

Project Planning & Development for Engineering Freshman

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Abstract

The nature and background of students seeking an engineering education has changed drastically in the last decade, as has the expectations of industrial employers. Many students lack the organizational skills needed for academic success. Similar organizational skills, although more advanced, are required for managing engineering projects. A new course was developed by the faculty at the School of Engineering and Applied Science at the University of New Haven. Through this course, a key component of the *Multidisciplinary Engineering Foundation Spiral*, seeks to promote higher retention rates, increase student motivation and begin a confidence-building transition to professional practice.

Project management concepts are integrated for application by students to project activities. Thus students develop the project and self-management skills required to successfully plan and implement selected projects within budgetary and time constraints using Microsoft Project. Projects use LabVIEW programming¹ for data acquisition and control and CAD tools for technical communication of design information. Students gain proficiency in each of these areas as they are applied to a series of projects spanning the course.

A novel feature of this course is the subdivision of a large highly complex project into multiple interdependent components with each team responsible for a specific component. Traditional project-based classes typically subdivide a project to minimize interaction among the teams or to limit each team to a single disciplinary perspective. This course uses the project subdivision to force a broader multidisciplinary attitude among the students. Each team must resolve the interface issues, so when assembled all components will operate together according to the specifications.

Developed and taught by a multi-disciplinary team of faculty from the University of New Haven, this course provides a foundation for subsequent engineering courses with exposure to content in areas such as mechanics, electrical phenomena and programming logic. In addition the course contributes significantly to the development of time management, teamwork, and oral and written communication skills.

Introduction

Teaching and learning may be enriched by integrating new technologies in the engineering curriculum, particularly in laboratory-based courses. Traditional pedagogical approaches of teaching theory before looking at applications do not adequately address the needs of today's students. During our years of teaching, we have realized that most students learn more quickly if they can see examples, i.e., by doing, not by talking about doing. Laboratory courses should be designed with this in mind, i.e., to help open students' imagination and to bridge theoretical concepts with their applied aspects, through carefully selected sets of open-ended problems in the laboratory. This novel approach will encourage and motivate students to engage in productive and quality work, and will ignite increased creativity and curiosity within the students. Moreover, the students also learn to implement an experiment, measure and acquire data in order to enhance their understanding of physical processes in a setting that mimics actual engineering practice. The emphasis in modern engineering education is placed on design and experimentation, with a high degree of multidisciplinary perspective², while utilizing the most current technological developments. It is now an accepted premise that computer based realistic projects provide a meaningful learning experience for students.

Course details

This course will run regularly in the first semester of the freshman year. A pilot version scheduled for the spring 2004 is divided into three units: LabVIEW, CAD tools for technical communication; and an integrated design project, involving visual programming using Fischertechnik and incorporating project planning in the design process. Students from a variety of disciplines form design teams to develop subsystems that are integrated to complete the overall project, thereby necessitating collaboration across teams. It has been underlined by others that working on multidisciplinary teams³ improves student retention of knowledge and preparedness for advanced studies because of the active learning approach. A typical framework for engineering work is provided that extends beyond the technical aspects. This includes:

- Cooperation in multidisciplinary teams
- Coordination of parallel work between the team members
- Serving as a vehicle for students to consolidate, enhance, and demonstrate the skills and knowledge acquired in the classroom
- Learning from failures to finally achieve working solutions

Quite often students devote a considerable amount of their time fabricating and assembling their designs. They do not know how to properly plan their projects, coordinate the efforts among project members of a team and maintain an open dialog with the instructor in the development process. They have a little experience in the completion of many tasks in a precise sequence. In order to address and remedy these pitfalls and make it possible for the students to run their project successfully with a

minimum wastage of resources, we have integrated some aspects of project management and planning⁴ into the course.

Project planning is the key to completing a project successfully. Creating a project plan is the first thing students need to do when undertaking any kind of project. A good project plan can save considerable time, money. Students are required to create a list of key tasks to be accomplished for each of the deliverables, identify milestones, assign responsibilities to team members, track progress and update the plan regularly and frequently. For each activity, students must estimate the amount of effort required to successfully complete the activity. All this information is organized in a so-called Gantt chart³, whose purpose is to help students track their progress. Gantt charts are bar graphs that help plan and monitor project development or resource allocation on a horizontal time scale. Typically, Gantt charts show the exact duration of specific tasks, but they can also be used to indicate the relationship between tasks, planned and actual completion dates, cost of each task, the student or team responsible for each task and the various milestones in a project's development.

