Scientists and Engineers for the Future

Tomorrow’s workforce is in the K-12 schools today. How will manufacturers get the skilled and educated people they’ll need a few years from now?

Karen Wilhelm

Although West Michigan has suffered economically in recent years, Grand Rapids is not ready to throw in the towel. It expects manufacturers to continue to need skilled workers and engineers. To help meet that need and to increase the number of historically underrepresented populations in science and engineering, Davenport University’s Grand Rapids Area Pre-College Engineering Program (GRAPCEP) melds the best secondary school career opportunities with demanding academic requirements.

The organization connects community resources — universities, manufacturing and biomedical companies, and the state and local educational agencies — to develop teachers, raise curriculum standards, and conduct hands-on activities to charge up students about engineering and biomedical careers. Students participate in company tours, job shadowing, and internship opportunities, as well as develop academically in classes, workshops, and summer camps.

GRAPCEP also sponsors and assists students who compete in individual and team competitions such as science fairs, inventor’s contests, and math challenges. Finally, GRAPCEP assists students in choosing and entering the college engineering or science programs that best meet their needs and career goals.

Students apply for GRAPCEP through their schools. Teacher recommendations, school grades, an application, and an interview are all part of the selection process. GRAPCEP looks for students with good school work habits and grades, motivation, creativity, analytical reasoning skills, and problem-solving abilities.

In Brief

Lean improvements are based on scientific thinking. Hypothesis, experiment, apply results if they work, or start over — PDCA (Plan-Do-Check-Act). People at all levels of the organization have to think that way. A program in Grand Rapids, MI produces high school graduates with those abilities and equips them with experiences that help them understand manufacturing.
GRAPCEP helps teachers enhance their skills in teaching mathematics and science, in using project-based teaching, active learning strategies, and computer technology. GRAPCEP also links teachers to engineers and scientists and to other resources offered by GRAPCEP business partners. This supports a curriculum focused on the real world of business and the requirements of college engineering and science programs.

**How GRAPCEP Started: Catching Them Early**

Attracting students to engineering and science careers starts with middle school activities. Even this early, students and their parents are making decisions that will open or close paths to science. Activities like rock-etry and math competitions make science fun and plant the idea that engineering holds opportunities for both boys and girls.

A middle school week-long "summer experience" helps students learn to think scientifically through projects, as their language arts, communication, and computer skills are enhanced by the presentations they make at the end of the week. Last year, 30 students completed the GRAPCEP Summer Experience, including two days at Kettering University. For their engineering experience at Kettering, they were challenged to construct an air bag for an egg using just ten sheets of paper and clear tape. At the end of the week, students found out whose air bags allowed eggs to survive being dropped from various heights. If their eggs made it through a six-foot drop, it went on to eight-foot and then 12-foot ladders. In the Kettering biomedical activity, they practiced being surgeons, sewing up incisions made in natural-casing hot dogs. Laparoscopic procedures were simulated by using a box with small holes for inserting forceps and needles.

Other middle school activities are supported by local companies. JP Morgan Chase Foundation sponsors a regional competition where middle school students play a computational board game called TIVITY, developed by Catherine Clark, a former NASA scientist. Students have clubs after school where they have fun using math skills and practice for the event. DTE Energy Foundation helps with the rocketry program. Middle school students launch six-foot rockets 3000 feet into the air over Lake Michigan, competing to have their teams build the most successful rockets. Middle school girls get involved in Grand Valley State University’s STEPS program where they attend classes in aerodynamics, plastics technology, and computer-aided design (CAD), and then use the skills to construct a remote-controlled plane.

Middle school isn’t all fun and games, however. Sandra Burmeister, executive director of GRAPCEP, says, "We’re doing a great deal of teacher development in teaching algebra this year. This is the first time that algebra has been dropped down to the middle school level in our district. Many eighth grade teachers haven’t taught it in many years or haven’t taught it at all. We’re trying to make sure that the instruction is supplemented as much as we can."

