Introducing Freshmen to Engineering Design: Weather Station Project

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Introduction

In recent years there have been many examples of engineering curriculum reform in the freshman year [1,2,3,4]. Some involve adding design to existing freshman courses [3], others involve the development of optional design courses [1,2], and yet others are quite focused on a particular engineering topic such as modeling [4]. This paper reports on a group design project that is part of a required engineering course that was designed during a major curriculum reform effort at Union College.

Union College is a private, undergraduate liberal arts and engineering college with approximately 2000 students. The engineering division offers programs in electrical, mechanical, civil and computer systems engineering as well as computer science. In 1995, the college was awarded a grant to revise the engineering curriculum. The freshman year was redesigned to include three 10-week trimester courses, illustrated in Table 1, that were common for all engineering and computer science students [5]. This course sequence included the equivalent of one course in computer programming, and two courses in basic engineering science and design.

Freshman Sequence: Fundamentals of Engineering and Computer Science		
Fall Term - ESC-016	***Winter Term - ESC-017***	***Spring Term - ESC-018***
Introduction to Engineering Modules and Case Studies	Engineering Science Topics	Design Project
	Computer Programming	Computer Programming

Table 1. Union's 1996-1998 Freshman Year Engineering Curriculum

The fall term course was an introduction to engineering through a series of modules and case studies. In the winter term students began the computer programming section of the course and were introduced to specific engineering science topics such as energy, statics, instrumentation, digital logic and assembly language programming. These topics were selected to prepare students for the spring design projects. In the spring term, students completed the second half of the computer programming sequence and a large design project. Students were allowed to select one of 2-3 design projects offered. Since the spring term design project occupied one half of a course, the contact time was limited to one 2-hour lecture and one 3-hour lab session each week. In the spring of 1998, the design project choices were a Newcomen steam engine [6], a truss bridge[7], and a weather station. Here we report on the weather station design project.

Project Overview

One of the original objectives of the spring design projects was to make them multidisciplinary. Multidisciplinary projects help motivate students to be interested in topics outside their eventual major and to appreciate the connections between disciplines and the need for life long learning. The projects also needed to be large enough for every student to play a valuable part while still holding out the possibility of completion to a functional state within one ten week term. The activity therefore needed to be fairly large, realistic, and multi-disciplinary and to have some longevity past its completion. The last criterion, longevity, was used both as a motivational factor for the students and also to serve as a point of reflection later in their education.

Another criterion for the formulation of the project was choosing a topic that all freshmen could relate to, not only in a superficial manner, but deeply enough to be interested in the portions of the project assigned to other students. This natural cross-disciplinary interest was important in the liberal engineering education required in the first two terms of their freshman year. Student interest in the worldwide web helped to generate the idea for a web-based weather station, designed from scratch, incorporating sensing, signal conditioning, meteorology, mechanical construction, data-acquisition, and information manipulation. Students were allowed to select one of the three spring design projects and of the 76 spring 1998 engineering students, 23 chose the weather station project.

A misconception that many engineering students bring into their undergraduate careers is that engineering is practiced as a democracy. To dispel that notion and to introduce students to some of the realities of industries driven by bottom lines, deadlines, and product safety issues, a "project team" model was used. The task was broken into functional areas. Each area had a "project manager" and a team. The managers further subdivided the functions into tasks for one or more students. Faculty members served as the project managers, a realistic analogy to industry where project managers tend to be senior members of the organization who have survived numerous similar activities in the past.

The overall structure of the project divided the participants into three groups. The major groups were sensors, acquisition, and data warehousing and display. The sensors group designed the devices that measured the physical quantities associated with weather phenomena and conditioned the signals into values compatible with the acquisition group. They additionally designed and constructed the physical elements of the weather station and its enclosure. The acquisition group took the signals generated by the sensors group and converted them into digital quantities representative of standard units of measure. In addition, their software smoothed and buffered the information in a micro-controller, which interfaced with the data warehousing and display group via a homegrown serial digital protocol. The data warehousing and display group recorded the information from the acquisition group for archival study and also for real-time presentation on the WWW. Each of these groups was divided into sub-groups as needed to break the multitude of tasks into blocks manageable by one to several students.