The project development aspect is carried in conjunction with the Fischertechnik and AutoCAD software. Fischertechnik is a construction system invented by Dr. Arthur Fisher in Germany that allows realistic, and novel systems of working models to be assembled using interlocking building blocks, motors, sensors, lights, computer controllers, and software. It is used by universities and industry to model (almost) anything as a scaled model. Fischertechnik parts are made of plastic, with excellent precision, so that models fit together well and are robust, and reliable. The low-cost Fischertechnik kit is an interactive platform that provides the students with a hands-on environment to develop fundamental skills in a variety of areas. This permits complex models with intricate moving parts to be built and develop an understanding of not only how devices and mechanisms operate but also how they can be improved and modified to enhance efficiency and making them cost-effective. Some of the skills that the Fischertechnik help promote are:

- Provide an insightful introduction to computer programming
- Promote a good understanding of technology
- Promote logical and deductive reasoning
- Identify multiple applications for a device
- Document the proper operation of a mechanical device
- Write logic programs to control devices & make them respond to sensors
- An ability to link together the separate parts of the system through a computer program
- Understand how software algorithms control the function of modern systems
- To support student discovery, enterprise and innovation

Fischertechnik allows students to explore their ideas and innovations that cannot be achieved in the real laboratory because of concerns for cost and safety. It can also be used to provide a pre-laboratory experience prior to the real experiments to deepen students' understanding of an insight into the experiment.

The constructed models are controlled via Lucky logic (LLWin) software that runs under Windows, as depicted in Figure 1. LLWin is very different from programming in a text based language such as FORTRAN or C. LLWin is a machine control language that uses a flowchart style language to describe the sequence of logic functions; it is developed by Fischertechnik for use with its Intelligent Interface Unit (IIU) shown in Figure 2. Example 1, shown below, illustrates the use of the Fischertechnik kit and the Intelligent Interface Unit and software in constructing a working conveyor.

Example 1: Construction of a working conveyor

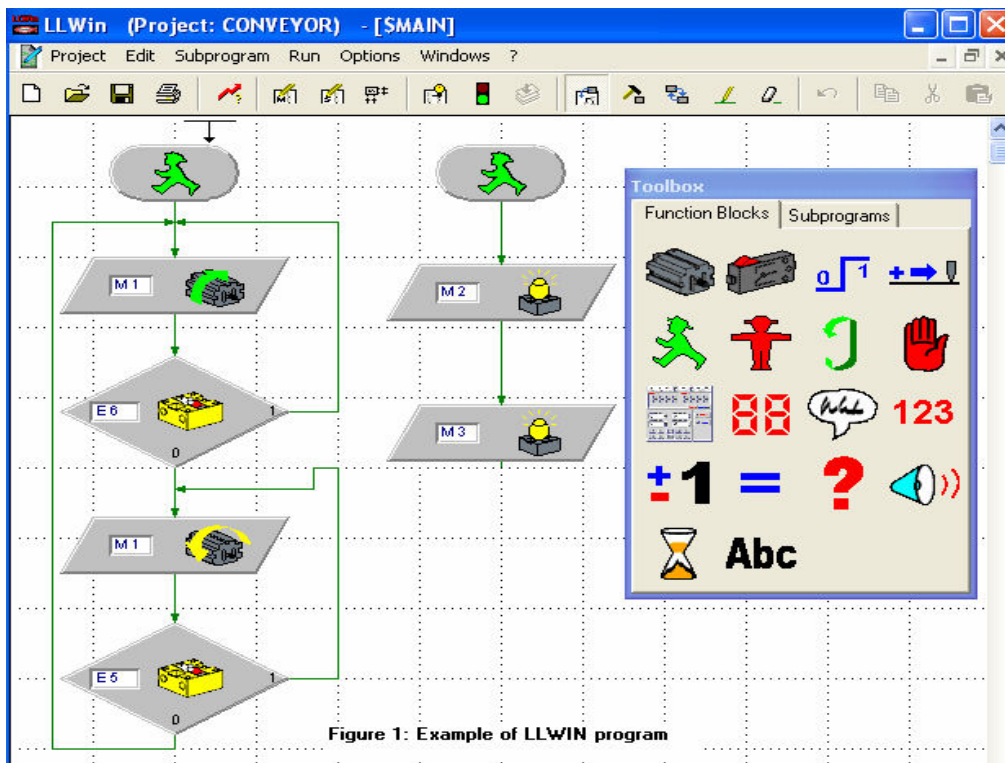
To tie all the pieces together, the following example is provided:

