AC 2012-5531: AEROSPACE MANUFACTURING MODULES FOR EXISTING MANUFACTURING PROGRAMS

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Aerospace Manufacturing Modules for Existing Manufacturing Programs

Abstract

For several years, the aerospace industry has been undergoing radical change driven by the pressures caused by an aging workforce and a customer base that has been demanding dramatic increases in productivity. Retirements have and will continue to lead to valuable manufacturing knowledge being lost during very critical times. In 2006, a team of faculty from four institutions received NSF funding to help address this problem through a better-educated incoming workforce via aerospace-centric manufacturing course modules designed to be inserted into existing manufacturing courses. The modules developed over the three-year life of this grant have been very well received and are currently being used by several community colleges, universities, and a number of aerospace companies.

In 2010, the team received a second NSF grant to continue their work. The new project will largely focus on the development of a few more key modules, the enhancement of several of the existing modules with defined laboratory exercises and kits and a published digital media for use with the modules. This paper will provide background on the first NSF project and describe the current and pending accomplishments with the most recent project. Details will be presented on the project's modular approach to aerospace manufacturing education including: topic selection, module development, lab kit development, module implementation, and module dissemination.

Current State of the Aerospace Industry

The aerospace manufacturing industry continues to face a myriad of challenges brought about through receding defense budgets and global economic conditions. Faced with a number of business contractions and conservative investment the aerospace industry related employment experienced in excess of 600,000 jobs in 2011, half of which were production workers[1]. The aerospace industry is nationwide, with California, Texas, and Washington having the largest employment and significant clusters in Alabama, Arizona, Georgia, and Kansas[2]. The Aerospace Industry Association projections through 2013 anticipate growth in the civil aircraft sector propelled by an increasing demand for fuel efficiency. The military aircraft sector, navigating through rough waters, continues to show promise as the country attempts to manage an aging fleet. The international markets for defense aircraft are strong yet exhibits signs of increasing competition from foreign governments. These international campaigns generate further opportunities to reduce costs and improve efficiencies of legacy aircraft programs.

Reported in the 2011 year end review and forecast, Marion Blakey, President of the Aerospace Industries Association stated; "The U.S. Aerospace industry continues to provide significant contributions to the country's economy and provides capabilities vital to our nation's security. With employees in every state of the union, it generates the highest positive trade balance of any U.S. manufacturing sector"[3]. In 2008, the aerospace industry's $57 billion trade surplus represents the largest positive trade balance of any U.S. manufacturing industry[4].

As new and improved processes and materials are being integrated into aerospace manufacturing the industry is faced with an aging workforce. The average age of a production worker is 54 years based on the 2005 President's report of findings and recommendations for the US aerospace industry[5]. These workers have continued to retire over the last few years as a result of corporate downsizing and employee reductions. These production jobs, when replaced in the coming years, will lack the skill brought about through years of stewardship and mentorship that have historically been linked to the industry. The introduction of the sophisticated technologies for manufacture of modern air vehicles requires a new type of aerospace manufacturing technologist that is educated and trained to understand and operate modern day systems entering production[6]. At the same time the academic community has been challenged to meet the needs of state and local governments. To meet the needs of industry these same institutions cannot afford to incur lengthy review processes required to change curriculum. Academic Institutions must be positioned to support industry through training in current processes and technology.

Project Background

The Aerospace Manufacturing Education Initiative is a funded NSF project being conducted by a team of faculty members from four educational institutions. The institutions include: El Camino College (Torrance, CA), Purdue University (West Lafayette, IN), Oregon Institute of Technology (Klamath Falls, OR) and Butler Community College (Andover, KS). The project initially received funding for three years from NSF in 2006 to investigate the skills and knowledge needed by aerospace manufacturing technicians and in turn design and create aerospace manufacturing curricula and learning materials to address the identified areas.

During the investigation, the team determined that while there were a lot of unique aspects associated with aerospace manufacturing, there were many common features with other related industries. With this finding, coupled with the team's experience with proposing new courses to existing curricula, the team determined that a learning module system approach that focused on the unique aspects of aerospace manufacturing was the best option to undertake. This approach would allow educational professionals to insert the created modules, or portions of created modules into existing courses as appropriate, eliminating the need for an instructor to develop an entirely new course.