The project structure presented a challenge to transform a class and lab meeting schedule into a semi industry-like design experience. Class meetings were converted into design meetings with a progressive set of objectives. The first two weeks were spent learning about teamwork, communication skills, and project expectations. In brainstorming sessions students were asked to talk about what would be useful in a weather reporting system, how it should work, whom it should serve, and what is important to meteorologists and the layman concerning weather phenomena. They were given assignments to find specific examples of web-based weather reporting and to contrast these approaches.

During the next six weeks class meetings were used for design presentations and discussions. These were formal presentations of progress, concepts, group interface issues and general problems and their subsequent solutions. All students where required to present information about their respective tasks. Even if a sub-team consisted of several people, each was given the opportunity to present the group's status and information on a rotating basis. Communications as a key element of the design and engineering process was stressed with a particular emphasis on communicating ideas to peers as well as those of other disciplines.

The last week was used for public presentations of the project to an audience that was completely unfamiliar with the project. The objective was to leave the spectators with an understanding of what the team was attempting to accomplish, the problems encountered, the solutions devised and the final results.

Lab time was used initially to build the prerequisite knowledge base for each project team. Topics of these lessons and exercises covered a diverse range including electronics to support sensors and signal conditioning, microprocessor programming, Unix and WWW programming and the mechanical design of sensors and support structures. This may seem like a daunting task but it carefully built on subject matter covered in the previous terms. The students already were familiar with the rudimentary concepts of signals, programming, information representation, and mechanical design. This was a well-received move into the practical aspects of their previously theoretical and academic endeavors in the liberal engineering program. Finally the mechanical engineering students began to see some reason behind their assignments in computer programming; the electrical engineers saw application of the stress and strain lessons, the civil engineering students found reasons for studying circuit design. As the preliminary lessons were completed, the students began to use the lab time to do their design work and then finally the integration and construction of the elements of the weather station.

Structure was maintained during the project by using carefully chosen assignments. In the beginning these assignments consisted of research about weather phenomena, how they are measured and their meaning to the forecasting and reporting of weather. As another structuring element that spanned the entire term, the student teams were required to keep an engineering notebook, summarized on a weekly basis, on a team web page. Their weekly presentations were given using their web based engineering notebooks. In addition, their final presentation was a web-based document. A byproduct of the online nature of the engineering notebooks and final report is their work is currently available to any interested party via the WWW [8].

To keep the project on track and teach the lesson of time management, the project managers published milestones on the course web page. Both overall system milestones such as "system assembled inside and tested" and team milestones such as "build, populate and test PC board" were posted at the beginning of the term. The team milestones implied individual assignments for each week and these were enforced by a weekly grade for the design presentations.

The importance of interface between working groups and the interdependence of milestones was stressed. Design teams were required to use time constraints and group interaction as a part of every design decision. Also, the concept of communicating problems and issues early and clearly became crucial to the smooth operation of the teams. For students who had been trained to compete against each other academically, this was not an easy transition. The ingrained response to downplay the accomplishments of others and highlight those of the individual surfaced on several occasions and it was the job of the project managers to reiterate that the only road to success was guided and structured teamwork.

Design Team Objectives: Sensors

The sensors team consisted of several sub-teams. The tasks of each sub-team were to investigate and select appropriate sensors, understand their operations, select the range of operands for the sensor and design and build the signal conditioning circuitry needed to interface to the acquisition microprocessor. In addition, one group also had the responsibility to design the power supply for powering the sensors and the signal conditioning circuitry, and another was given the task of designing the enclosure for the electronics and mounting for the sensors. After initial brainstorming, the group decided upon seven parameters to measure for the weather station: precipitation, wind speed, relative humidity, temperature, UV level, wind direction and barometric pressure. After researching available sensors, the group decided to implement the first three parameters to provide pulse/digital inputs to the processor and the last four to provide analog inputs. The decision was made in part to simplify the acquisition microprocessor software by eliminating the need to switch between analog input channels of the microprocessor to be used.

