Challenging Students with an Open Design Space for a Junior-year Practicum Capstone Project

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Abstract

At the conclusion of a three semester practicum sequence, students were required to perform a three week product design based on the National Instruments myRIO. The wide-open design space was a new experience for most, initially making some very uncomfortable. Weeks before the design period, randomly assigned teams of two were asked to formally propose a project that would be a reasonable effort for a three week duration. After submitting proposals, each team was required to make a ten minute presentation to the class. Each team evaluated every other, made recommendations, and characterized the difficulty. Modified proposals were due before project start. The approach proved effective in getting students to honestly evaluate each other. Results at the end of the cycle exceeded all expectations. The teams each created a conference style poster, and presented and demonstrated their final designs to faculty and other students during a mini-expo.

Keywords

Design, project, myRIO, open, proposal

Introduction

A practicum sequence was inserted into a well-established Electrical Engineering Technology curriculum with the intent of: (1) giving students an opportunity to integrate knowledge learned across multiple courses into practical solutions; (2) teaching project management skills using a learn-by-experience approach and (3) introducing needed-skills training absent elsewhere in the curriculum. Feedback from employers, and observations of senior-year capstone project mentors led to the realization that although the students were being thoroughly prepared with material, they were not necessarily able to turn that into practical solutions when challenged.[1]

As the final assignment of the third and final course in the sequence, junior level students were required to develop a project scope and requirements, make a proposal of that project (with modifications if required), and then execute the project during the final four weeks of the course. The presentation of their project was done conference-style; each team had to create a professional poster presentation of their project and demonstrate their design at a mini-expo held during their final exam slot. Faculty, staff and students from across the department were their audience.

Background

Students worked over the period of a semester and a half implementing instructor defined projects. These were well-defined projects, with specific requirements, but with an open solution space. Early projects were one to two weeks in length, later projects increased to three weeks in length. Each of the projects was based around a student-owned National Instruments myDAQ data acquisition device and coded in LabVIEW. The primary goal of these projects is for students to gain a new level of insight into application of their course material to solve real problems.[2]

Initially students struggled with the open design space; they had been trained via homework problems and exams over the period of three plus years to find the precise solution when given a problem. Early on in the course, typical student questions were "What is the best way to solve this?" or "Exactly which way do you want us to do this?" Students were repeatedly told that any solution that met the requirements would receive full credit. It was explained that in industry, there may be criteria that made one solution better than another based on factors like budget, schedule and verification complexity. Analogies were drawn to their own situation, such as their own evaluation of how long one approach would take versus another, or the relative simplicity or complexity of their code and its effect on their own troubleshooting.

Project Proposal and Approval

Two weeks prior to the scheduled start date for the capstone project, students were randomly assigned into groups of two. Each group was required to propose a project of their choice. Projects had to be based on the National Instruments myRIO, be relevant to Electrical Engineering Technology, include multiple inputs and outputs, and be packaged. The difficulty level of the project was intended to be a fair three-week effort. Formal written proposals were submitted for approval to ensure a clear statement of the problem[3], definition of specific requirements to be evaluated at the conclusion of the project, and instructor concurrence.

Initially students were extremely disturbed by having to define their own projects; this was a completely new area for them. They were perplexed about where to start and how to define the problem. This was a very deliberate approach, used to help students identify and conquer the uncomfortable feeling of approaching an unknown problem space.[4] Frequent interaction and discussion during the proposal period led to each of the student groups successfully selecting an idea and honing it into a specific proposal.

During class on the day the proposals were due, the students were informed that they each had to make a five minute verbal presentation to the rest of the class about their proposal. The guidelines given were that they needed to explain the idea, what the end project would be, how they would go about executing it, and what materials they would use. The remainder of the class was allowed a five minute question and answer period for each project. Following the presentation, each group was able to provide verbal feedback to each other group, as well as vote on the difficulty of the project by show of hands: "just right," "too little" or "too much." Students were surprisingly frank with each other in their assessments. Some groups were told by their peers they need to step it up and add more to the project, and suggestions were given. Other groups were told they were biting off too much for three weeks, and suggestions on how to cut the project down were given.

Project Execution

During the three week build of their projects, the level of motivation of all of the students was noted to be higher than had been experienced on past projects. This is a similar result as seen by others when assigning creative projects; a student is intrinsically motivated when they have a vested interest in the topic and the outcome.[5, 6] Another observation was in thoroughness of approach: whereas some students were happy with just barely reaching a minimum level of "working" on their assigned projects, they set a much higher standard for themselves on components of their self-selected project. It is hypothesized that they feel a different level of pride in their own project, resulting in a higher level of drive toward success.

Project Results

Six different two-person teams completed projects. Each of the projects completed or exceeded their objectives, some teams going beyond original plans by adding features or enhancements. Two of the teams negotiated changes in scope to their projects by deleting originally planned features and adding more complex features. The projects selected were as follows:

- Motion activated music synthesizer (Figure 1) – a touchless musical instrument with the ability to record sequences and play them back simultaneously with new inputs. Each of the eight possible notes was selected by waving a hand over one of four infrared sensors, each at one of two distance ranges.