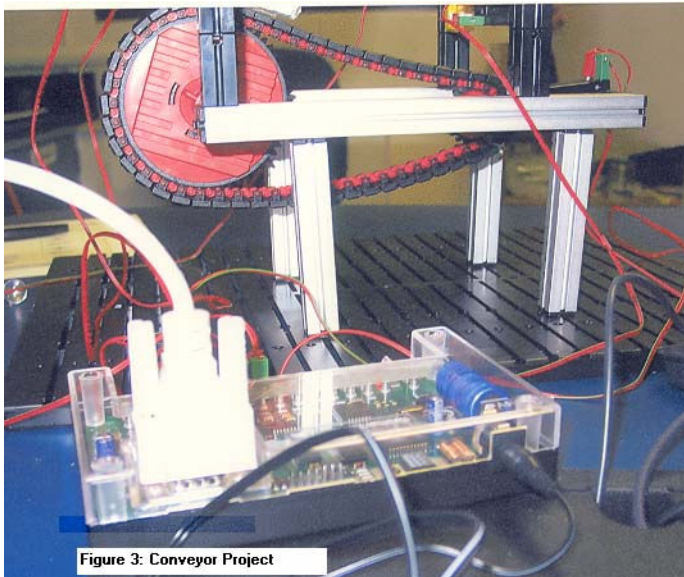
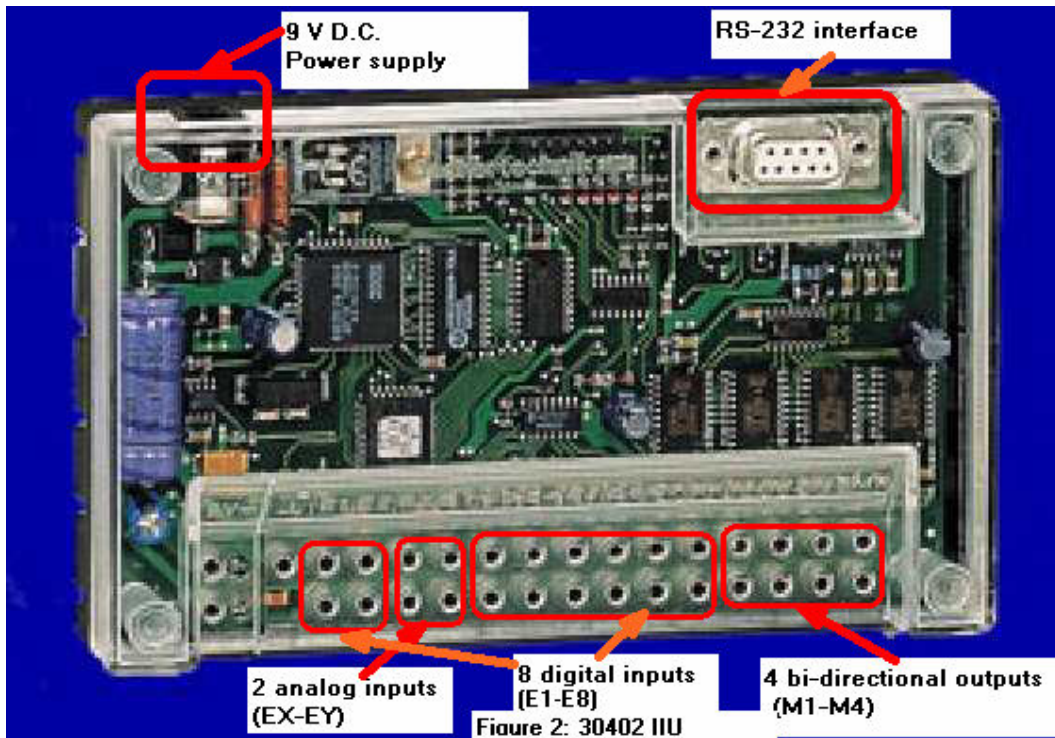
Objective: Construct a working conveyor using the Fischertechnik kit to build the conveyor, the Intelligent Interface Unit, and the Lucky Logic software to create the motion in the conveyor. The final project is depicted in Figure 3.

The following step-by-step instructions represent a typical approach to building this type of system.