Managers, engineers and technicians were surveyed and interviewed to compile a list of skills and knowledge needed by an aerospace manufacturing technician with a two-year degree. Next, in collaboration with the International Aerospace Automation Consortium and the Society of Manufacturing Engineers, the team prioritized the skills and knowledge into technical and non-technical areas. Technical content was then designed and developed into modules that could be inserted into appropriate pre-existing courses. All materials are available digitally on a project website for use by faculty, instructors, and industry trainers. The website provides access to relevant information, presentations, papers, and other resources.

In 2010 the team received another three-year grant from NSF to enhance and improve the modules developed during the first grant, as well as develop several new modules. Through this grant the team is also committed to enhancing all appropriate new and existing modules with a defined laboratory project kit complete with several developed laboratory exercises. The following sections will provide some detail on the existing and planned digital content, as well as background on the new laboratory kit initiative.

Digital content

The project's strategy for technical content development was to develop modules that could be easily used in existing courses as opposed to developing a completely new course. This approach was taken partly based on team member's experiences with adding new courses to curriculum and partly based on the fact that there are large number of manufacturing programs that are not completely aerospace-centric, but may wish to include aerospace examples.

The digital content available is developed to augment existing course material for approximately a two-hour lecture environment. The development of each module attempts to follow similar formats using the standard development sequence outlined in Table 1. The modules include presentations in PowerPoint format and instructor notes in Word format. Both formats may include links to online content that has been identified as relevant and vetted by the academic review team. The graphics contained in each module reflect real world applications and have been approved for public domain. Recommended lab activities are also included as a part of the instructor's notes. Current and planned technical content is outlined in Table 2.

Lab kits have been introduced with the newest grant and lab exercises are available through the website. The flexibility of the digital content enables the end user to customize delivery as required, whereby the user can use everything as it was originally developed or use only small portions of the materials to embellish a course that may be more time constrained.

Table 1: PROPOSED MODULE DEVELOPMENT SEQUENCE.

Module Development Sequence
Introduction to the Topic
Historical Overview of the Topic
Definitions
Basic or Advanced Science behind the Topic
Existing Known Actual and Perceived Problems
Root Cause of Problems
Awareness of solutions
Future Opportunities and Applications

Table 2: TECHNICAL CONTENT WITHIN EACH MAJOR FOCUS AREA.

Composites	*Materials*	*Fasteners*	*Automation*
Fiber Reinforced Plastic	*Deformation/ yielding*	*History of Fasteners*	*Applications for Automation*
Aluminum versus Composites	*Thermal Shock*	*Permanent versus Temporary Fasteners*	*Horizontal Rivet Injector*
Parts Development	*Materials Fracture*	*Thread Terminology*	*Broken Arm Robot*
Automated Layup	*Ceramics and Plastics*	*Fastener Applications*	*Barrel Fastening*
Future Directions for composites	*Root causes of Materials Failure*	*Fastener Materials*	*Flex Track*

Application Lab Exercises

While proposed lab activities were included in those modules created during the first grant, it was determined that the availability or identification of specific lab kits would be helpful for instructors less familiar with the topic areas and for those instructors without lab facilities focused on those topics. It was determined that where possible, the team would attempt to find "off the shelf" lab kits that could be used or adapted to compliment the technical module.

This approach is currently being tested, with reasonable success, using the project's composite module. It was projected that users of the modules would be primarily schools without access to extensive composite materials. The defined criteria the team set for the kits included:

- Available through a commercial vendor
- Affordable price point (specific for each program according to its budget; the kits include different price options for equipment and materials)
- Quick turn around
- Adapt well to identified lab exercises
- Directly apply to technical module

A kit supplier was identified and sample kits were obtained from the supplier. The kits were originally intended for hobbyist and found to have the basic materials needed for defined laboratory, but the contents of each kit was not always uniform. After discussions between the team and the supplier, the supplier committed to prompt delivery and standard kit contents. Lab exercises were then designed by members of the project team to use the components of the kits. Lab exercises were designed in such a manner that the user would be able to integrate the exercises into common class delivery times. The times identified were for one hour classes, 75 minute classes and three hour block classes.