**Chaos in the Cafeteria**

To celebrate National Engineer’s Week, GRAPCEP worked with engineers from companies like Fishbeck, Thompson, Carr & Huber (an architectural, engineering, and environmental firm), OMM Engineering, and Steelcase to run quick engineering contests in urban schools.

Philip Moerdyk, GRAPCEP’s curriculum specialist for physics, says, "We schedule a lunch hour competition in each of our four urban high schools. A team of volunteer engineers will go into the cafeteria with our staff, and we will set up three or four hands-on, mostly intuitive, activities that work in some math and engineering concepts. So, for example, this last time, we used a real simple aluminum foil folding boat to see how many pennies you could load in it and still keep it afloat. That brings in the concepts of buoyancy and design. We also had a laser tag activity where the students had to place mirrors inside a box so that the laser pointer hit a target, so they..."
had to calculate angles. We've rolled balls down ramps to get them to calculate the flight of the projectile and figure out where to place the catching basin. The activities tend to be things that students can do in three or four minutes each, and students complete three or four different activities. The events are hands-on, and might include a couple of problems to work out on paper.

'The event has to be something that catches students' attention, that is essentially intuitive, and that they can do very quickly,' continues Moerdyk. 'We try to connect teachers to the engineers and the activity they conduct with the students. Last year a physics teacher looked at our laser tag activity and said, 'That's really cool. I can't get students to learn that in class, and here they are working with the concepts,' so sometimes activities get adopted into the classroom.

'The engineers run the events, and they talk to students about where they're from and what their companies do. That gives the students the opportunity to ask questions. On the scoring sheet, in order to get some of the points, students have to ask the engineers questions and get some information. We hand out materials about engineering, but it's just a quick way to get into the general population, to say, 'Hey, here's engineering.' We use the events to pull them in. And it is fun for everyone. For the sponsoring companies, their logos are on the score sheets, the posters, and the publicity for the competitions.'

Burmeister adds, 'It's chaotic, it's hectic, it's real hard work, you stand on your feet for hours in a hot cafeteria with kids everywhere, but you feel like you've done something to contribute. It gives people from these companies a chance to get in the schools, interact with students, and encourage students to ask them questions about what an engineer does and about engineering education. Everybody feels, with all kinds of kids coming around and talking to you, maybe this kid or that kid makes the connection and will look into engineering as a career, but for the most part, it's just fun.'

A School of Their Own

In 2003, Creston High School in Grand Rapids became the home of an intensive program of study and work experience. Burmeister says she and her staff worked with Grand Valley State University faculty in engineering, biology, and chemistry and with scientists from the Van Andel Research Institute, to develop a biomedical and engineering curriculum that would raise standards and prepare students for success.

The industrial arts school building behind Creston High School now has large areas for working on projects, as well as a computer lab where students learn CAD, and a biochemistry lab. Burmeister says it is becoming the kind of space you want future professionals to work in. When asked by GRAPCEP for help, local partner companies

![Figure 1. Students in the GRAPCEP Engineering & Biomedical High School dissect a pig heart to learn about the cardiovascular system.](image-url)
pitched in to provide equipment. Pfizer, says Burmeister, gave $70,000 worth of expendable science supplies, and Steelcase provided state-of-the art lab benches and chairs. Computers and other equipment came from other companies.

Students in the GRAPCEP Engineering and Biomedical School at Creston High School are from diverse backgrounds, with 80 percent of them female or minority, and many from low income backgrounds. By the time they are seniors, these students will complete a rigorous college preparatory program of study. They will also understand and be able to use advanced 3D CAD. When they graduate, they will be ready to enter apprenticeship programs, pursue two-year technology degrees, enter four-year engineering colleges, or stair-step their way through any of those goals.

**Teachers and Curriculum**

As they work to raise curriculum standards, GRAPCEP curriculum specialists work side by side with teachers, connecting them to colleagues at colleges and universities such as Grand Valley State. In the 2007-2008 school year, the school added Advanced Placement (AP) biology, AP physics, AP calculus, and AP English to the program.