A commercial precipitation gauge was procured for precipitation monitoring. It consisted of a tilting bucket sensor with a switch closure to count each tilt. After measuring the catchment area and the bucket volume, the group verified that each tilt of the sensor was equivalent to 0.01 in. of precipitation. The team also determined the power requirements for a heater to convert snow ice to water for measuring liquid equivalent in the winter. The switch closure was interfaced with the pulse counter sub-system of the microprocessor through a switch debouncing circuit so that only one count would be measured per bucket tilt.

A capacitance type relative humidity sensor, Micro-CAD2 by Panametrics, was procured for measuring relative humidity. This is a low cost sensor used in home humidifiers. The sensors characteristics are stable but they offer a $\pm$ 20 percent capacitance variation from unit to unit. An RC oscillator circuit using an op-amp was designed and built where the waveform period was directly proportional to the sensor capacitance within $\pm$3 percent. The circuit was calibrated against a commercial relative humidity meter in a glass fish tank in which the relative humidity could be varied. The calibration data was nearly linear and was supplied to the data acquisition group. The period of the positive phase of the oscillator output, after suitable calibration, served as a measure of relative humidity.

Wind speed was measured using an airplane anemometer. The output waveform amplitude of the anemometer was also proportional to the speed of rotation of the anemometer. A clipping circuit was built to prevent overloading the input circuitry of the microprocessor. The anemometer output frequency was calibrated against a hot-wire anemometer by placing both in a wind tunnel. It was decided that the frequency of the anemometer output would be determined by measuring the waveform period using the input capture function of the microprocessor. One problem with this approach is that on a calm day the measured period would be infinite. The sensor and the acquisition groups agreed that a wind velocity of less than 1 mph, where the period measurement would overflow a maximum value would be considered a calm value of 0.

Temperature was measured using a Motorola LM34CAZ Fahrenheit temperature sensor. To accommodate for temperatures below 0°F, the sensor output was offset using a negative voltage and a resistor combination. The resulting voltage was converted to a range of 0V to 4V corresponding to a temperature range of -40 °F to + 120 °F.

For Ultra-Violet radiation level measurement, a commercial UV sensor (Davis model 7843) was used. This unit provides a 0 to 2.5 V output for UV levels corresponding to UV index ranges of 0 to 16. In our measurements during the term, we did not encounter levels above 3. The unit's output was amplified by a factor of 2 before providing it to the microprocessor input.

Barometric pressure was measured using a Motorola MPX4100A sensor donated by Motorola, Inc. This unit provides a 0V to 4.96V output corresponding to a pressure range of 0 to 15.2 psi corresponding to a range of 0 to 30.9 in. of Hg. A circuit was designed and implemented to expand the transducer voltage range of 4.1 V to 5 V to correspond to a voltage range of 0.12 V to 5 V to provide higher sensitivity of pressure measurement. The corresponding output voltage for 29.9 in. of Hg (1 Bar) was 3.91 V.

Wind direction was measured using a weathervane connected to a Midori precision potentiometer. The potentiometer had a dead band, which was placed between N and NNE. Potentiometer output was converted to range between 0.4V to 4V. Sixteen ranges were chosen for wind direction. It was decided that the effect of the dead spot would be resolved in the microprocessor software.

Sensors were mounted within and on top of a PVC pipe structure in the form of a T. The rain gage, UV sensor, wind direction and wind velocity sensors were placed atop the T. Temperature, pressure and relative humidity sensors were placed within the pipe that was perforated at the bottom to permit accurate sensing. The T was clamped to the back of a NEMA enclosure. The enclosure housed the microprocessor and the signal conditioning circuitry. Connections from the sensors to the enclosure were made through weatherproof connectors. Another set of weatherproof connectors was used to connect the enclosure to the data acquisition computer and to supply power to the enclosure. The enclosure was insulated with polyurethane foam and was provided with a heater to control inside temperature during the Schenectady winters. Electronic circuitry operating voltages and precision reference voltages were developed within the enclosure from 24 V AC power supplied through one of the connectors.

The students developed Figure 1 to describe the sensor subsystem.

