

Guitar Building Course Gives High School Students A Taste of Engineering

By

Dorene Perez, Jim Gibson, Sue Caley Opsal, Rose Marie Lynch
Illinois Valley Community College
and
Richard Mark French
Purdue University

High school students are getting a taste of engineering and earning college credit by building electric guitars. Illinois Valley Community College (IVCC) is offering a Taste of Engineering Careers (TEC) course on guitar building modeled after a Purdue University workshop and supported by a National Science Foundation (NSF) grant. The course is part of an NSF grant-funded project to recruit people into engineering and engineering technology careers.¹

In fall 2009, 12 students completed the first TEC course. For a minimal fee, each student emerged with the guitar he or she designed and built.

Evaluations of that first class are promising, with assessments indicating the class met its objective of building interest in and commitment to engineering-related careers. Additional sessions are being scheduled with one just for high school women being planned.

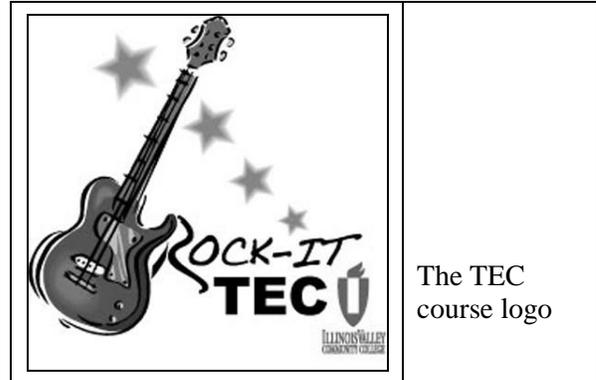
Background of the TEC Course Concept

Concern about the availability of engineers and engineering technicians in the future has been growing. Of special concern is a decline in interest in engineering careers among high school students as reported by a National Science Foundation task force and the ACT.² As part of a larger, NSF-funded recruiting project to address that concern in the IVCC district, IVCC faculty envisioned a Taste of Engineering Careers course that would provide high school students with hands-on exposure to engineering-related experiences. The idea to build the TEC course around guitar construction originated from a guitar project in the e-CREATE program of the Midwest Coalition for Comprehensive Design Education.³ That coalition was headquartered at Purdue University and included four community colleges. Purdue University's department of Mechanical Engineering Technology had well-established guitar building programs that included workshops, college courses and a dedicated guitar laboratory, the Mechanical Engineering Technology Acoustics Lab or METAL.⁴ Purdue had been hosting guitar building summer workshops for high school students and for the general public as well as offering its students a guitar building course in Instrument Manufacturing and Testing through the College of Technology.

During 2009, with support from an NSF grant, IVCC engineering technology and electronics faculty utilized the expertise of Purdue University staff and the capabilities of the Mechanical Engineering Technology Acoustics Lab to develop and offer the Taste of Engineering Careers course. Two of us from IVCC visited the Fender Guitar Company in California and then

received training in guitar building and built our own guitars. In summer of 2009, before offering the first session to high school students, IVCC offered a guitar building workshop to area high school teachers to generate interest and buy in for the TEC course. Future workshops for high school faculty are being planned.

Like the Purdue University workshops, the TEC course is designed to encourage young people to prepare for engineering or engineering technology careers by engaging them in a high interest project that teaches them basic technology skills. The IVCC TEC course, however, takes the concept a step further by offering college credit to high school students.



The TEC course logo

Description of the TEC Course

Taste of Engineering Careers, or GNT (General Technology) 1210, offers two semester hours of credit accepted in Associate in Applied Science programs, but not intended for transfer. The course is open to high school seniors, with juniors eligible if seats are available. Available lab space and funding limit the number of students to 12. Through 2011, the NSF grant is supporting tuition and a portion of the cost for guitar components, as the table below illustrates:

Funding for TEC course through 2011 per student

Expenditure	NSF Grant	Student
Two semester hours of tuition + enrollment fee	\$144.50	
Guitar components	\$125.00	\$75.00
Total per student	\$269.50	\$75.00

For a fee of \$75 during the grant period, each student is emerging from the class with the electric guitar he or she designed and built.