A curriculum specialist like Moerdyk is part of a number of classes, seeing what’s going on, seeing where resources are needed. The goal is to get inquiry-based learning, or at least demonstrations, into the schools. Moerdyk says, "We team with the classroom teachers, we do a lot of teacher support, instructional development, and instructional planning. We bring them the hands-on practical activities related to the work of engineers or scientists. Students typically don’t have enough exposure to engineering careers and don’t understand what engineers do, so engineering is not on a student’s radar screen of possibilities. Part of our work is to try to get them to think, what is engineering? What is applied physics? How does this apply to your life? For example with civil engineering: Why did your water faucet work this morning? Did you flush your toilet, where did the waste go? Did you drive along the road? Did you cross a bridge? Why do we trust these structures to hold a car? When we do some of the electrical, mechanical, or kinematics, we try to say where the activities tie in to the work of engineers."

The curriculum and teachers focus on doing, on hands-on labs and projects, not sitting in a traditional classroom. To help the students choose between the engineering and biomedical programs offered at Creston, groups of sophomores researched careers in both fields. They made PowerPoint presentations to each other to share what they learned. Sophomores also experimented with making water filters, from various materials that would turn pond water into clean water. Their research included visits to two water treatment plants.

Sophomores even took a trip to the Museum of Science and Industry in Chicago. In addition to exploring the muse-

Figure 2. Students in the GRAPCEP School design and test a device that filters pond water to make it safe for drinking. They learn about the biomedical aspects of organisms in water, and the technology and engineering concepts of filtration processes.
um, students had to complete assignments directly related to several academic areas. In English and science, students explored and interacted with the “Decoding Genetics” exhibit. They had to write a letter about various genetic issues and include a solution to them. For social studies at the transportation exhibit, students had an assignment on the development of airplane flight. In math, students had to perform calculations involving the Pioneer Zephyr, the first diesel-electric streamlined train in passenger service.

In 2007, juniors in the engineering program designed and built robots for a series of contests, including pulling the most weight, traveling the fastest, climbing the steepest incline, and traversing terrain containing sticks, rocks, and sand. Juniors in the biomedical program visited Grand Valley State University to learn about biological chemistry. Seniors built Rube Goldberg machines to squeeze orange juice, with Moerdyk warning teachers that they might see students bring some rather unusual objects.

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**Students Show their Enthusiasm about Learning**

**Advanced Biology**  
We are currently studying the skeletal system. We just finished the chapter that covered the basics of the system and are now moving into the actual bone names. Last week we did an ELIZA to see if samples we were given contained an antibody that fights off HIV. So far this year we have covered the lymph node, digestive, and nervous systems. The class is challenging, but what can be expected when we are learning from a college level textbook?  
By Josephine Ware-VanBrunt

**Physics I**  
Hey, we've had a great year so far in physics. Over the past couple of weeks we have been in the study of electricity. We had to build a model of a defibrillator. For those of you who don't know, a defibrillator is a device that sends a shock through the heart to restore a natural heartbeat. The model we made was smaller and less powerful. We are now writing our final reports for this project.  
By Adam Ferner

**Physics II**  
This class just finished up chapter six on work and energy. Before Christmas break there will be the test on chapter seven that we are currently working on. In this chapter we are working on impulse and momentum with many of the problems based on sports such as golf, baseball, and volleyball.  
By Shawn Weiss

**Biochemistry II**  
2nd marking period in Mr. Smith’s Biochemistry II class has been very interesting. We started off learning about nuclear fusion, nuclear fission, and different high- and low-level radioactive wastes. We eventually presented our findings from a CANT flyer regarding radiation and proved that the statements were true, false, or partially true. Currently, we are learning about energy contained in the foods that we consume. We did an experiment with a calorimeter to see how much energy an everyday snack food has by burning it and seeing how much energy was transferred from the snack food to the calorimeter. We also are keeping track of what we are eating everyday. We are doing this to find out how many calories we receive from different foods everyday and to find out the amount of calories contained in different foods we eat.  
By Terrence Martin
Awareness of college opportunities starts early. In March 2007, sophomores traveled to Western Michigan University’s College of Engineering and Applied Sciences. Paper engineering is one of the programs students learned about, including the tip that WMU has scholarships available specifically for that program.