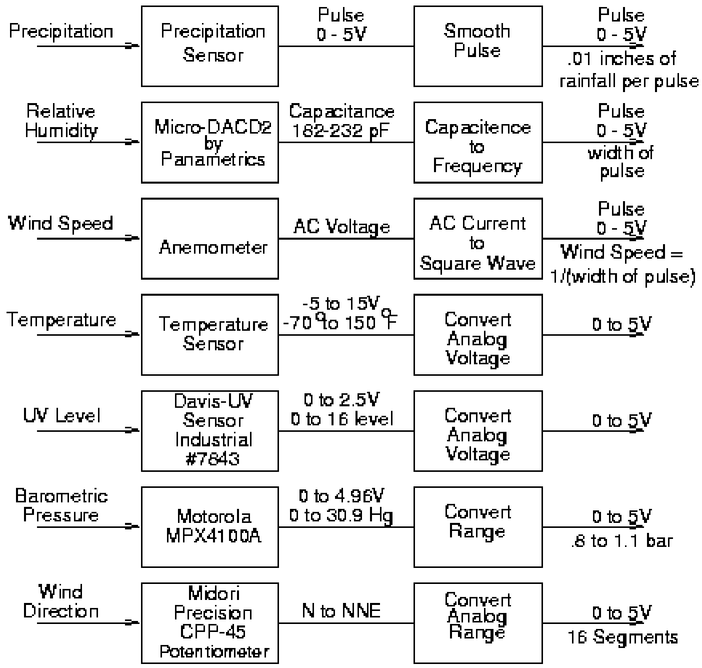

Figure 1. Block Diagram of Sensor Designs

Design Team Objectives: Acquisition

The acquisition team consisted of five students and their task was to design an interface between the weather station sensors and the main host computer that ran the data warehousing and display software. The interface included a Motorola 6811 microcontroller and software to sample and condition the data from the sensors and to send the data to the host computer when requested.

Students had already been introduced to microprocessor programming in the winter term, but needed to learn more of the instruction set and about some of the systems specific to the Motorola 6811 microcontroller such as the pulse accumulator and the A/D converter. Simple assignments were given in the first weeks to lead students through this material. Once the brainstorming and design of the overall weather station was complete, students were assigned to particular sensor subsystems (wind direction, humidity, temperature, etc). One student was assigned to work on the communication protocol with the host. The students developed the diagram in Figure 2 that represents the structure of the hardware interface of their project and illustrates the connections to the other subsystems.

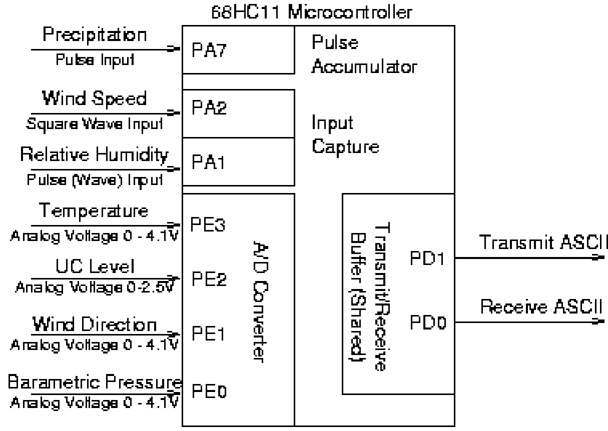

Figure 2. Acquisition Team Interface Design

Each student developed a subprogram to interface with the sensor(s) assigned. Students had to work closely with members of the sensors team to understand the meaning of incoming signals. Some were analog signals, some were pulses, and some were variable frequency signals. The signals were converted to "real world" units and then stored in memory. Once the individual programs had been written and tested, they were combined into a single program. The overall program was a simple loop that continually updated the values in memory and checked for a request from the host. The student working on the protocol design was also responsible for constructing the final program from the subprograms developed by other students. Once the final program was constructed and tested on the development system, it was programmed into the target EPROM 68HC11 microcontroller that would be mounted inside the weather station.

