Amateur Radio in the STEM Classroom

One Technical Tool—Countless Lesson Applications

By Edith Lennon, N2ZRW*
edithmlennon@gmail.com

AMATEUR Radio was formed by experimenters who wished to push the envelope of radio technology. That purpose remains at its core, which is why it fits perfectly with science, technology, engineering, and math (STEM) education.

Also known as ham radio, its emphasis on hands-on investigation and experimentation make it a perfect tool to help students understand complex technical subjects. It also aligns with both state and national learning objectives. Moreover, incorporating Amateur Radio in the classroom is a proven effective way to teach both practical applications and theory.

Using wireless technology literacy as a starting point, instructors can build a solid foundation across multiple subject matters and grade levels as Amateur Radio integrates math, science, engineering, and technology, as well as other content areas, such as geography, reading, and writing. As both a teaching tool and as a hobby, it has demonstrated a strong motivating influence, one that readily leads to careers in computer sciences, consumer electronics, broadcast engineering, research sciences, medicine, telecommunications, and more.

Beyond that, it encourages community involvement, while cutting across social, political, cultural, geographic, and physical handicap boundaries, contributing to the goal of sending forth truly educated graduates.

This article provides a sampling of how Amateur Radio is being used successfully in the classroom by teachers who attended professional development workshops offered by the Amateur Radio Relay League (ARRL), a non-profit, national association that supports STEM instruction through its Education & Technology Program (ETP).

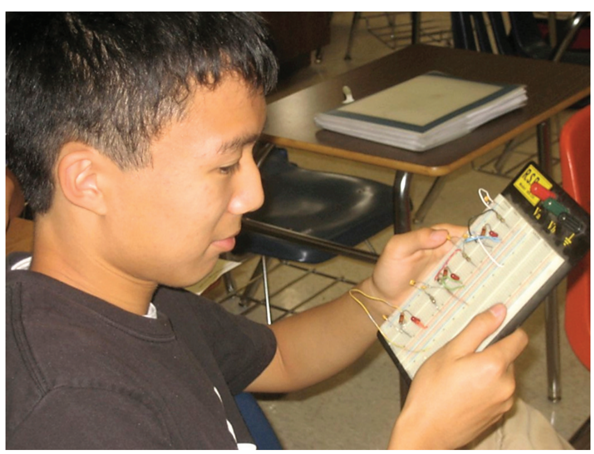


Photo 1—Liberal Arts & Science Academy (LASA) High School student Brian Cui, KF5SZS, examining a "Blinky LED" circuit

The workshops, known as Teachers Institute on Wireless Technology TI-1 (beginner) and Teachers Institute on Remote Sensing and Data Gathering TI-2 (advanced), provide educators with equipment, training, and resources to incorporate radio science and wireless technology in their instruction. The sidebar "Amateur Radio in Brief" provides a short introduction to the topic and resources for more information, including the Teachers Institute on Wireless Technology Summer 2016 workshops.

Building Circuits, Tracking Satellites, Bouncing Signals Off the Atmosphere

The broad range of Amateur Radio applications that can be used to achieve educational goals is exemplified at Liberal Arts & Science Academy (LASA) High School in Austin, Texas. Here, government/law instructor and Amateur Radio operator Ron Risinger, KC5EES, used TI-1 training and an ETP equipment grant as a springboard to form Amateur Radio school club K5LBJ. From that initial step, he developed a complete course based on wireless technologies.

His students learn basic electronics and are guided in building crystal radios, Morse code oscillators, and

*Licensed Amateur Radio operators, some clubs, and special stations are assigned a combination of letters and numbers, known as a call sign.

Edith Lennon, N2ZRW, is a freelance journalist and Amateur Radio operator.

"Blinky LED" circuits (Photo 1). Other lessons build on his TI experience in constructing and controlling a Parallax BASIC Stamp BOE-Bot (short for Board of Education robot), an ideal platform for introducing robotics and programming.

Earth sciences came into focus after the installation of a weatherfax receiver that broadcasts graphic weather maps and other graphics via HF radio for daily weather images direct from National Oceanic and Atmospheric Administration (NOAA) satellites. Students soon decided to put a computer monitor on top of the hallway lockers to display the weather images showing current conditions as directly received from the satellite.

Leaving the Earth's atmosphere behind for a once-in-a-lifetime experience, Risinger arranged with the Amateur Radio on the International Space Station (ARISS) program for his school to host a live radio con-tact with the ISS.