The course is being offered to students in high schools that have established Tech Clubs, which are also being supported by the NSF grant. Those clubs are open to students with an interest in any science, technology, engineering or mathematics (STEM) area and are intended to provide high-interest activities that develop commitment to STEM careers. Seats in the TEC class are available by application with Tech Club members given preference. Additional factors evaluated in selecting students include the student’s STEM background and potential for a career in an engineering-related area.

Scheduling the course to accommodate the already full schedules of high school students is difficult. At this time, Saturday mornings, from 8 a.m. to 12:30 p.m. has been the best option. The class meets for nine sessions in the IVCC Manufacturing Laboratory.

Content of the TEC Course

Each of the TEC course sessions includes:

- Lecture(s), exercise(s), and/or demonstration(s) on STEM topics related to guitar construction, and,
- Laboratory work on guitars.

The content for each of the nine-week sessions is listed in the table below.

Nine-week TEC course plan

Week	Lecture – Exercise - Demonstration	Laboratory Work on Guitars
1	<ul style="list-style-type: none"> • Building a Guitar in CAD and Solid Modeling • The Math and Physics of the Guitar 	<ul style="list-style-type: none"> • Solid Works session in CAD lab • Students receive guitar body and begin hand sanding
2	<ul style="list-style-type: none"> • Guitar body and neck styles • Importance of uniformity and tolerances 	<ul style="list-style-type: none"> • Student use resources to decide on headstock design • Design their own using CAD
3	<ul style="list-style-type: none"> • Science and physics behind fret boards 	<ul style="list-style-type: none"> • Sand and finish necks • Glue fret board to neck • Install frets
4	<ul style="list-style-type: none"> • Guitar electronics: wiring diagrams • Guitar finishes 	<ul style="list-style-type: none"> • Students do setup and wiring • Students complete sanding and finishing
5	<ul style="list-style-type: none"> • Using Solid Modeling to program tool paths • More on CAD 	<ul style="list-style-type: none"> • Use Solid Works and Mastercam to program CNC machine • Use 3-D printer to subscale parts and check for compatibility
6	<ul style="list-style-type: none"> • How a guitar works: acoustics 	<ul style="list-style-type: none"> • Finish necks • Cut out head stocks
7	<ul style="list-style-type: none"> • Assembling a guitar: pickups, strings, tuner, string nut 	<ul style="list-style-type: none"> • Assemble guitars • Check tolerances
8	<ul style="list-style-type: none"> • Final assembly 	<ul style="list-style-type: none"> • Finish assembly
9	<ul style="list-style-type: none"> • Measuring build variation • Jam session 	<ul style="list-style-type: none"> • Check tolerances • Tune • Play

Additional instruction on guitar construction is integrated into the lab work. Information on engineering and engineering technology careers and on programs and courses available at IVCC is integrated into nearly all course sessions. The course does not utilize a textbook, but *Engineering the Guitar: Theory and Practice*⁵ is available for reference.

The students are supplied with a Humbucker pickup guitar kit, which includes a rough-shape Telecaster or Stratocaster guitar body, headstock, and all of the hardware to wire and assemble it. They are also supplied with wood finishes and supplies such as sanding paper and glues.

The guitar design is based on ones used in workshops at Purdue; the instrument is slightly simpler than the typical electric guitar so that it can easily be completed during workshops. The

most obvious design feature difference is the single pickup rather than the two or three pickups usually seen on electric guitars.

The students finish the guitar body, cut and finish the head, assemble and solder the electronics following a schematic, install the electronics, and assemble the guitar.



Students in the TEC course work on sanding the guitar body and installing frets.