Teachers are recruited for their ability to relate to kids as much as for their knowledge of subject matter. Nathan Austin is a math teacher with degree in cybernetics engineering from UCLA. Though he could have gotten a much higher-paying job in industry, he chose to teach. He said, “I get to do math all day long, and I get to work with kids. It’s a nice social environment, and the kids are great.” When he teaches geometry, Austin uses SolidWorks solid modeling CAD software, which relates to understanding advanced manufacturing processes.

Classroom instruction is just part of what Austin and his fellow teachers do. Support for the students’ success in the challenging programs involves regular tutoring, which all 10th graders, including those participating in sports, are required to attend twice a week until they have a 3.0 GPA. At lunch at a student day at an SME exposition, math teacher Nathan Austin heard one student worrying about his calculus class. He had passed the point where his mom could help with homework. “Come see me,” Austin tells him, quickly spotting a chance to give him a helping hand.

Moerdyk says industry partners help most with making the curriculum/workplace connection, the how-it’s-used-in-the-field connection. He says, “If we can sit down with an engineer and say, ‘We’re working on Newton’s forces and motion, so where do you as part of your company use that? Where does that come into play? Tell us in a manner that we can transfer it to high school students.’ That kind of advice can be a matter of a phone call or an email or a sit-down for a quick lunch or brief meeting.”

Summer is not time off from learning. GRAPCEP 10th graders participate in summer camps at Michigan Technological University, University of Illinois-Chicago, Ferris State University, or other universities, where they

**Science Education Becomes a Global Priority**

Countries around the world are looking at their elementary and secondary schools to enhance the capabilities of young people to fill technical jobs in coming years. Brazil’s president, Luiz Inacio Lula da Silva, minister of education, Fernando Haddad, and Miguel A. L. Nicolelis, scientific coordinator of Edmond and Lily Safra International Institute of Neuroscience of Natal (ELS-IINN), in *Scientific American* magazine in February 2008, said the country is taking action to empower millions of its citizens, particularly young people, to become true participants in a global society that is continuously changing at a stunning pace.

Brazil is beginning to create a network of 354 institutes dedicated to teaching science and technology to high school students and to training thousands of new teachers. The goal of the initiative is to enroll one million children from the nation’s public school system in the most comprehensive science and technology education program in Brazilian history. A vision of “science cities” beckons, where social and educational programs make it possible for members of the community to participate and become part of the science workforce.

In remote and under-developed Natal, a group of Brazilian scientists in 2003 established a research institute for producing state-of-the-art science to spur social and economic transformation. In addition to its research programs, its science education program is teaching a thousand children in what has been one of the poorest performing public education districts in Brazil.
continue to develop their understanding of science and engineering. Some GRAPCEP 11th graders spend the entire summer at Kettering University studying calculus, chemistry, and computer science while engaging in engineering projects and activities. Because of their good performance at Kettering University during the summer, some GRAPCEP students have been awarded up to $34,000 in scholarships.

Shadows and Interns

For some students, summer is the time to get real world experience with paid internships. The development of a successful intern begins with job-shadowing experience. "A student might sit in on a real planning meeting," says Burmeister. "They prepare ahead of time on the subject of the meeting. For instance, they do packaging engineering at Steelcase. The student has to do research on Steelcase and what the company does. Then they have to learn some things about packaging engineering. They know the topic that’s going to be covered and they prepare specific questions to ask during the meeting. If the company can help by bringing in some of the pieces beforehand, packaging materials such as cardboard, plastic wrapping, wooden corners, then it’s even more interesting.