1. Use the AutoCAD drafting software to prepare a sketch plan of components to build the conveyor.
2. Select the Fischertechnik components.
 - a. The chain mechanism used for the conveyor track must be linked by combining numerous tiny links that will form a closed path approximately 2 feet in total length
 - b. Treads must be connected to this track to form the surface of the conveyor belt
 - c. Gears or cogwheels must be selected to engage with the conveyor track. We selected two different sizes to cause the conveyor to have a ramp effect
 - d. A motor will be used to rotate a pinion gear to pull the track
 - e. Photocells will be used to control the starting and stopping of the conveyor to avoid a “package” dropping off the end of the conveyor belt.
3. Produce a Gantt chart to keep it up to date for use in planning your project. The Gantt chart is setup according to these guidelines:
 - a. Use hours at the time unit
 - b. Identify up to five milestones
 - c. Elaborate thoroughly on design tasks
 - d. Review and update Gantt chart periodically and frequently
4. Assemble the parts onto a foundation board (see Figure 3)
 - a. Build struts to support the conveyor above the board and to hold the parts.
 - b. Connect the gears to these struts
 - c. Install a motor connected to the pinion gear
 - d. Run the conveyor belt around these gears
 - e. Install lights and photocells as pairs near either end of the conveyor
 - f. Lead wires must be stripped and connectors attached at the ends to make connections

- g. Wire the motor to M1 on the control module as an output
 - h. Install light source near the start of the conveyor and one near the end
 - i. Wire the lamps (light source) to M2 and M3 on the control board as outputs
 - j. Wire the photocells to the control board as digital inputs, E5 and E6
5. Create the program using Lucky Logic software to run the system
- a. Function boxes are used to control the motor to start, stop, or pause
 - b. Begin the program with the “start” icon.
 - c. Insert the “motor” function block and specify the turning direction
 - d. Insert the “switch” icon but indicate this as a photocell. This block is similar to a condition statement in a program. If the condition is “yes”, it loops back and continues to run the motor. If the condition is “no”, it moves forward in the program.
 - e. Insert the “motor” function block and change the turning direction
 - f. Insert another “switch” icon for the second photocell at the opposite end of the conveyor and loop this back to the beginning.





Another aspect of this course is the use of the Laboratory for Virtual Instrumentation and Electronics Workbench (LabVIEW), developed by National Instruments and introduced in 1983. LabVIEW⁵ has grown popular in many research laboratories and industries. It is part of a new graphical programming language⁶, called “G”. It uses terminology, icons, and ideas that are familiar to technician, scientists and engineers. This software is

both powerful and flexible, and it can be used for a wide range of instrumentation projects.

The signal generated from the hardware circuit components is sent to Data Acquisition (DAQ) board and is simulated using LabVIEW software. LabVIEW rapidly creates test, measurement, control, and automation using intuitive graphical development. It creates user interfaces to interactively control the system. It specifies system functionality by assembling block diagrams.

In this unit, a variety of sensors will be utilized to convert physical phenomena to measurable signals⁷, typically voltage and current. Students will become familiar with the critical specifications of sensors, such as range of operation, maximum/minimum, resolution and sensitivity.

Sensors come in two flavors, digital and analog. Digital sensors can only be in two states, namely on and off. Examples of digital sensors include inductive proximity sensors, which are used to detect the presence of metals, and optical proximity sensors that use light to detect the presence. Analog sensors, on the other hand, output values over a range. Examples of these include thermocouples, which produce a small voltage proportional to temperature, and potentiometers, which provide a resistance proportional to an angle or displacement.

Example 2: Working with sensors using LabVIEW

Objective: Investigate popular industrial and laboratory sensors and determine their critical specifications. Then use the LabVIEW environment to carry out the following experiment:

A mass on a spring will be made to oscillate, and students are asked to measure the position and acceleration. Then the data is captured in the LabVIEW environment where it is processed and graph plotted relating the input output relationship.

Assessment

In this course, there are four major items of assessment⁸. These are: a design engineering report, a team presentation; individual programming assignments using Lucky Logic software and LabVIEW programming, and lastly but not the least, the integration of project management techniques into the design process. The group presentation consists of each team demonstrating the working design.

Conclusion:

In this paper we have proposed a course that utilizes project management and planning through a series of experiments and design projects making use of visual programming. Our preliminary results indicate that students have made significant progress in the way they handle projects. The visual programming appeared more intuitive and efficient.

Students were able to break up their design into stages that represent separate tasks. . Feedback from students has been very positive to date, they were eager to use the technology, and noted the challenging aspects of the projects. Students have commented on how much fun they are having. As the semester progressed students engaged themselves in constructing and programming. The amount of efforts students expended on their projects, and the sheer joy and pride they had in their work were obvious. They were active and they were involved.

Acknowledgement

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