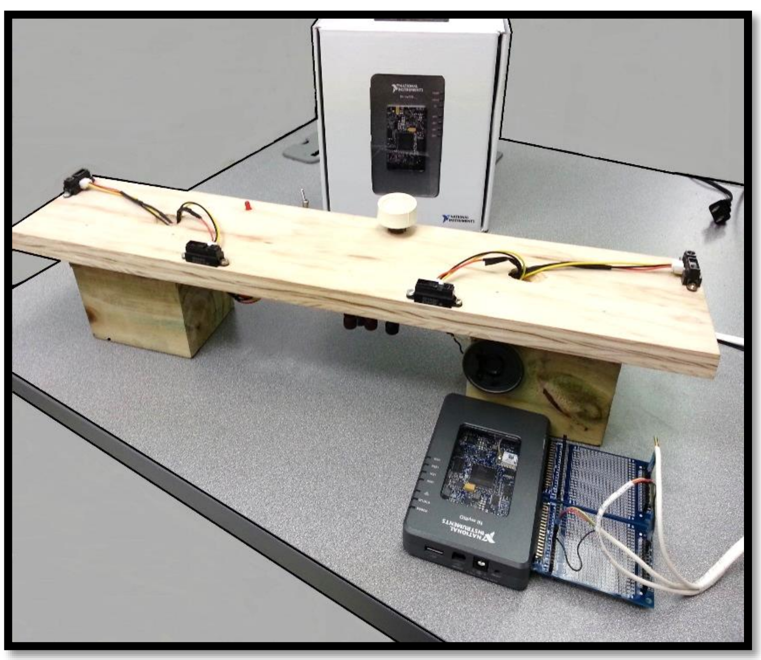

Figure 1-- LabVIEW Motion Activated Music Synthesizer [7]

- Drink Mixer – a device containing two different drinks, such as lemonade and iced tea, that would mix the fluids into a glass depending on which of a series of buttons on the device were pressed. Valves were controlled based on time.

- Turret gun (Figure 2) – a Nerf gun built onto a camera-controlled, student-built turret allowing 90 degree vertical and 180 degree horizontal movement using servos and relays. Controlled and fired by an operator at a remote terminal, aiming was based on camera feedback.

Figure 2 -- Turret Gun [8]

- Labyrinth Redesigned (Figure 3) – a traditional wooden labyrinth game modified to be controlled by a remote user holding 3-axis accelerometer input device. Tilt of the input device was translated into servo commands to tilt the labyrinth table accordingly. A force sensor under the table determined when a ball fell through.

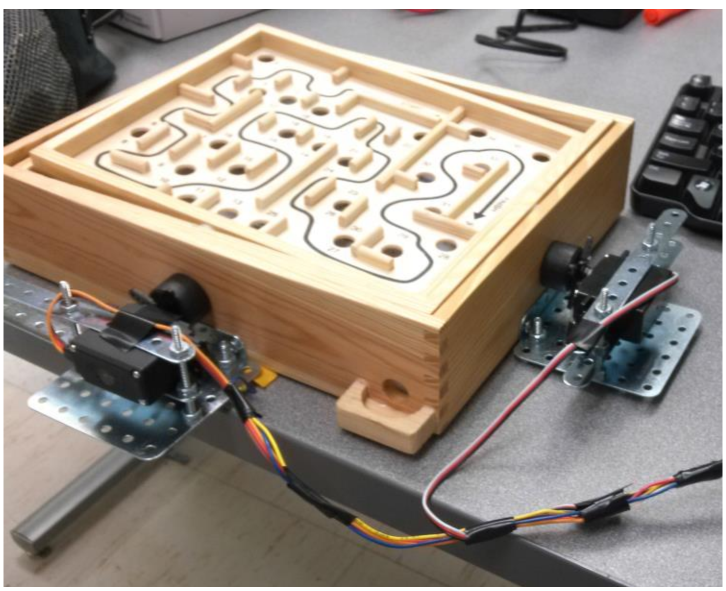

Figure 3 -- Labyrinth Redesigned [9]

- Pedometer – a multi-mode pedometer based on a piezoelectric vibration sensor that calculated steps taken, distance travelled, and calories burned. The caloric calculation was based on weight input by the user. The device had separate walk and run modes.

- Window Matic 1000 – a mini-blind control system that used light sensors to automatically adjust the tilt of the blinds dependent on the amount of direct light impinging externally, and could be manually opened or closed with the wave of a hand using ultrasonic proximity sensors.

Project Presentations

As their final exam in the course, students presented and demonstrated their finished projects at a mini-expo. Students and faculty across the department were encouraged to attend. The teams each created a professional conference-style poster which they displayed at their station along with their functioning project. As the audience navigated the displays, students actively engaged them explaining their work and answering questions. The posters showed their project statement, overall approach, issues encountered, and pseudo-code, as shown in Figure 4.

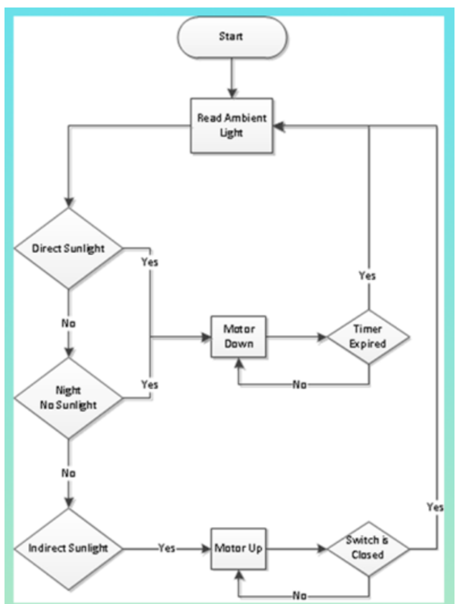

Figure 4-- Window Matic 1000 Flowchart [10]

Conclusions

Allowing the students to select and propose their own capstone projects led to a quantum increase in the quality of the students work. A level of pride was evident in all of the students that had not been observed in previous projects; this was observed during the execution of the design, as well as during the presentation of the final products. The initial awkwardness and fear they experienced in having to define a project for themselves was quickly forgotten as they achieved new levels of self-satisfaction in making a product aligned with their personal areas of interest. The elevated quality of the work was evident in the reactions of faculty and a dean that attended the mini-expo.

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