Pre-Engineering STEM Capstone Project to Design an Oil Cap Remover Tool to Help General Aviation Cessna Pilots

Sandy Feola
National Center for Manufacturing Education (NCME)
Sinclair Community College

ABSTRACT

High school students enrolled in the Project Lead the Way (PLTW) Pathway to Engineering curriculum complete a final capstone project their senior year for the Engineering Design and Development (EDD) course at Kettering-Fairmont High School (south of Dayton, Ohio). The knowledge and skills the students have gained from completing three pre-engineering courses (IED) Introduction to Engineering, (POE) Principles of Engineering, and (CIM) Computer Integrated Manufacturing, link many STEM principles to problem-solving activities.

This Extended Abstract paper will describe one team's experience as they apply pre-engineering course competencies to solve a problem that women and older general aviation pilots encounter - difficulty to open over-tightened Cessna 152 or 172 engine oil caps during the pre-flight check. Industry professionals from three local companies provided STEM (science, technology, engineering, math) mentorship targeted to support project plan activities best suited to their key support strengths. To help facilitate communication between students and industry mentors, a collaboration Web 2.0 tool, *mycareerme.org*, was used to post status and communicate progress and encouraged on-line participation when it was difficult to meet in person.

Keywords: STEM, Conference Proceedings, Hands-on Learning, Partnering

PRODUCT REQUIREMENTS

The students kicked off their project at Dayton-Wright Brothers Airport to gather customer requirements and to identify tasks that addressed design/prototype and the manufacturing, quality, and delivery processes to meet a 10 week project schedule. They used the internet to confirm their local customer needs investigation by posting a question on a free forum for Cessna 172 owners: *"Fairmont53: Does anyone have a problem loosening the oil cap? A female pilot came to me with the problem of loosening the oil cap on a Cessna aircraft. I was curious if anyone else had the same issues that occurred to her. Any comments would be very helpful."* Fifteen responses from pilots across the country expressed a similar experience.

The students also set two stretch goals - to patent their idea and to determine how to manufacture the tool so that future classes would be able to make and sell this product to help generate money for their program activities no longer funded by their school. The students wrote customer requirements to address form, fit, and functional needs to help guide their product design based on customer surveys they collected from pilots at the local airport. Mid-way through the design and prototype phase, they discovered that not all customer requirements can be addressed, and after doing a prioritization checkpoint to weed out the "most important" from the "nice-to-haves", the students were able to regain focus for their design.

DESIGN PHASE AND PROTOTYPE USING 3D PRINTING METHOD

The students borrowed an old Lycoming engine oil dip stick from the Aviation Sales Inc. maintenance department to model where their new product's tool-end would fit onto the cap-end. Their first design solution tackled one important requirement from the aviation maintenance department; that the device could only be used to loosen, not tighten the oil cap. They also discovered that one, quick trip to the airport to gather data wasn't enough to complete the prototype. Further measurements were needed to determine oil cap's reference surface placement related to differences between cowling engine opening clearance on 152's and 172's. Seven planes were sampled multiple times during design analysis to re-confirm measurements critical to dimensional and tool performance constraints.

One positive observation was that the students built enough time into their project plan to gather local pilot feedback for testing different handle styles. This extra scheduled time helped, since they learned that offering too many options for usability feedback made it difficult for pilots to select "a best" handle style. Materials and manufacturing methods also continued to be part of on-going project discussions as the students worked through the design phase. One schedule constraint the students encountered while building their design was use of reliable prototyping equipment. Their school's 3D printer would not consistently run the prototype file, which slowed down their ability to print new models and re-evaluate design changes. The Sinclair Community College's Rapid Prototyping Services team stepped in to offer their support by printing several prototypes for the students to evaluate changes to their product's fit and function.

STEM INDUSTRY COLLABORATION

Three industry mentor organizations supported the students with technical, customer, and product realization input during for the project. Just as industry teams benefit from cross-functional participation, no individual mentor would have been able to support the students' project goals. During February, Bastech, Inc. hosted the students for a job shadow day at their facility. The students were able to strengthen their 3D rapid prototyping fundamentals, and to run their first design's prototype. Visualization from the CAD drawing to an actual printed 3D model put the perspective of size (e.g. tool was too large) related to the CAD drawn part dimensions.

One difficulty encountered by the students was finding time for industry mentors to be at the high school when the students needed, and visa-versa for the students' availability after the school day. An educational social networking tool, *mycareerme.org*, was set up at the beginning of the project to support on-line project communication. *Mycareerme.org* offered a way for mentors to could keep up with the students' project deliverables and to respond with mentoring advice. All project participants were able collaborate using Web 2.0 technology. The importance of actual "face time" wasn't diminished, but this application offered an alternative solution to try to collaborate in-between any on-site mentor visits.

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AUTHOR'S INFORMATION

Sandy Feola is an independent quality professional in Dayton, Ohio, providing consultation and training to manufacturing and service organizations about performance improvement initiatives for quality systems. She also supports the National Center for Manufacturing Education (NCME) as a Customer Engagement Manager, and teaches Industrial Engineering and Quality Engineering courses at the University of Dayton, and at Sinclair Community College. She is a senior member of the ASQ Dayton Section, and the IIE Dayton Chapter.