INTEGRATED PROJECTS CURRICULUM: OPPORTUNITIES FOR HANDS-ON ALTERNATIVE ENERGY PROJECTS

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The Department of Engineering started a new curriculum called the Integrated Projects Curriculum (IPC) in 2007. It is a seven course sequence starting in the sophomore year of the engineering program and includes many projects in areas such as transportation, communications, disability resources, water, biomedical, and energy. The focus of this paper is the numerous projects found in the Energy Group of IPC. The Energy Group students work on projects which include producing and using alternative fuels (biodiesel), designing and building solar photovoltaic and solar heating systems, and use of wind energy. Several projects have received grants from the United States Department of Energy, Pennsylvania's Sustainable Energy Fund, and the Innovation Transfer Network

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Introduction

The Integrated Projects Curriculum (IPC) [1] is a seven course sequence in Messiah College's Department of Engineering. Starting in the sophomore year, all engineering majors take a Group Orientation course, choosing or being assigned to one of six areas: biomedical, communications, disability resources, energy, transportation and water. In the junior year the students begin four project courses in their chosen group, finishing in their last semester at the college. The students also take two seminar courses in their senior year relating to vocation and practical matters such as graduate school, job search strategies, finances, etc. These are writing intensive seminars. This year there are 22 engineering majors in the Energy Group, divided into five major projects; biofuels which includes production of biodiesel, researching of feedstocks, and a methanol recovery system, three solar photovoltaic systems, and a solar hot water heating system. Students are responsible to research, design, specify and order components, build the system, test and re-test, and document the development of each step of the project for the specific project area that they are involved in.

Biofuels

Alternative biodiesel fuel production has been going on for many years at Messiah College using the waste oils from various dining halls and snack facilities on campus. Before IPC was initiated, students had developed a mobile trailer with a 40 gallon biodiesel production capability. As part of the IPC, a methanol recovery system using the waste glycerol from the production process has been completed. Students have also taken the initiative to develop a smaller production unit and a smaller methanol recovery system, utilizing funds from US Department of Energy [2] and the Innovative Transfer Network [3]. This year there are seven IPC students working on this project. Basic goals for the biodiesel project group include:

1] Develop a process(es) that converts any location-appropriate feedstock to ASTM-standardized biodiesel fuel in appropriate quantities. For example, feedstocks may include switch grass, rape seed oil, palm oil, etc.
2] Consistently produce ASTM-quality biodiesel fuel on Messiah College campus for local consumption.
3] Provide and maintain a manual that addresses all safety and maintenance concerns, clearly describes systematic procedures, and provides a user-friendly list of input variables with instructions for dealing with them.
4] Create a business plan for implementation of community biodiesel reaction facilities both here in the USA and overseas.
5] Minimize waste by managing glycerin and other biodiesel side streams.

IPC students are also involved in developing a quality control lab as part of the 3 year DOE grant . Five key tests associated with ASTM D6751 quality standard for biodiesel have been identified for this lab. These tests include: ASTM D 93 Standard Test Methods for Flash Point by Penksy-Martens Closed Cup Tester, ASTM D 2709 Standard Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge, ASTM D 2500 Standard Test Method for Cloud Point of Petroleum Products, ASTM D 664 Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration and ASTM D 6584 Test Method for Determination of Free and Total Glycerin in B-100 Biodiesel Methyl Esters by Gas Chromatography. Equipment has been purchased, procedures are being developed, and testing is being performed to verify the biodiesel fuel is meeting the ASTM standard.

Solar Photovoltaic Systems

The students in the Department of Engineering have been involved in designing and building solar photovoltaic systems since the 1990's either as part of senior projects or through the Collaboratory [4] Most of the systems have been designed for countries in Africa such as Burkina Faso, Zimbabwe, Mozambique, and Zambia. Projects have included 24-hour electricity service for a maternity clinic, a solar water pump facility for a handicap rehabilitation center, a pilot grid-tied electricity for a theological college, and a system for well water and electricity for a mission and development station.

Recently the IPC students completed a Solar Scholars project for a pavilion on the Messiah campus, partially funded by a Sustainable Energy Fund (SEF) grant [5]. The 3.3 KW system is

housed in an outside pavilion named in honor of Clifford L. Jones. The system is used to input energy to Frey Hall on campus. The pavilion is also used as part of the Oakes Museum educational tour for elementary and middle school students. Last year a solar PV demonstration cart was also designed and built for the tour by the IPC students. There are three students involved in this project.
This year's goals of this project include:

1] Install an Internet connected monitoring system capable of displaying real-time data and operating conditions of the solar pavilion.
2] Install a heating and cooling system for the pavilion's monitor.
3] Complete maintenance documents for the solar pavilion, including documents for general system maintenance, battery maintenance, and battery equalization.
4] Continue maintenance of the batteries and other components in the pavilion.