Design Team Objectives: Data Warehousing and Display

The data warehousing and display team (DW&D) was primarily focused on several objectives that were mostly software based. The work of this group can be seen as a flow of information from the acquisition group to the WWW. This flow naturally divided itself into three major areas. Interfacing with the acquisition group was done by the protocol sub-group, storage and condensation of the information was performed by the storage group and presentation was handled by a web sub-group.

The interface or protocol group needed to develop a reliable and robust method of getting information from the acquisition groups micro-controller to the Unix system for processing. This required very close interaction with the sub-group handling the protocol in the acquisition group and a well-structured interface for handing off the data to the sub-group in DW&D that was handling the storage and condensation of the information.

The storage and condensation sub-group needed to pick up the information imported by the interface sub-group and deal with several tasks. The real time information was provided directly to the display group after dealing with final transformation into real-world units and also compensating for and reporting gaps or failures of the acquisition and interface mechanism. When weather information was not making it to the DW&D group the web presentation of the data had to indicate that the information was not present rather than continue to present out of date information. In addition the storage and condensation group averaged appropriate weather information over several different granularities, hourly, daily and weekly and made it available for download and study via the web presentation sub-group.

The presentation sub-group created the interface that a browser would see when accessing the project's web site. This interface consisted of several progressive iterations of the real-time weather station display and a scaleable interface to the archival weather information offered in several formats.

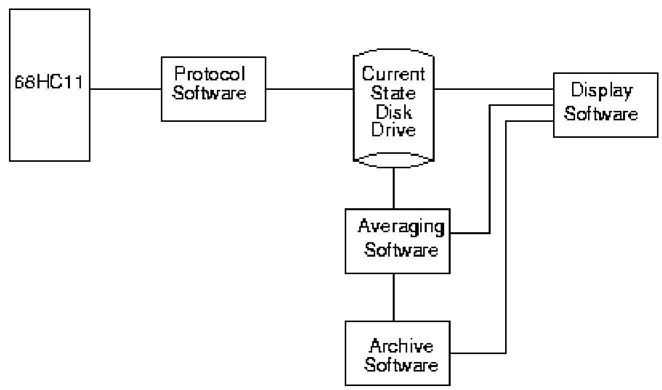

Figure 3. DW&D Team block diagram

Obtaining the background knowledge for these tasks was formidable but it worked out well because of the strong desire of members the group to learn. In addition, no preconceived boundaries were placed on their work other than the time and minimum deliverables. They were never told which aspects of their work were considered difficult in a traditional academic sense.

The interface sub-group was faced with acquiring enough knowledge about communication protocols to be able to write a robust transport mechanism. In previous terms they were introduced to the concepts of signals carrying information, the representation of numeric values using parallel binary signals and then the multiplexing of signals over the same lines. They had heard of "serial ports" and were familiar with ASCII but knew little else. Their initial investigations were to understand the RS232 serial interface and how symbols were sent over this interface. They experimented with asynchronous data, observed it on an oscilloscope and were able to capture using triggering a character and tell what it is.

The next experiment they conducted was to connect the micro-controller to the Unix (Linux) system via a their serial ports and attempt to send a symbol first in one direction and then the other. They observed the transit of the characters with a dual channel scope. Soon they began to see the problems associated with debugging such an interface and gladly learned to use a simple line protocol analyzer. Next, they experimented with a rudimentary ways to get information from the micro-controller to the Unix system, soon discovering that one of the two systems should be "in charge" and wisely settling on the Unix system as the controller.

The micro-controller was programmed in 68HC11 assembler and the Unix system in Perl. They were given some resources referencing protocols, checksums and error checking in general and asked to incorporate this into their query-response code. Through a combination of reading resources and discovery they began to realize that there were many complex issues including timing, loss, and when to give up. They also discovered that their if-then-else programming structures were getting too complex to deal with all the problems. The project manager then introduced the concept of a state-machine, which when adapted to their problem allowed them to progress to a reasonably reliable protocol.

