AC 2008-1280: USING GUITAR MANUFACTURING TO RECRUIT STUDENTS INTO STEM DISCIPLINES

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Using Guitar Manufacturing to Recruit Students into STEM Disciplines

Abstract

The challenge to recruit students into manufacturing engineering technology degree programs continues to be competitive and requires creativity and innovation. Creating an interest in STEM related programs has become the new frontier for many colleges and universities across the nation. The traditional recruitment approach of static websites and brochures fail to attract the interest of potential students. This approach must be adjusted to include the evolving interests of each new incoming generation of students; if it's not animated, colorful, virtual, "cool" and most importantly part of their current world, capturing student interest is difficult at best.

This paper will address a planned summer workshop for high school students that will use the guitar to introduce the "fun" side of engineering and specifically manufacturing. The workshops build on experience from semester classes in stringed instrument manufacturing and from an adult summer workshop on guitar making. Additionally, details of the guitar workshop, funding and support from industry, professional societies, and state and federal agencies will be discussed.

Background

A recently completed study by the Indiana Department of Workforce Development (DWD)[1] presents the results of research to identify and analyze the root causes of occupational and skills shortages across Indiana's 11 economic growth regions. Given the importance of manufacturing to Indiana's economy (Figures 1 and 2) it is not surprising that manufacturing was included as one of the industries most affected in all of the identified root cause areas.

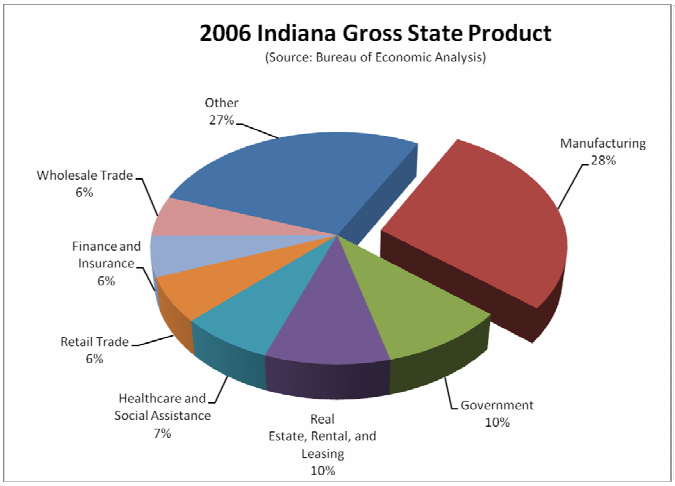

Figure 1: 2006 Indiana Gross State Product
(Source: Bureau of Economic Analysis)

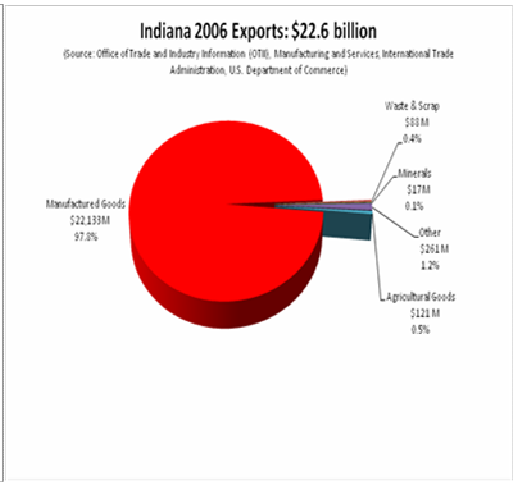

Figure 2: 2006 Indiana World Exports (x $10^6)
(Source: Office of Trade and Industry Information)

The DWD report identified five primary, statewide root cause areas: 1) Talent & Pipeline Issues, 2) Education & Training Capacity, 3) Employer HR Capacity, Policies, & Practices, 4) Wages & Benefits, and 5) Leakage & Brain Drain. Economic Growth Region (EGR) 4 (encompassing all WIRED counties except Fulton and Wabash) is included in the list of "Regions Most Affected" for the first three root cause areas. A separate report was submitted by the EGR #4 Tecumseh Area Partnership proposing actions to address the lack of awareness of career opportunities and pathways in manufacturing.