"If students are carefully trained," continues Burmeister, "they can contribute real work to businesses as interns. Because many of our students are from low-income backgrounds, they need to make money over the summer, so from the beginning we said they had to be paid internships, not free."

GRAPCEP puts together the internships. Burmeister contacts the companies, works with them, builds rapport, and finds out generally what work they want students to do. On one recruiting foray, Burmeister says, "I went to one of the board meetings of the Grand Rapids chapter of the Society of Manufacturing Engineers (SME), asking for more internships and more connections. That led to a relationship with the GR Spring and Stamping company, where Dan Armock and Jim Zawacki have been very strong supporters. They have had interns there every summer for eight years." (See the article, "Grand Rapids Spring & Stamping Sees Value in Supporting GRAPCEP.")

Students in the internships have to have a 3.0 or better grade point average. They interview with the companies, which could be looking for CAD or SolidWorks on the engineering side, or good bench science skills on the biomedical side.

GRAPCEP trains the students for seven full Saturdays before they go to their jobs. "You cannot do a surface job of training those kids or they won’t be able to do the job well and we won’t have the internships in the future," says Burmeister. Training covers areas like business culture, working in teams, how to act in a business meeting, how to send the right email, business writing, and other aspects of working as a professional — things students are inexperienced in. Internship training is connected to teacher development by involving GRPS (Grand Rapids Public Schools) teachers to work with GRAPCEP to conduct the training sessions. Then the teachers see real world applications of what the students learn in class.

Students may be inexperienced in some areas but they are well versed in CAD, and that’s a popular skill set among employers. Since students started by learning geometry by using SolidWorks, whether they’re on the engineering or biomedical track, they can create objects, manipulate them, apply principles of geometry, and create something. In their Saturday training, they review what they’ve learned in CAD and find out how it will be used in their new jobs. One intern at Monarch Hydraulics quickly demonstrated his value. Based on his good performance, the company increased his hours and continued his employment through the school year. He was even involved in designing some parts that are now in production.

Even after the intensive training, it takes careful monitoring and supervision to make sure internships are successful. Weekly supervisor messages to the GRPS teachers and GRAPCEP staff alert them to any reason to meet with interns and to give them further training.
Families and the Future Engineer

Parents are invited to monthly meetings to acquaint them with the GRAPCEP staff and teachers and curriculum, as well as to get feedback about the programs and build community awareness. A parent advisory board has been formed to help select topics for the parent meetings and to help establish relationships among staff, teacher, parents, and students within the program.

Starting in their junior year, students and their parents receive very specific guidance on choosing colleges and successfully applying for admission. They are advised to retake the ACT test over the summer to raise their scores, even if they did well the first time. Even a point or two will give them an advantage. They get instructions for how to set up and prepare for at least three college visits and evaluate their pros and cons. They get the inside story that applying before October of their senior year will make a big difference on whether they are accepted.

They also learn that early submission of the FAFSA financial aid form will put them in the pool of applicants for the most money. Moerdyk says, "When we sit down with those students their senior year, to look at some of the engineering colleges that we’d really like to get them into, they look at the cost and say, 'I don’t have the money.' Some of it’s real, and some of it’s that they don’t think they have options. They haven’t gone through the financial aid process and they don’t understand it. But if somebody came and said, 'I’ve got a thousand dollars to kick in to get you started,' it’s enough encouragement to get them to think, 'I’ve got that much, maybe I can get the rest.'"

GRAPCEP’s program for attracting and preparing young people for careers in science and engineering takes company support: in kind, financial, and personal. In Grand Rapids, they are carefully developing and applying methods in a kind of a test kitchen. That conceptual testing of an innovative educational approach will give other communities the benefit of their knowledge and experience. If we’re to have the workforce of the future, it’s the kind of recipe we need to test anywhere.

Editor’s note: For more information about the Grand Rapids Area Pre-College Engineering Program, contact Sandra Burmeister 616/733-1188 or Sandra.burmeister@davenport.edu.

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