Product Design and Development to Demonstrate Quality Engineering and Process Improvement Tools

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Abstract - Junior industrial engineering majors at Western New England University are required to take a 2 credit laboratory course. This course is designed to expose students to tools associated with quality engineering and process improvement. Course evaluation by students has indicated that the course is difficult for students, as the material in the course has been too conceptually based. The course utilized case studies and small laboratory experiments to help demonstrate quality engineering and process improvement concepts. Faculty associated with this course noted as lack of engagement by the students. Therefore, the faculty redesigned the course to incorporate the design and fabrication of a simple device to improve the learning of quality engineering and process improvement concepts. Additionally, the design, fabrication, testing and improvement of a device is included in the course as a mechanism to actively engage the students. The course educational outcomes and basic assessment tools remained the same.

The major change to the course was to immediately engage students with a simple challenge, ‘build and design a product for less than $100 that has abilities equal to or greater than that of a similar commercial product which can be purchased for at least $500’. Students should work in teams of two to design and fabricate a simple working prototype of a specified device and then test and redesign their device utilizing quality engineering and process improvement tools. These tools were introduced weekly in class. These tools include: brainstorming, cause and effect diagrams, data collection, process improvement, stratification, and failure modes and effects analysis.

The fall of 2012 semester was the first semester these changes were implemented. The specific product that students were to develop was a ‘people counter’. People counters come in many forms and serve many purposes. The main purpose of these counters is to determine the arrivals properties of people or objects through an entry way or defined passage. They are frequently used in manufacturing, retail, and service industries to estimate arrival frequencies. The following design criteria were provided to the students: 1) the device must operate wirelessly; 2) the device must be able to record the time and height of any arrival; 3) the device must cost less than $100; 4) the device must be able to eliminate false readings; 5) the device must self-calibrate and be independent of entrance mounting location; and 5) the device must be able to accurately estimate the number of male and female entries through an entrance. Similar commercial products that would nearly meet all of the design specifications currently sell between $400 and $2000.

A brief introduction and several example applications to the Arduino microcontroller, passive infra-red sensors, LEDs, and sonar sensors were provided to students. Students had no prior working knowledge of these devices. Students were then divided into teams of 2 and were given 2 weeks to have a working prototype. From the working prototype students refined their product designs by implementing the process improvement and quality engineering tools. These tools were introduced weekly and the student product designs and working prototypes would change weekly based upon implementation of these tools. Finally, at the end of the 15-week semester students presented

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their final product design and a functional final prototype. An example of a student prototype is shown by Figure 1 below.

![Arduino Uno with Micro SD Shield and Working Prototype with Sonar Sensor and 9V Battery Pack](image)

**Figure 1: Student Designed 'People Counter'**

Students were able to design and develop an effective working prototype to meet the design specifications. The cost of their devices ranges from $65 to $95. Investigating assignments associated with the assessment of student outcomes showed higher average assignment scores and a high level of learning when compared against the same assignments from previous years. Students demonstrated the correct application of the quality engineering and process improvement tools and demonstrated the ability to change their designs and implementations based upon the application of these tools. Qualitative input from course exit interviews indicate that students embraced designing and implementing their own working prototypes and successfully utilized quality engineering and process improvement tools toward their design. Finally, a high level of effective teaming was observed within each student team and a healthy competition between student teams was observed. This was evident by the high level of participation / communication among and between student teams. It was also observed that student teams continually set their own goals and students freely expressed ideas within each team.

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