The DWD report outlines the following factors as contributing to the shortage of young adults and other participants interested in pursuing manufacturing careers:

- A lack of communication between the potential workforce, manufacturers, educational institutions, and regional community
- Parents and schools are not encouraging students to pursue careers in manufacturing
- School counselors rate the quality of information available to them as fair to very poor
- Manufacturing still has a negative (outdated) stereotyped image

Additionally, economic briefings by academic and professional policy analysts continue to recommend that Indiana shift its economic focus away from "…manufacturing goods to providing profitable services" and that "…Indiana college graduates are attracted to other states that are making that shift, causing a so-called 'brain drain.'" These recommendations fail to address the magnitude of the structural economic shifts that would be required, not only in training programs, but also the daunting task of growing and attracting companies to Indiana in industry sectors even more susceptible to global market forces, as the price and delivery of service sector goods are far less dependent on geographic location than most manufactured goods.

Workshop Rationale

Advanced manufacturing equipment and production processes existing in most manufacturing facilities, regardless of sector, often hide the advanced skills and knowledge required to operate the equipment – similar to watching a professional athlete "effortlessly" perform their craft at the highest levels. Individuals lacking an accurate understanding of the required knowledge and skills may see a potential career in manufacturing as simply "pushing buttons" – reflecting the EGR #4 finding that "…individuals considering manufacturing employment tend to think in terms that jobs that pay well rather than careers that are personally fulfilling." Conversely, advanced manufacturing technology may also intimidate those who are less confident in their abilities, but no less able to succeed in a manufacturing career.

The Purdue guitar manufacturing workshop seeks to directly address this disconnect in perceived personal fulfillment by providing individuals with a hands-on opportunity to manufacture a fun, interesting product that many can relate to and as a bonus think is "pretty cool". Controlled procedures and methods for using hand and power tools along with select automated equipment and software, combined with highly technical demonstrations will shed light on how their science, technology, engineering, and math courses can lead to rewarding manufacturing careers.

Additionally, this workshop will attempt to address a growing need to attract students into STEM disciplines. According to the National Center for Educational Statistics, the number of engineering and engineering technology Bachelor's degrees awarded in the US since 1980 has been relatively constant, even as the total number of Bachelor's degrees awarded has increased by 59%. In 1980-81, a total of 935,140 undergraduate degrees were awarded in the US. By 2005-2006, this number had increased to 1,485,242. The growth has been largely in non-technical fields as shown in Table 1.

Table 1: Bachelor's Degrees Awarded (Source: National Center for Education Statistics)

Field	**1980-81**	**2005-06**	**% Growth**
Technical			
• Engineering	63,642	67,045	
• Physical Sciences and Science Technologies	23,936	20,318	
• Engineering Technology	11,713	14,565	
• Mathematics and Statistics	11,078	14,770	
Total	110,369	116,698	5.7%
Non-Technical			
• Business	200,521	318,042	
• Social Sciences and History	100,513	161,485	
• Psychology	41,068	88,134	
• Visual and Performing Arts	40,479	83,297	
• Communication, Journalism and Related Programs	29,428	73,995	
• Liberal Arts, Gender Studies and Humanities	21,643	44,898	
• Parks, Recreation, Fitness and Leisure Studies	5,729	25,490	
• Philosophy and Religious Studies	6,776	11,985	
Total	446,157	807,326	81.0%

Workshop Overview

The high school targeted workshop is modeled after another one that was targeted at a more mature age group as an open enrollment, non-credit, summer workshop with a fee of $1299. The activities of the existing workshop sequentially step participants through the entire scope of manufacturing and assembly processes to complete an entire instrument during a one week period. During the workshop, each participant makes their own instrument while learning some of the underlying design principles and applications of advanced manufacturing processes (see figure 3). Processes range from minimal CAD design and CNC machining where participants design the shape of their headstock and then proceed to cut it out on a CNC milling machine, to the use of hand and power tools to detail, finish, wire and assemble the product. Figure 4 shows the CAD model of the guitar neck while figure 5 demonstrates the neck being cut on a CNC milling machine.

