work toward addressing a lack of night-time reading light in the developing world. By targeting particular aspects of these projects, workshop participants designed and built rechargeable light-emitting diode (LED) flashlights that could be used to provide light for reading.

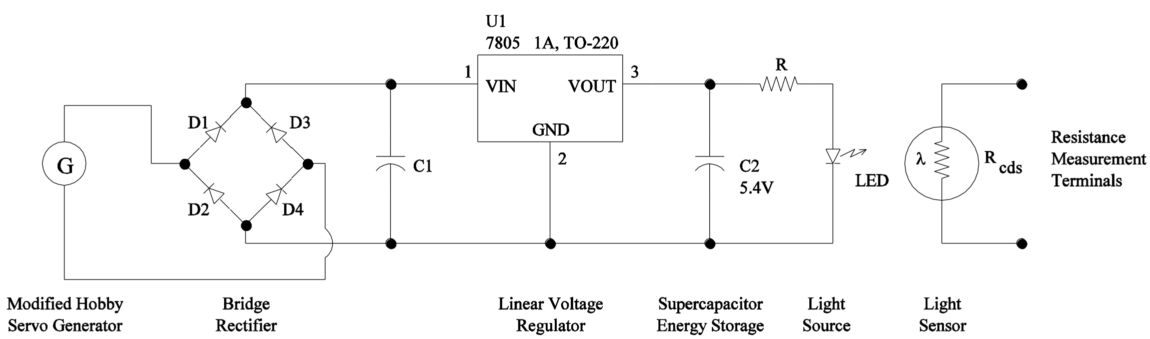
Of the 30 workshop attendees, approximately one-quarter were Electrical Engineers, half were Mechanical Engineers, and the balance from other disciplines and professions. This cross-section of backgrounds was welcomed since a goal of the RWEP initiative is to engage as many participants as possible through hands-on activities and meaningful goals.

The workshop was considered a success. Irrespective of their backgrounds, participants were able to construct working prototypes within the limited timeframe. This required an understanding of the relevant technologies, the tradeoffs present in the design, and knowledge of the goal-oriented design process itself. Participants also acquired knowledge about the IEEE RWEP initiative and its broad library of hands-on projects.

The remainder of this section outlines the project development activities that workshop participants were stepped through. The sequence and depth of these activities was motivated by the time limit of the session. Participants were informed that the RWEP curricula are more rigorous in that structured engineering characterization and analysis is typically required, whereas the workshop focused on qualitative assessment and a brief overview of the characterization methods.

Pairs of participants were provided with kits of parts and equipment required for the development of the LED flashlights. These consisted of prototyping supplies (wire and breadboards), measurement tools (a multimeter and a photoresistor), a hand-cranked DC generator (made from a modified hobby servo), and a variety of electronic components (a 7805 voltage regulator, a supercapacitor, rectifier diodes, and a variety of LEDs and resistors).

Participants were provided the schematic, shown below, incrementally in a left-to-right sequence as they progressed through the workshop activities.



1. In the first step, the generator was characterized. Voltage across the terminals was related to speed and direction of the generator cranking action. Polarity of the voltage depends upon cranking direction, and the magnitude upon the speed. Participants connected a particular LED and current-limiting resistor to see how the cranking speed and direction affect brightness.

2. The effect of the electrical load on generator cranking was explored by shorting the generator terminals: the increased cranking difficulty was related to current draw and energy flow.

3. It was explained that most electronic components require a particular operating voltage range and that a bridge rectifier helps with one aspect of this: voltage polarity. The need for control over the polarity was related to the fact that not all users have the same dominant hand, and therefore will not crank in the same direction. They discovered through breadboard prototyping of the rectifier that this situation was addressed.

4. A linear voltage regulator was introduced to limit the cranking voltage. An LED and current-limiting resistor were connected to show that the brightness had its maximum set via the limited voltage at the regulator output. Heating of the regulator during vigorous cranking was pointed out as a source of energy loss; the use of different regulator technology to reduce this loss was suggested.

5. The energy storage element, a supercapacitor, was introduced. Participants noted that the voltage across the capacitor rose slowly during cranking, and this was related to the time constant of the circuit. Further, discharge of the capacitor while it sat without being charged was noted and the real (lossy) nature of the components was indicated.

6. Participants were then asked to try different LEDs and combinations of LEDs to find a color and brightness of light that they thought would be appropriate for the application: a light source for reading. The importance of the current-limiting resistor and the nature of the LEDs were emphasized. Different participants came up with different combinations (series and parallel), as encouraged and expected.

7. Finally, a photoresistor was introduced for use as an inexpensive light meter. Using this device allows for quantitative evaluation of the amount of light being emitted. The limits of the use of this sensor were noted, indicating that it is important for the user of a tool to know its limitations. It was, however, sufficient for all to note that the light level corresponded to the charge on the storage element, and that this charge was depleted faster with brighter LED configurations.

