The FabLab Classroom: Learning Middle School Science Through Engineering Design and Manufacturing

Background

The undergraduate engineering curriculum is being transformed by advanced manufacturing technologies. Within the past year, desktop manufacturing systems have become affordable at the K-12 level. The Commonwealth Engineering Design (CED) Academies are being established with two goals:

(1) To help create the skilled workforce needed for the future by preparing K-12 students for the jobs expected in the future and related skills required for those jobs

(2) To respond to draft Next Generation Science Standards that call for integration of engineering design into science education (National Research Council [NRC], 2011)

The draft standards respond to a crucial need for our nation to have both scientifically and engineering literate students. The CED Academies are being developed to address this need by teaching middle school science in the context of engineering design through use of advanced manufacturing technologies.

Documented Results

The FabLab Classroom (NSF DRL-1030865) is exploring use of digital fabrication to allow students to create digital designs that are realized as physical objects, such as model satellites (in collaboration with NASA), wind turbines, and speaker systems. This work provides a context for addressing the goals described above.

For example, in one project, undergraduate engineers collaborated with science teachers on a series of hands-on lessons involving periodic motion. An initial activity illustrated the nature of periodic motion through paint flowing from a swinging bucket. A 3D-printed valve that could be easily opened and closed by a child produced an even flow of paint. Once the concept was illustrated through a physical demonstration, it was extended with a physical pendulum that recorded its motion on an electronic strip chart on the screen of a tablet computer.

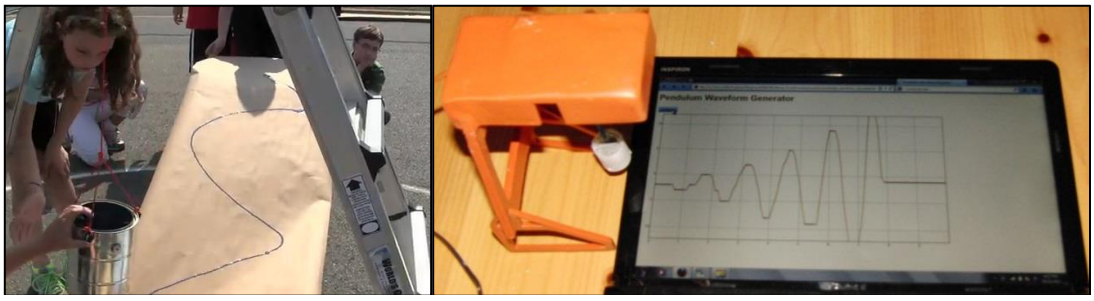

Figure 1. Paint flowing from a swinging bucket on the playground generates a sine wave, and a mixed-reality pendulum with a simulated paint bucket records its motion on a computer screen.

The understanding gained through these concepts and relationships was then used as the basis for designing a digitally fabricated speaker. This provided a real-world context for applying the knowledge gained through experimentation.

Figure 2. Ariana, a middle-school student, inspects the speaker that she manufactured.

The students then compared the acoustic characteristics of the speakers that they designed and manufactured to commercial speakers. They used their analyses of the frequency response curves to revise their designs for woofers and tweeters. This provided a real-world context for applying the concepts they learned.

This project illustrates the range of activities possible through advanced manufacturing. A 3D printer was used to manufacture the mixed-reality pendulum and other science equipment. This allowed the science teacher to design and create science demonstrations through advanced manufacturing technologies. The pupils employed the same technologies in the design of working speakers, supported by the teacher.

Potential Applications

We are creating an infrastructure for teaching science through advanced manufacturing technologies. The project has demonstrated that participating teachers can use CAD software and fabrication hardware and are enthusiastic about doing this. In the process, they gain experience in incorporating fabrication in science instruction. A systematic approach to learning related engineering concepts is needed to allow teachers to achieve the full potential of these technologies. To achieve this, the Curry School of Education and the School of Engineering and Applied Sciences are jointly developing a course, "Engineering for Science Teachers." Once the course has been piloted, it will be made available to science teachers nationally in an online format.

For More Information

The activities and designs for the pilot activities described are housed on WISEngineering, a learning management system for K–12 engineering education, and are available at http://wisengineering.org/soundwaves/. Other resources that support digital fabrication in the classrooms are available at http://maketolearn.org/.