Figure 3: Participant in 2007 Solid Body Workshop

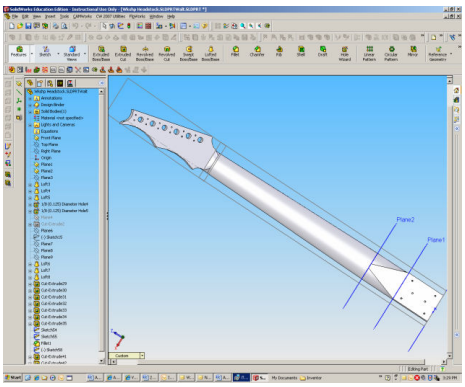

Figure 4: CAD model of guitar neck and headstock design

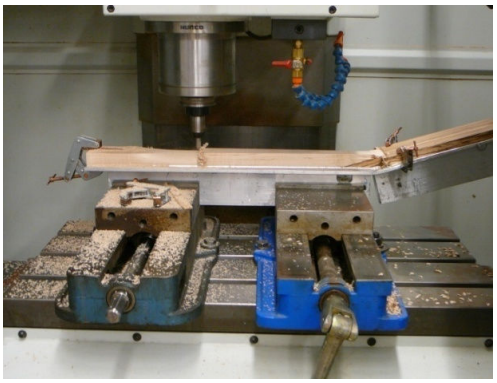

Figure 5: Hurco CNC milling machine cutting guitar neck

The initial offering of this workshop was successful and the next one will be about twice the size. However, there have been repeated questions about high school student participation. Since there were no provisions for chaparones or lodging, these potential attendees were generally turned away. There was clearly an opportunity and an interest to extend this activity to reach high school students. The obvious limitation was that high school students couldn't be expected to pay the full cost of the workshop. Based on the interest and the uniqueness of this program, funding was secured through both the Society for Manufacturing Engineers (SME) and the Department of Labor (DoL). As a result, two separate workshops will be offered in the summer of 2008. One of the workshops will be residential, so students from outside the immediate area can attend.

Figure 6: Workshop Participants with Completed Instruments

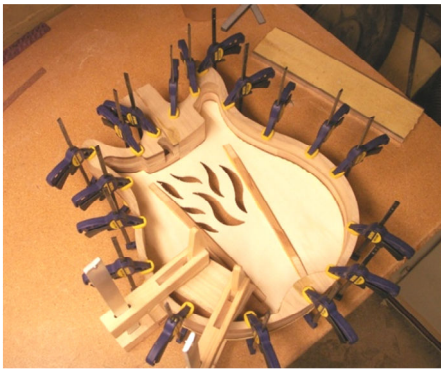

Figure 7: Acoustic Electric Guitar Body during Construction

The high school workshops will be roughly similar to the adult workshop (see Figure 6), but will be more structured and the students will make an improved instrument. More importantly, instruction and workshop activities will focus more on the role of manufacturing technology and engineering technology in the production process.

In the summer 2007 workshop, one attendee was accompanied by his 14 year old son who spent the week making a prototype of the new instrument. His experiences lead to an improved second version. Figure 7 shows the inside of the body during assembly.

Workshop Activities

The four day workshops will use guitar making as a means of introducing high school students to manufacturing as a possible career choice. Thus, we will be presenting the process of making a guitar as an example of how a precision product is manufactured.

On the morning of the first day, the students will receive a parts kit consisting of body and neck components, hardware, magnetic and piezoelectric pickups, a pre-amplifier, oil finish and illustrated assembly instructions. Before starting assembly, they will be introduced to the process in a step by step fashion.

