



Ignite Zeal for STEM Learning

BY HECTOR MORALES

Incorporating business skills such as problem-solving, public presentations, collaboration and self-direction into STEM (science, technology, engineering and mathematics) subjects is an excellent way to build students' enthusiasm for these disciplines. And when educators add workplace internships to the learning experience, they are well on their way to attracting students to STEM-related careers.

By following these principles, the School of Science and Technology magnet high school, housed at Merlo

Station High School near Portland, Oregon, has ushered numerous seniors into scientific and technical careers, particularly in engineering. The school serves approximately 165 students in grades nine through 12 and offers a science-rich curriculum covering a range of subjects, such as: earth science, astronomy, conceptual physics, general chemistry, biology and health. In their junior and senior years, students take advanced science courses in their areas of interest: geology, field ecology, marine biology, animal behavior, advanced top-

ics in biology, environmental chemistry, science research, or psychology; they also take Advanced Placement chemistry and physics.

From their freshman year onward, all students are required to develop real-world skills such as analysis, collaboration, and self-evaluation through learning experiences that combine traditional classroom instruction with field and research experience. Classroom lessons include hands-on experiments that focus on scientific inquiry and, at times, engineering challenges.

Hands-On, Self-Directed Projects

Since students come to the school with varying abilities in math and science, they are frequently given the latitude to design their own projects—within preset parameters like stated deadlines—in order to cultivate the particular skills in which they are lacking. (Throughout such projects, teachers serve as consultants.) Self-directed projects start with students choosing which tools they want to explore and learn more about from an array of scientific and engineering tools. The instruments made available for selection are spectrophotometers and various sensors for ultraviolet light, infrared light, pH levels, inorganic ions, motion, force and electrical flow.

The lab and field instrumentation presented are already familiar to most of the students because they have used the tools in their academic classes. However, the selection also includes online research tools provided by the school district, as well as Web sites used in scientific research so that students can study the background of the tools they choose and see the current status of scientific studies in that particular area. No matter the grade level, self-directed projects also consist of students sharing what they already know about the subject with their teacher before beginning their projects. That is, they are required to write a background piece demonstrating that they have some basic knowledge on their chosen topic.

One of the values of self-directed projects is that they impart a sense of ownership and scientific exploration that serves as an almost guaranteed source of motivation. Students tend not to fake ignorance or choose something that they have previously learned because they know that they will be bored doing what they already know.

In addition, the students have to develop creativity and problem-solving skills by making their own goals for their projects. They also create their own grad-

ing rubrics and submit those to teachers for approval beforehand. Constructing the rubrics and setting their own criteria enables them to understand and determine at what point they have earned an A, B, C and so on. Once a project is completed, teachers review what each student accomplished with regards to the confirmed criteria and indicate whether they agree or disagree with students' self-evaluation scores.

conductivity, levels of nitrate, ammonium, chloride and dissolved oxygen, as well as changes in concentration. That meant that the robots had to be programmed to pick up and exchange the various probes. Also, pH and salinity data cannot be collected at the same time, so students had to create programming logic that would have the robots properly time the tasks. To prepare for this experiment,

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Projects are Multidisciplinary

Since many real-world scientific endeavors involve multidisciplinary efforts, several of the projects consist of the same. For example, in the robotics class, students coupled robotics and biology for a water quality experiment. The science-related objective was to expose them to field and lab measurements and also have them follow changes in measurements, assess the conditions of the location and provide follow-up studies, causes and remediation.

Since the field studies were conducted in a nearby nature park and along creeks within three miles of the school, and involved hourly measurements for a period of nine to 18 weeks, students had to design robots using LEGO MINDSTORMS NXT sets to take the measurements. In addition, they had to program the robots to use a variety of sensor probes from Vernier Software and Technology.

The water characteristics measured were the following: pH, temperature,

students first had to master robotics by doing MINDSTORMS NXT tutorials in independent learning sessions. After they had solved the smaller challenges of how to make robots move, pick up items and so on, they were ready to move onto the actual project.

Past students have reported that such hands-on experience serves them well in college. For example, those who go on to do robotics in college find themselves using the same logic and approach, if not the actual programming language, so they feel extremely comfortable with their college courses.

Public Speaking at Science Fair

Another business skill encouraged in students is making public presentations. Ninth- and 10th-graders are required to create science or engineering research projects for local, regional and state science fairs while the students in the higher grades have the option of participating. The students have to successfully present

and explain their projects at a series of science fairs with increasing geographical coverage. At the regional science fair, participants have to place within the top three in order to be eligible to present their project at the next event.

At the state competition, students compete with teams that include students from the University of Oregon and have to place “Best of Fair” in their area in order to be eligible to go on to the culminating event, the Intel International Science and Engineering Fair (ISEF), considered

had communicated their eagerness to see how their science and technology classes translated into the real world. Since poor preparedness and insufficient information about chosen careers are likely to result in disillusioned college students abandoning their STEM majors, the school’s teachers wanted to ensure that any program implemented would involve more than students just “shadowing” a job for a day. Teachers wanted students to be around STEM-related worksites and be an active part of the science community for

Some students conclude that they want to pursue another area of study during their internship, but most provide extremely positive feedback about the internships and continue working at the sites through the summer vacation months. They even return to the worksite every summer during their time at college. Former students who have now become professionals are taking on interns from the school, and at least one past student was hired by a site that participated in the program. These graduates report that the internship experience resulted in them developing a good work ethic and made it easier for them to become independent workers.

The School of Science and Technology does tend to attract students who are enthused about science and technology in the first place, but there are a fair number of students who have a lower level of interest, at least initially. Since one of the school’s tenets is that every student is capable of performing at high levels, all are held to the same standards and must meet the same requirements. Those who start out with lower interest, grades and abilities not only benefit from being in a classroom with engaged high achievers, but also from the problem-solving challenges they encounter. While regular schools may have to dilute similar efforts, incorporating business skills and real-world demands into lessons promotes a level of engagement and ownership that jumpstarts students’ critical thinking about their schoolwork and their future careers. ■

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the world’s largest pre-college science fair competition. In 2009, the School of Science and Technology’s students engineered a detection system that would protect users against pickpockets and successfully presented it throughout the series of science fairs, resulting in them earning a place on the statewide team of students that went to the Intel ISEF in Reno, Nevada. They were able to meet and compete with students from more than 56 countries.

Work Experience via Internships

Students’ time at the School of Science and Technology culminates in yearlong internships which came about through discussions among teachers and input from students and parents.

Since its inception, the school had always placed an emphasis on learning outside of the classroom, and students

prolonged durations so that students gain exposure to the workload and environment that they can expect to experience in a particular field.

With the cooperation of local government agencies and businesses, the internship program was established in 2005 so that seniors could conduct research or work in the area of interest that they are most likely to explore in college, for example, medical science, computer science or engineering. Internship sites include Intel, U.S. Natural Resources Conservation Service, the local veteran’s hospital and even the school’s lab equipment supplier, Vernier Software and Technology. The seniors go to their internship site every Friday throughout the school year and work there all day instead of attending classes. While on the job, students are doing work that the employers consider appropriate.



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