The steps of each exercise were tested in actual team member class laboratory activities to assure that the exercises fit as designed. Additionally a pre and post test for each lab exercise was developed. The results from the first lab exercise pre and post test were encouraging. Each module posted gains of an average of 28 to 30% gain[7]. All Lab exercises are available on the website complete with detailed instructions for the instructor, pre and post tests, and a module test bank.

Instructor Access and Interaction

To date, the team's dissemination efforts have included a heavy emphasis on workshops and presentations at campus and corporate locations, and technical society trade shows and conferences. The project website has served primarily as a warehouse for participants to download project materials developed by the team; however, a new website recently launched will systematically add new features that will add several new dimensions to the project's dissemination practices. The URL for the project web site is: http://aerospacemfg.org/. Screen shot of the modules' section of the website is shown in Fugure 1. Sample of a slide of the *Aerospace Fastener Applications, Part 1* module could be found in Fugure 2.

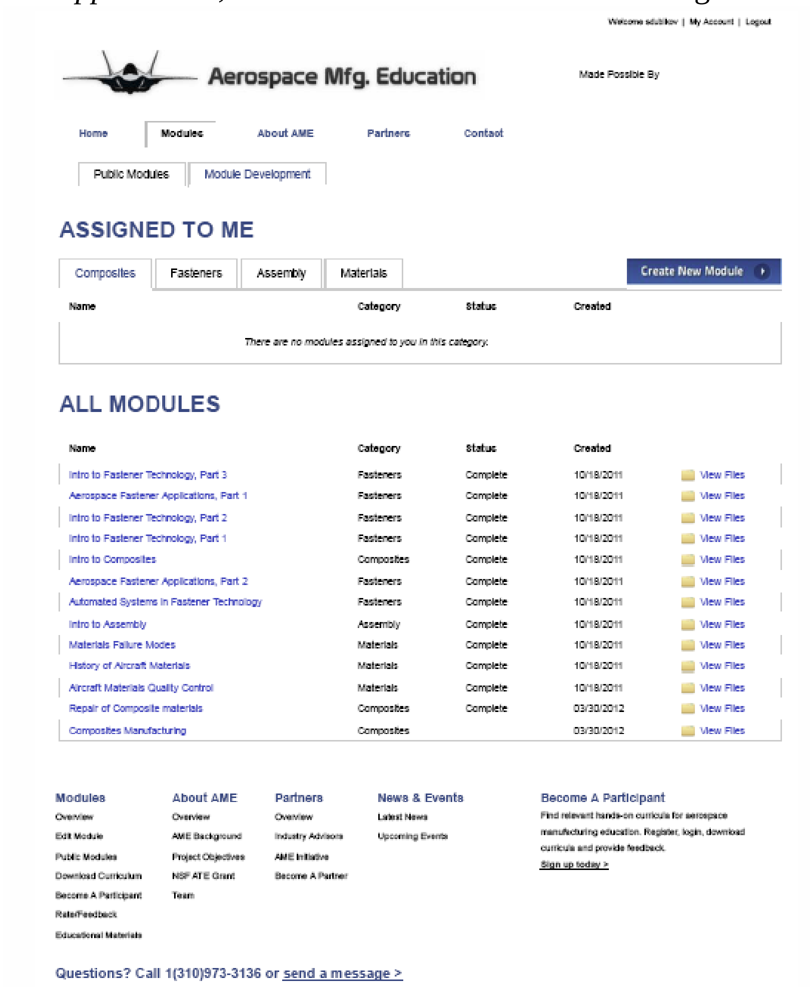

Figure 1: Screen shot of the module section of the website.