Most of the heavy machining will be done before the class starts so that time with the students can be devoted to the most valuable activities. Demonstrations will be substituted for those processes too time consuming for the students to perform. For the solid body instruments in the first workshop, the body blanks were glued together, the necessary pockets were cut and the bodies were processed to their final shape. Students were only required to sand the bodies, cut any contours they wanted and apply finish. Similarly, the neck blanks were glued together and the necks were milled roughly to their final shape. Fretboards were slotted and milled to a 12 in radius. Students had to install a steel truss rod, glue the fretboard to the neck, install frets and finish the completed neck.

The high school student's time will be split between assembly operations and activities that teach design and manufacturing concepts. The assembly process will be divided into separate stations to mimic the layout of a factory. The stations include:

- CAD for Headstock Design
- CNC for Headstock Machining
- Body Sanding
- Body Finishing
- Neck Sanding
- Neck Finishing
- Fretting
- Electronics and Wiring
- Final Assembly

Supporting Facilities

The workshops will be held in a large teaching space and supported by a dedicated stringed instrument manufacturing lab. The lab houses two CNC routers, a CNC laser cutter, associated computers and a range of woodworking tools. These include a band saw, a resaw (wide blade band saw), a table saw, thickness planers, thickness sanders, spindle sander, drill presses and assorted hand tools. Air quality is maintained by several dust collectors and an air filtration system. In addition, there is a machine shop equipped with several large CNC milling machines and other equipment.

Anticipated Outcomes

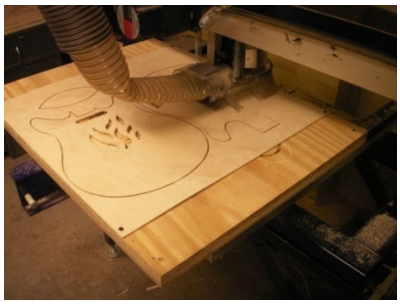

Figure 8: A Top and Back Being Cut on a CNC Router

Figure 9: Body Being Machined

Once individuals experience the pride and accomplishment of manufacturing a complete, functional, attractive, musical instrument that they can actually play (or learn to play), they will have first hand knowledge and insight into the area of manufacturing and whether or not it is right for them. If their experience was not positive, they can move on to explore other areas of study; however, if their experience was positive, participants will be presented with a number of suggested activities in which they can participate to better prepare them for a manufacturing or other technical career. Suggested alternatives will include participation in such programs as Project Lead the Way (PLTW), First Robotics, other SME STEPS summer camps, Dream it- Do it, as well as several other workshops and summer program offered by Purdue University College of Technology.

Additionally, based on the success of the original workshop and the interest that it created, faculty from other colleges and universities are already expressing interest in forming partnerships so that similar high school workshops can be held at other locations. For institutions without the appropriately equipped laboratories or the capital to equip them, projects are ongoing to supply component kits to partner institutions. The component kits may be accompanied by videos demonstrating the more advanced processes.

Conclusion

The first summer Guitar Manufacturing Workshops for high school students will be offered during the summer of 2008. Based on the strong response and reviews that were received from initial open enrollment summer workshop, as well as, feedback from parents and potential participants we expect a similar response to the high school focused workshops.

The activities of the workshop will be coordinated to emphasize and relate back to various applied technical areas of study and connect how there is a need for more people pursuing careers in these areas of study. The overarching goal of the workshop is to build an excitement and awareness of manufacturing related activities and opportunities. Our hope is that the experience these young adults receive will build their level of confidence in their abilities to learn and apply new technical skills and knowledge to accomplish a very rewarding task whereby they will be excited about a technical field and not intimidated.

[1] Strategic Skills Initiative Summary Report "Root Causes of Occupational and Skills Shortages in Indiana." Indiana Workforce Development, Research and Analysis Division, April 2006.