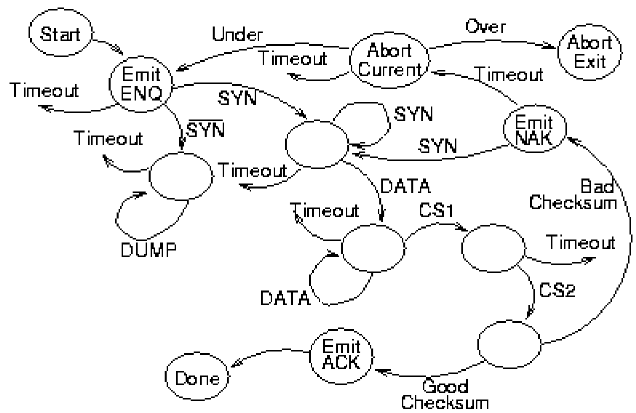

Figure 4. Protocol State Diagram

The data was already converted into ASCII representations of the values in the acquisition group's micro-controller so it was fairly straightforward for the interface sub-group to get the information into a format that the condensation sub-group could deal with. They jointly decided to poll the acquisition group once a minute and write the information into time-stamped files for processing by the condensation sub-group. Again, in a decision involving time versus performance they chose to use the Unix file system rather than more sophisticated techniques of inter-process communications.

The condensation sub-group was made up of computer science majors who had to decide on a programming language in which do to their work. Their first choice was C++ with which they had the most experience but that was soon supplanted by Perl because of the rapid development turnaround and powerful string and manipulation nature of the language. In addition to providing the interface between the raw polled data and the display group they were also responsible for providing realistic simulated data for the display group so they could progress in parallel. A large amount of the design effort expended by this group was focused on storage requirements, archiving, and the creation of realistic test data. This group was the most self-guided of the three sub-groups in the DW&D group.

The last sub-group was the display group. It was responsible for presenting the real-time information on the web and creating an interface to the archival data. It was difficult for this group to accept a progressive approach to the display of information. Their initial design was a fully animated weather display with dials and readouts written in Java. Their perceived pressure from the rest of the project team to build a "sexy" interface made it difficult for them to proceed methodically and do a step-wise refinement type design.

Eventually they settled into a methodical approach to the problem and built some fairly sophisticated CGI code in Perl on the Unix platform to power their pages as well as unique Java applets that tackled inter-applet communication. Simple examples of Perl CGI scripts were supplied along with references to numerous Perl resources as a starting point. Their initial assignments involved displaying simple information in text form from random number generators and then from files on the host system. They settled on a three tiered approach to the real-time display, first a simple self-reloading text display of the information, then a real-time Java display with text readouts that were self-updating and finally an animated instrument style display that mimicked physical weather instruments.

The DW&D group made significant progress because they were supplied with enough information to make informed decisions, but still allowed to experiment on their own. The success of this type of learning experience required the supporting faculty to be closely tuned to the progress of the various subprojects and willing to adjust the learning assignments. These adjustments were made in a dynamic manner to specifically fill the needs and knowledge gaps of the students. In this manner, each faculty project manager was a combination of educator, mentor, boss and collaborator. By carefully injecting examples, partial solutions, or similar mechanisms project managers empowered the students to learn in an exploratory manner.

Each group was encouraged to produce testing environments in collaboration with their adjacent interfacing groups. Even with this methodology, interface problems were inevitable. Analysis of these failures provided material for the classroom discussions and presentations.

The end result was a reliable self-recovering communications protocol that fed a condensation mechanism which made real time and archival information available to a CGI driven Java based display system. They never did get the dial gauge look-alike applets finished but they did have real time text displays with bar graphs operating by the end of the term.

Teamwork and Communication

In previous design projects where course objectives included teamwork and communication, students were left to "discover" these skills by necessity. The weather station project was also designed to require a lot of communication and teamwork, but we also chose to provide instruction on these topics at the beginning of the project. We used a discussion format and went over the specific individual skills that are required for good teamwork and communication. As the project progressed we continued to point out where these skills were important, and to evaluate the student's performance in these areas.

Project Assessment and Further Curriculum Revision

The objectives of the weather station project included the technical objective of achieving a functional weather station and student outcomes including teamwork, communication, documentation, design and ethical decision making skills. The technical objectives were mostly met. Each team demonstrated working subsystems. Time ran out for complete system debugging, but the full integration was completed by the end of the term. The final project presentation and design reports demonstrated the result of the teamwork, communication, documentation, design and ethical decision making skills that we were hoping for. Students were very enthusiastic about the project and in the following academic year they formed a "Union College Weather Station Club" to continue to work on the system debugging and installation.