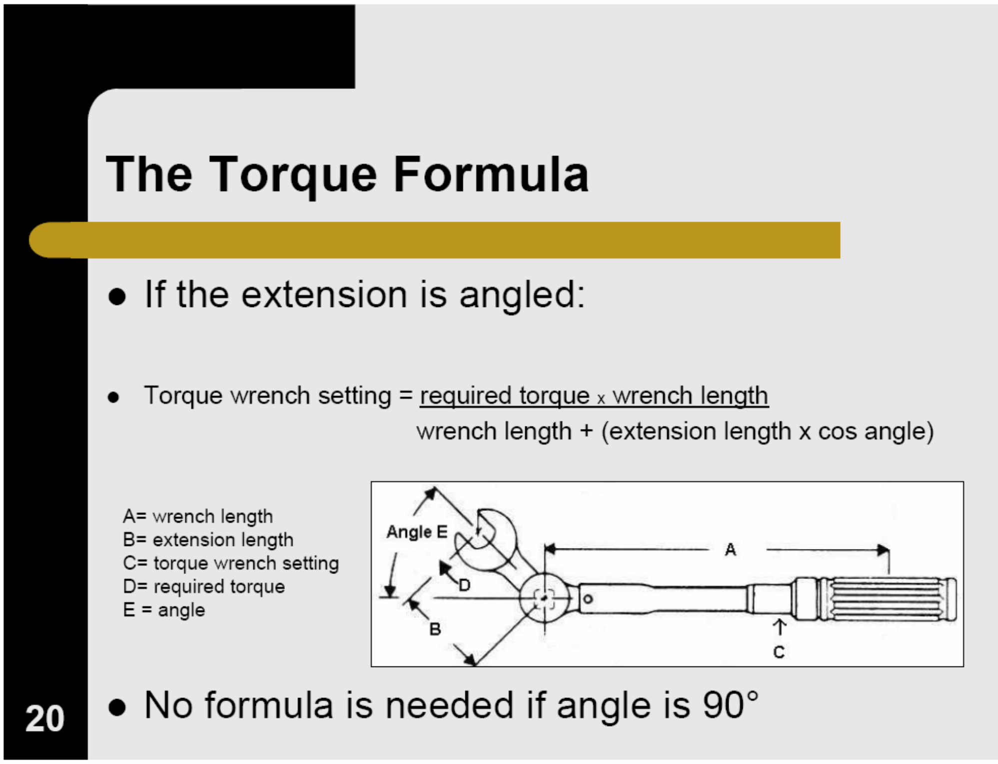

Figure 2: Sample of a slide of the *Aerospace Fastener Applications, Part 1* module.

Workshops will continue to provide information to potential and current users regarding information on course modules, projects, and classroom delivery methods and strategies. Workshops are arranged mostly in face-to-face meetings. However, using the new website capabilities, the team is in the process of developing interactive web based workshops that will facilitate dissemination while mitigating travel costs for the project team and attendees. Online workshops will enable the project team to reach and interact with a wider audience cost effectively and will facilitate real-time interaction with content users.

Additionally, the new project website contains a blog where users of the modules may provide feedback and recommendation on project modules. The blog provides a vehicle for collaboration and interaction between module users. Bloggers must be registered users of the web site and postings are reviewed before released for dissemination. Recommendations provided through the blog are monitored through the Open Line system where actions are assigned and tracked by the project team.

Planned online surveys through the web portal will provide timely and effective information to the project team and facilitates ideas and actions for new modules and labs and provides for continuous improvement of existing materials. Efforts are also underway to create a web presence via social media sites such as, Facebook, Twitter, YouTube, LinkedIn and others. These tools will provide visibility and interaction with the receivers of our modules, namely the students.

Conclusion

The NSF Aerospace Team has provided a meaningful solution for the development of current and future aerospace technicians. Aerospace technicians are viewed by this project as graduates of two year degree programs pursuing careers in the aerospace field as production workers, manufacturing engineers, or analysts. The solution has also provided a framework in which companies can train current employees and potential employees in current aerospace concepts.

The success of this project is due to a number of factors including ease of utilization, significance of the subject matter, and ability to modify content to meet the needs of the instructor. The team recognizes the challenges for instructors to find up-to-date content that has been vetted through the academic review process and has developed materials to aide in this endeavor. The team also recognizes that the continued success and acceptance of this work will be through the continued development of partnerships between education and industry. These partnerships are critical to ensuring that value is provided to all downstream users including corporations, suppliers, academic institutions, instructors and most of all students.

The project has plans to transition modules to web based video streaming using content experts to deliver modules to assist the instructor in delivering content to students via the project web site portal. The Web-based delivery strategy will facilitate dissemination of program modules by providing instructors a prepackaged, easily and readily adoptable technical aerospace manufacturing program that will require less time for instructors to incorporate into existing courses. Modules will be available for presentation when needed by the instructor and instructors may allow students to submit questions to content experts via the blog. Further development includes social media web site technologies to enable an instructor to create chat rooms to support module discussions and tracking. These strategies will facilitate instruction in face-to-face as well as online classroom environments.

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