Units on remote sensing and data gathering—which introduce basic sensors, analog/digital conversion, and using APRS (Automatic Position Reporting System) to convey location and other data messages—also involve tools taken from Amateur Radio. A particularly interesting one is known as the Mars Amateur Radio Exploration Activity (MAREA). For this activity, students will use a robot platform and a satellite-tracking station they built to send APRS messages containing commands via the ISS, simulating NASA's control of its own Curiosity rover via the Mars Global Surveyor satellite.

While there was an initial setback (a 9 V battery on the robot died while awaiting signals), students have spoken with other hams via satellite (SO-50) and sent "tweets" via the ISS as proof of concept, and a new group is excited to try again.

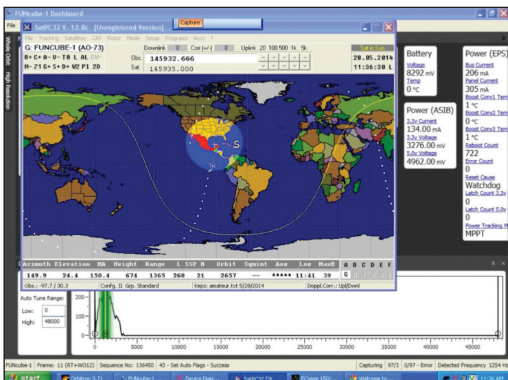


Fig. 1—Screenshot of first FUNCube (AO-73) telemetry received by K5LBJ, May 2015

Photo 2—LASA Amateur Radio Club, K5LBJ, students in front of the satellite-tracking computer as FUNCube passes over their high school

Until then, the class is enjoying monitoring the FUNCube (AO-73) educational satellite's various telemetry and messages and learning about its orbit/rotation (Photo 2, Fig. 1).

Risinger says that wireless technology has had a lasting impact on his classroom. Radio club K5LBJ's president Lucas Baltisberger, KG5GHP (Photo 3), who is presently building an 80 meter receiver, agrees. "Ham radio shows you a whole new world of electronics and communications that I really never knew about," says Lucas. "In Physics, you get a basic introduction to concepts such as Ohm's Law, but in ham radio, you really learn about components and circuits, and get to see how it all works together to receive a signal."

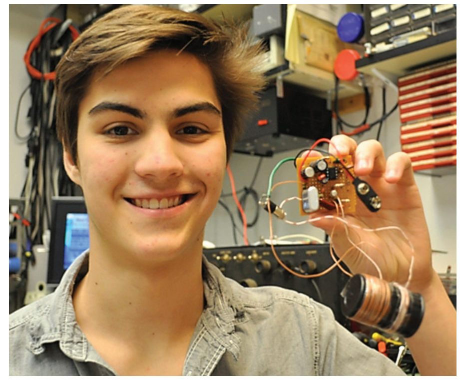


Photo 3—K5LBJ president Lucas Baltisberger, KG5GHP, with his 80 meter receiver project

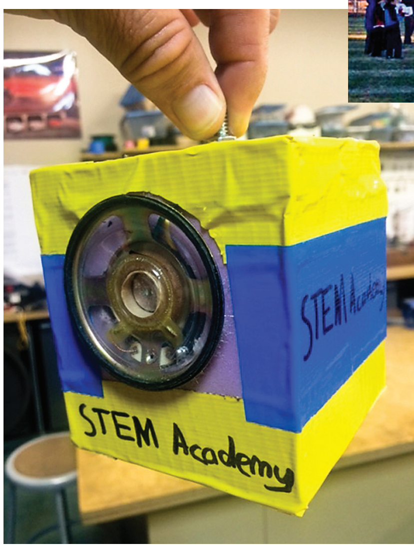
Lesson Takes Off with Weather Balloon Tracking

At the STEM School and Academy, which serves 5th- through 12th-grade students in Highlands Ranch, Colorado, volunteer Academy instructor Paul Veal, NØAH, teaches wireless technology applications and offers after-school enrichment programs. To engage students, he focuses on how their wireless devices work using RF energy, concepts easily demonstrated through Amateur Radio equipment and project-based learning. Working as teams, they built a ham station and contacted people around the world. Some took it a step further and learned how to not only hook up antennas, but to design and build them using antenna analyzers.

These activities led to the formation of a school radio club, which soon began networking with other area clubs and Edge of Space Sciences (EOSS), a Denver, Colorado-based non-profit that promotes science and education through Amateur Radio and high-altitude balloons. Edge of Space refers to the area of

Photo 4 (right)—STEM School and Academy students and others watch their weather balloon take off.