Building on lessons learned in Purdue workshops, students in the TEC course customize their guitars; Purdue workshop experiences have shown that students' interest and enthusiasm grow significantly when they can express themselves through the creation of a unique instrument. Also based on Purdue experiences, customization opportunities are limited to specific parts of the instruments. Fortunately, the most visible modifications, paint and headstock design, have relatively little to do with the function of the instrument. Students contour the bodies of their guitars to make them more comfortable to play, paint them as they like, and design their own headstocks.



A TEC course student who works on an ambulance customized his guitar with an EKG theme

The students utilize a variety of software, equipment and tools, including: AutoCAD, Solid Works, 3-D Printer, multimeter, electronic tuner, fret press, drill press with a plug cutter, band saw, circular and belt sanders, clamps and pins, vices, files, chisels, rasps, soldering irons, cordless drills, cordless screw drivers, and a number of hand tools.

Grades are based largely on an evaluation of their lab work and project completion.

The course is team-taught by two of us from IVCC who were trained by Purdue University staff in guitar building and built our own. Our backgrounds are in CAD and electronics but, at this time, neither of us plays the guitar. One-third of the students in the first class played the guitar. Some of those who didn't said they planned to learn, but the others were satisfied with learning the process and owning an instrument they had designed and built.

Effectiveness of the TEC course

While the course is too new for a thorough analysis of its effectiveness, initial evaluations are promising. In anonymous surveys, students who enrolled in the first class reported enjoying the class with one student writing, "Even though I had to get up every Saturday morning, this was the best class I've ever had."

At the start of the class, nine of the 12 students were planning on engineering or engineering technology careers, with the others in related areas including nanotechnology, tool and die, and forensic science. But five of the students had not decided on a college. By the end of the class, all had picked colleges, and more of them were planning to attend IVCC. The students had not changed their career plans during the class, but most said the class made them more likely to pursue an engineering career. They also reported having a better understanding and appreciation of certain aspects of engineering including the creativity, teamwork and practical applications of science. All of the students are being tracked to see if they do enroll in the colleges and programs they identified in their post-class assessments. Surveys completed by parents of those TEC course students were not useful in evaluating the success of the class, largely because too few completed the post-class survey. In future sections, the final parent survey will be administered just before students complete the class. The parent pre-class surveys revealed positive attitudes and perceptions about engineering careers, which is not surprising given their children's career plans.

The first class included 11 boys and one girl. For future classes, high school counselors and teachers in math and science are being encouraged to reach out to girls, but offering a section open just to girls is likely to be the most effective way to reach them. Counselors and teachers are also being encouraged to reach out to students who are undecided about careers. If more undecided students enroll, assessments from those classes should prove more useful in evaluating the effectiveness of the course in creating interest in engineering-related careers.

The first class was highly successful when evaluated on the basis of generating publicity. Nearly all of the area newspapers carried at least one major feature on the class over the past year. Front page headlines, such as "Engineering can be cool," and "IVCC teaching 'Rock – it science,'"

appear to be contributing to the overall objective of making engineering more attractive to young people.

The future of the TEC course at IVCC

Although a significant portion of the TEC course costs are currently being funded through a grant, charging students for tuition and for guitar components will be a reasonable option in the future. Based on current rates and costs, a student would emerge from the class with two hours of college credit and his or her hand-made electric guitar for \$350.

Adaptability of the TEC course to other institutions

The TEC course concept is adaptable to other institutions, and it is especially suited to community colleges because of their generally moderate tuition rates and flexibility to offer credit for career-oriented courses not intended for transfer. IVCC has developed content, as well as promotional, application and evaluation materials, which it will be making available on its web site⁶; Purdue University has developed the infrastructure to support the development and offering of guitar building courses including training for faculty, consulting assistance, and guitar components.

Guitar design and building is proving to be a high interest project for giving young people a taste of engineering at IVCC. It could be a reasonable and exciting tool for other colleges.

References

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