Although the engineering modules in the winter combined with the spring design projects were very successful, they were also expensive. The number of faculty involved in the winter and spring (not including the computer programming section) resulted in a student faculty ratio of about 9:1. The projects are also expensive in terms of equipment and materials costs.

The spring of 1998 was the last time that the large design projects were offered. Assessments revealed that the addition of the two courses to the freshman year resulted in a workload that many freshmen could not handle. There was also an increasing sentiment in the division that students should be spending more time on their math and science courses. The new Dean of Engineering entering in the fall of 1998 decided to address these problems by reducing the engineering science and design content of the freshman year. This was done in two steps. In 1998-1999 the spring term design project was removed from the curriculum and in 1999-2000 the winter term engineering science part was removed.

The freshman year now includes a single introduction to engineering course that takes place in the fall term. The computer programming part is a separate course. The design component has been moved into the fall course in the form of a lab/studio experience where students do in-class exercises to learn design and teamwork skills, and then work in teams to build a device for a design competition. The lab/studio design competition idea was first introduced in the winter of 1999 to replace the engineering science modules. It was then incorporated in the fall term course in the fall of 1999. The single course is now run with a student faculty ratio of about 20:1. Further assessment will be needed to determine if this approach is successful in meeting the objectives of the freshman year experience.

Conclusion

The weather station project was an ambitious and successful freshman design project. Students were exposed to a realistic design problem and provided with both technical information and instruction on how to communicate and work in teams. The emulation of an industrial environment forced students to rely on teamwork and communication skills to accomplish their task. The final results, illustrated on the web pages and the physical weather station, attest to students meeting the objectives. More pre-planning and a slightly longer term would be needed to complete the debugging stage to produce a working final product. However, the formation of the student-run weather club to complete the debugging also has many virtues.

Although this type of large, realistic project has many advantages, and has been supported and praised here at Union, the reality is that long term support is difficult to maintain. Since each project is a new experience, the time commitment on the part of faculty is very large, and the number of required faculty to provide the individual instruction necessary is also large. As a result, Union's engineering division has chosen to investigate other methods to achieve the same objectives.

[1] Louis A Martin Vega, Gregory L. Tonkay, Richard Sause and Harvey G. Stenger, "Integrating Design into Freshman Engineering: A Lehigh Experience," Proceedings of FIE '97, Pittsburg, PA, November 5-8, 1997

[2] Richard Porter and Hugh Fuller, " A New "Contact-Based" First Year Engineering Course," Proceedings of FIE '97, Pittsburg, Pennsylvania, November 5-8, 1997

[3] Karl A. Smith, "Design of an Introductory Engineering Course," Proceedings of FIE '96, Salt Lake City, Utah, November 6-9, 1996

[4] Craig James Gunn, "Design in the Freshman Engineering Curriculum," Proceedings of the 1997 ASEE Annual Conference and Exposition, Milwaukee, Wisconsin, June 15-18, 1997

[5] George H. Williams, James M. Kenney, "Integratng Engineering Design Projects and Economic Case Studies in a First-Year Course," Proceedings of the 1999 ASEE Annual Conference and Exposition, Charlotte, North Carolina, June 20-23, 1999

[6] Frank Milillo, Richard Shanebrook, Frank Wicks, "Construction of a Newcomen Engine as a Freshman Engineering Project," Presented in Session 3233 of the 1999 ASEE Annual Conference and Exposition, Charlotte, North Carolina, June 20-23, 1999

[7] F. Andrew Wolfe, Christine C. Laplante, "Bridge to the Future: the Freshmen Capstone Design Bridge Project at Union College," Proceedings of the 1999 ASEE Annual Conference and Exposition, Charlotte, North Carolina, June 20-23, 1999

[8] "Spring 1998 ESC-018 Weather Station Project," http://tardis.union.edu/weather/, Spring 1998

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