Photo 5 (below)—Payload designed to study sound propagation during EOSS balloon flight



the stratosphere where high-altitude balloons (weather balloons), filled with either hydrogen or helium, can fly. They typically reach a height of approximately 100,000', where the atmosphere is comparable to that of Mars. Of course, the students were thrilled to launch their own weather balloon (Photo 4).

Through designing and constructing experiments, or payloads (Photo 5), lessons cut across curricula and incorporate math, science, engineering, and of course, Amateur Radio tactics used to track the balloons. Payloads may have as many as a dozen experiments tied to a cord up to 60' long hanging from the balloon. They must be capable of surviving the extreme environment (including temperatures as low as –70° F) and the parachute descent back down after the expanding gas causes the balloon to burst. The objective is to have the experiments return to Earth intact with retrievable data.

To retrieve the balloon's payloads, students use Amateur Radio tracking equipment and techniques, including Automatic Packet Reporting System (APRS), a digital communications information channel for ham radio. "APRS sends out bursts of information on Amateur Radio VHF bands, telling us exactly where the balloon is, its speed, altitude, and upon landing, its precise location," says Veal. "For backup, we also have on-board Amateur Radio beacons so, should the APRS fail, we can locate the balloon by triangulating on the signal the beacon puts out" (Photo 6).

Photo 6 (above)—Sophomore and Amateur Radio operator Anna Veal, WØANT, speaks with other hams via a field radio as their convoy tracks an EOSS flight.

The goal for the program, about to launch its fifth high-altitude balloon, is to improve upon the last design, while engineering new ideas and concepts. "The best success we have had is reaching apogee with our experiments still functioning," says Veal. "Our GoPro cameras have captured amazing footage of the actual balloon burst, clear shots of the moon, and occasional dust particles" (Photo 7).

Columbia College Delves Deeper with Buoys

Jeff Tolhurst, N6JWT, teaches Earth Sciences and GIS (Geographic Information Systems)/GPS at Columbia College in Sonora, California. Last semester, he introduced students to the Buoy Sensor System he obtained from the ARRL TI-2 course. The lesson began with them observing its parts and describing how the system collects air and water temperature, air pressure, battery voltage, and GPS location information.

After deciding on the best location for the buoy, the class paddled out onto the San Diego Reservoir,

Photo 7 (right)—Image taken with EOSS payload's GoPro camera at around 95,000' on descent

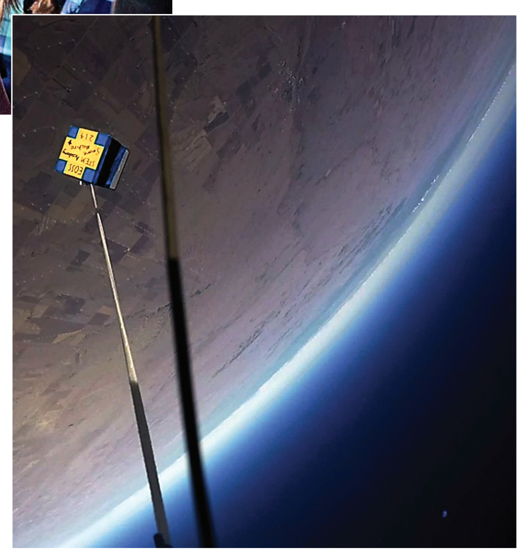


Photo by Jeff Tolhurst, N6JWT

Photo 8 (above)—Columbia College Physical Geology students paddle out to the buoy deployment site on the San Diego Reservoir.

a four-acre body of water on the campus that's used for field studies. There they deployed the buoy to collect that same data themselves (Photo 8). In addition to the buoy sensor package, lesson equipment consisted of an APRS 2 meter Amateur Radio and digital repeater system known as aprs.fi, a Web database that provides APRS information and offers real-time map views.

Students monitored the system to see when the batteries ran out of power, which was approximately three weeks. They then downloaded the data the various sensors had collected. "During that time, I showed the class how the data was broadcast to the aprs.fi website, then processed and cleaned up for analysis," says Tolhurst. "Students then analyzed the data using Excel spreadsheets and graphing functions" (Fig. 2). This helped them visualize how air and water temperature change at different rates and understand why water holds heat differently than air.

Tolhurst says the big takeaway for students seemed to be an understanding that sensors and radios are an integral part of observing Earth systems and that they are now cheap enough to deploy almost anywhere and can help us make sense of nature. "It's nice to utilize technology like a scientist would in the field," said Brian Beasley, a Columbia College Physical Geology student.