The session concluded with a survey of the documents associated with the projects. The differences between the workshop exercises and the student exercises were emphasized: students are expected to further verify their observations and discoveries with calculations and characterization. Further, this is used to assess performance of the design as it relates to the overall project objective.

By the end of the workshop, participants had successfully created prototypes, even in the face of underlying complexities. Like students, the participants were guided through technical material in a fashion that allowed them to take satisfying, meaningful steps toward an objective that could improve the world in some fashion. Embracing the complexities of the topics and the design process, rather than avoiding them, serves both as a launching-point for further investigations (topics), and brings about an understanding of what a practitioner in the corresponding area does. In the case of students, understanding that role will aid them in making an informed choice of which program to enter, thereby improving retention.

VII. FUTURE PLANS, PARTNERSHIP WITH INDUSTRY AND FUNDING AGENCIES

The RWEP program is meeting its goals of making state of the art first year projects available for use in first year college programs globally. As more faculty members become aware of the availability of these IEEE sponsored projects, the advisory committee is working with authors who are using these modules for their classes to get their input and conduct an assessment of the student learning. We also plan to partner with industry and business who have projects for the

K-12 learning activities so that some of the hardware/software can be incorporated into the RWEP projects keeping in mind that we want to avoid any commercial message or specific product advertisement. Because of the importance of STEM programs for the funding agencies such as the National Science Foundation, we would like to prepare proposals to NSF and other agencies for possible funding so that we can attract more schools to adopt these first year freshman engineering course materials and encourage more students to major in the fields covered by the RWEP program. Recently we have participated in several conferences including Frontiers in Education (FIE), ASEE 2011 Annual Conference workshop in Vancouver and plan to have exhibits at the IEEE International Conferences on Electro Information Technology [3]. We would like to gather feedback from some of the authors who have used their own projects instead of RWEP as part of program improvement.

Furthermore, we plan to continue building the RWEP library, identify topic gaps and recruit new project authors. A communications and marketing plan is being developed to promote the use of RWEP in classrooms and as part of first-year curriculum. An assessment plan to determine if the RWEP having the intended effect will seek answers to the following questions. How many faculty are using the projects in their lesson plans? How many students have used the projects? How have faculty viewed the project? How have student users viewed the project? The long-term plan is use of the projects helping to expose first-year students to the real practice of engineering and having an impact on retention and recruitment of new students to these fields. We are currently looking at RWEP assessment plans and how to move forward.

VIII. RWEP STATUS

Since 2007, the portal has grown to 25 approved projects. Each year, the number of approved projects added is a function of the committee review process and of the diversity of library topic areas. The library presently offers the following projects:

- Error Correction Codes for Wireless Communication Systems
- Manipulating Everyday Objects With Prosthetic Hands
- Solid State Lighting for the Developing World
- Power Electronics System: A Look at Renewable Energy
- Smarter Vehicles
- Feedback Controlled Brushless DC Motor with Personal Electric Vehicle Application
- The Coding of Sound by a Cochlear Prosthesis
- Pico Power Generation for Developing Nations
- Design of a Guitar Tab Player in MATLAB
- Human Energy Generation and Electrical Signal Measurement
- Image Processing: Image Enhancement and Watermarking
- Developing a Personal Health Record Using Visual Studio .NET
- Arrhythmia Detection Algorithms for Implantable Cardioverter Defibrillators
- Language Identification Software
- Discovering Wireless Sensor Networks: Applications in Structural Health Monitoring
- Study of Piezoelectric Materials for Energy Harvesting

- Water Desalination via Energy-Efficient Capacitive De-Ionization Process Employing Nanomaterials
- Electrocardiogram Amplifier Design Using Basic Electronic Parts
- Microcontroller-based Smart House for Improved Energy Efficiency
- Computer Science: Map Mashups
- Digital Logic: Hardware Implementation of the Smith-Waterman Algorithm for DNA Comparison
- Coping with the Emerging Energy Demand for Charging Plug-in Electric Vehicles
- Public Service Announcement Movies Made with the Alice Programming Language
- Remote Surgical Robotics: control systems and human-machine interfacing
- Vehicle Passenger Safety: Exploring Whiplash Protection Systems
- Birth Weight Measurement in Midwifery and Mobile Health Care Delivery

IX. CONCLUSIONS

We have presented a successful program to introduce incoming first year engineering and science students to the electrical/computer engineering and closely related fields by providing the faculty members with realistic engineering projects to be used for a period of two weeks so that students can perform simple experiments in important application areas of the electro information technology with impact to the society. We have presented the essential elements of the IEEE's RWEP program and discussed the following aspects of this important educational activity for the world-wide audiences:

- Success in establishing RWEP and in creating the process for vetting projects
- A complementary mix of projects available for faculty use
- Successful workshops at ASEE and FIE and other venues
- A program that is positioned well for expansion and full implementation

The future development plans include assessment results collection, partnership with business and industry. Plans also include seeking support from funding agencies for the program's growth as well as reaching more universities and attracting additional authors for the first year engineering projects.

REFERENCES

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