A solar PV system has been developed for Grace Mission Conference Center in Haiti. This system is scheduled to be implemented in January 2010. Four IPC students will be travelling to help oversee the installation. Specific goals included:

1] Design a potentially expandable system to supply 100% of power to the conference center under normal circumstances
2] Install and test the system to ensure proper operation
3] Create a manual that explains how to properly maintain the system and troubleshoot basic problems
4] Train a team of people permanently on site on the general maintenance of the system so the system can operate with as little outside assistance as possible

A third IPC project is the kilowatt hour meter project for use in the solar PV systems already installed in Mahadaga, Burkina Faso. This multi-year project will design and construct a device capable of providing feedback on the amount of electrical energy used by a house or small building and also limiting usage based on a set energy quota. There are three systems which need to be monitored and then the energy shared with the villagers. Three students are involved. The multi-year goals include:

1] Design and construct a first generation KWHR meter based on the proof-of-concept device, which shall include all functionality of the proof-of-concept while also conforming to safety and environmental requirements.
2] Coordinate with the client in Burkina Faso to conduct a complete, in-field functionality test and document the test with a complete report of successful and failed functionality, recommended improvements, and other relevant information.
3] Perform a manufacturability analysis of the first generation device and document with rationale any necessary design changes for cost-optimization or ease of manufacturing.
4] Design and construct a prototype of a second generation device incorporating the results of the in-field test and manufacturability analysis conducted using the first generation device.

5] Construct between 5 and 10 second generation devices and coordinate with client to implement them in Burkina Faso in conjunction with the existing solar energy systems at the mission station.
6] Conduct a long-term use test of the devices, documenting any further design flaws or desired changes.
7] Write user's and installer's manuals for the second generation device, incorporating feedback from client and other testers.

Solar Hot Water Heating System

Solar hot water systems have also been designed, built, and tested by students before the IPC curriculum started. Presently a system is being designed for the Theological College of Zimbabwe. Five students are working on this. The basic goals are:

1] Design and/or build/develop a working thermosyphon system from existing solar heating systems obtaining hands-on experience on how it is constructed and how it works.
2] Disassembly and reassemble it from scratch and write a user friendly instruction/assembly manual, forming a “kit”.
3] This thermosyphon “kit” supplied with components and assembly manual will be sent to Zimbabwe for the client to assemble on their own.
4] Ideally, the students will oversee actual assembly.

Hands-On Experience for the Students

As one can see from the examples of the projects mentioned above, the IPC curriculum gives students ‘real-world”, hands-on engineering experiences with clients’ projects. In the Energy Group students gain much knowledge in the areas of alternative energies, develop good teamwork and communication (verbal and written) skills, and have opportunities for leadership.

Each project has a faculty advisor with some projects having additional advisors/consultants that are alumni and still live in the area.

Seniors often are the project leaders, carrying much of the oversight of the project and mentoring their replacements.

The main evaluative tool for the IPC curriculum is a portfolio required of each student before he/she graduates. The portfolio contains artifacts which represent the student’s work in ten areas which ought to be accomplished before leaving with a degree:

1] Teamwork (mentoring, communication, brainstorming, conflict resolution, leadership)
2] Project Management (writing and carrying out SMART goals, scheduling using Gantt charts)
3] Client Interface (working with a client, evaluation of needs, assessing results)
4] Research (gathering, organizing, and evaluating information)
5] Analysis/testing (analysis, testing of prototype)

6] Design (design process, application of engineering principles)
7] Economic analysis (budgeting, economic justification)
8] Prototype Implementation (manufacture of toleranced parts, writing software)
9] Documentation (engineering drawings, written reports, Wiki pages, logbooks, slide show presentations)
10] Dissemination (oral presentations, interaction with clients)

Conclusion

The introduction of the IPC curriculum has been successful by giving many opportunities to the engineering majors to develop ‘real world’, hands-on experiences. For the Energy Group of IPC, alternative energy systems are explored over the 2 ½ years of the curriculum. Students are involved in every aspect of a project; from initial concepts, to designing and specifying components and systems, to building prototypes, to testing and re-testing, to documenting for client’s and future IPC students, and to actually implementing the results of the project for the client, be it here in the USA or overseas.

The Integrated Projects Curriculum is “an approach that integrates knowledge, skill, and purpose through a consistent focus on preparation for professional practice [and] is better aligned with the demands of more complex, interactive, and environmentally and socially responsible forms of practice”. [6]

References

1] “Integrated Projects Curriculum”, Integrative Learning Conference of Association of American Colleges and Universities (AACU) Conference, Denver, CO, October 2005.

2] Research and Development Grant, US Department of Energy, Award No. – DE-FG36-08GO88068, June 2008.

3] Seed Assistance Grant, Innovative Transfer Network, Contract Number – SG08-09, May 2009.

4] For more information on the Collaboratory for Strategic Partnerships and Applied Research, see the website http://www.messiah.edu/Collaboratory/.

5] For more information on the Sustainable Energy Fund, contact Bill Dougherty at wdougherty@thesef.org.

6] Tatu, Robin, “A Call for Radical Change”, ASEE *Prism*, September 2009, pg. 60 excerpted from “Educating Engineers: Designing for the Future of the Field”, S. Sheppard et al, Thunder’s Mouth Press 2008.