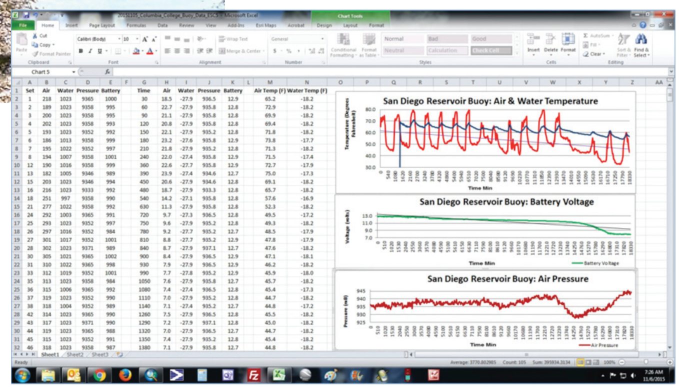


Fig. 2—Screenshot of San Diego Reservoir Buoy Data

Branching Out—Added Value for Students, Greater ROI for Institutions

Amateur Radio readily lends itself to cross-subject learning, extra-curricular activities (all but mandatory for college admissions), and career-oriented learning. At the Petal High School Career Tech Center in Petal, Mississippi, Information Technology Instructor Brad Amacker, N5MZ, has made industry certifications a primary focus in his IT classes. Even the state end-of-course exams for his InfoTech I and InfoTech 2 programs are IT industry-certification exams. He incorporates wireless technology into his lessons on electricity and electronics, safety, Ohm's Law, and wireless networking. His students often leave the program not only with IT certifications, but also an FCC Amateur Radio license.

The school Amateur Radio licensing program he instituted soon expanded into a Law & Public Safety course, which introduces students to the fields of law enforcement, firefighting, and emergency medical services and includes a communications unit with a focus on licensing. As the result of teaching his four sections, 35 students received their Amateur Radio licenses in the fall of 2015 alone.

"Not only do we work to get students licensed, we also want to have them actively involved in the Amateur Radio community," says Amacker. The school club provides safety and logistics communications for several area 5K runs. "The local organizations get quality communications and our students get practice in providing public service communications," he says (Photo 9).

Photo 9—Petal High School student and Amateur Radio operator John Brady Amacker, K5JBA, providing communications for a 5K race sponsored by the Petal YMCA

Several area hams purchased a repeater (an electronic device that receives weak radio signals and retransmits them at a higher power) and installed it atop the high school stadium press box. "We use the repeater for many activities, including communications among licensed second-year IT students who travel between campuses in the district to perform maintenance and repair on computer equipment as part of the job shadowing component of the program," he says.

Amacker sums up his experience as follows:

"Career & Technical Education has always stressed real-world, authentic learning experiences and focuses particularly on building skills to help students succeed in the workplace. Earning validation of these skills, such as industry certifications and FCC licenses, not only teaches the skills students need, but provides verification that can help set them apart from other applicants. The Amateur Radio curriculum has brought tremendous value to these programs, not only affording the opportunity to earn the license, but by strengthening other content areas with practical applications."

Author's note: The author wishes to thank Ronny Risinger, KC5EES, Paul Veal NØAH, Jeff Tolhurst, N6JWT, and Brad Amacker, N5MZ, for their invaluable contributions to this article.

Amateur Radio in Brief

The FCC established Amateur Radio as a voluntary, non-commercial radio communications service. It allows licensed operators to improve their communications and technical skills, while providing the nation with a pool of trained radio operators and technicians who can offer essential communications during emergencies.

Twenty-seven frequency bands throughout the spectrum are allocated to this service internationally and are used by Amateur Radio operators for self-training, intercommunication, and technical investigations. Some 1,300 digital, analog, pulse, and spread-spectrum emission types may be transmitted.

In the classroom, applying the technologies and techniques of Amateur Radio is an ideal way to promote STEM education experiences in a way that prioritizes hands-on learning and fosters student engagement and achievement.

To learn more about Amateur Radio and how to get started using this tool in the classroom, see the following resources:

American Radio Relay League (ARRL)—www.arrl.org

Amateur Radio in the Classroom—www.arrl.org/amateur-radio-in-the-classroom

ARRL Education & Technology Program—www.arrl.org/education-technology-program

ARRL Teachers Institute Workshops and Summer 2016 schedule—www.arrl.org/ti

