



Water, Water...

Students and faculty at colleges and universities are helping people in the developing world gain access to the world's most precious resource. By Karen Leggett

Imagine living in a town with one faucet— for the entire town. Now, imagine being a student asked to help change that.

The United Nations Environment Programme (UNEP) estimates that two of every three people will live in a water-stressed area by the year 2025. Two of every ten people in the world have no source of safe drinking water. On World Water Day 2010, UNICEF reported that “unsafe water, sanitation, and hygiene claim the lives of an estimated 1.5 million children under the age of five each year. Lack of access to water, sanitation, and hygiene affects the health, security, livelihood, and quality of life for children, impacting women and girls first

and most...because they are the ones burdened with collecting drinking water.” The nonprofit organization Global Water reports that contaminated water causes 80 percent of the health problems throughout the world, often because the only water source is a badly polluted shallow well used by both humans and animals. Unsafe drinking water is a major cause of such diseases as diarrhea (identified by UNICEF as the second biggest killer of children under five), hepatitis, and typhoid. When he was Secretary-General of the United Nations, Kofi Annan said, “We shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation, and basic health care.”

A growing number of U.S. colleges and universities are joining the conversation, wrestling with wide-ranging issues, from figuring out how to transport concrete pipes to remote villages to engaging communities in identifying and implementing appropriate solutions to their own water problems. Projects and programs fall into three broad categories, with significant overlap:

1. student-directed efforts,
2. credit- or degree-granting opportunities, and
3. training and educating foreign faculty and water professionals.

Bolivian M.Sc. students collecting groundwater sample from seepage meter during field methods short course in 2008.





Anywhere?

EDITOR'S NOTE:
This article is the fourth in an occasional series on international development and international higher education. Each article focuses on one kind of international development work. The first article, "Fledging the Phoenix," on reconstruction efforts after natural disasters was published in the July/August 2009 issue; the second, "Developing K-12 Education," was published in the November/December 2009 issue; the third, "Feeding Mouths and Minds," was published in the March/April 2010 issue.

Students in Charge

The model and inspiration for many student-directed efforts is Engineers Without Borders, established in 2002 after University of Colorado civil engineering professor Bernard Amadei learned from a landscape worker in his backyard about water problems in the worker's village in Belize. EWB-USA now has 350 projects in 45 developing countries, most organized by students to address problems with water, sanitation, renewable energy, and more. Amadei has moved on to direct the University of Colorado's Mortenson Center in Engineering for Developing Communities, but the CU student chapter of Engineers Without Borders supports active projects in Nepal, Peru, and Rwanda.

Safe Drinking Water in Nepal

When Devon Rourke, a former Peace Corps volunteer introduced students to the Namsaling Community Development Center (NCDC), a Nepali nongovernmental organization (NGO) working on sustainable community development in 2007, it marked the start of the EWB-Nepal project. Through NCDC, the people of Namsaling had identified safe drinking water and health-related needs as primary concerns. NCDC

asked EWB to design a waste-water treatment plan for a 50-bed addition to the community hospital. Rourke, who is waiting to start graduate school in physics, says the student team is designing a terraced wetland in which reeds will filter out waste from effluent water. The treated water can then be used for toilets and irrigation. A previous EWB team had helped villagers protect the springs that provided their drinking water.

Fellow student Amelia Lyons, who taught English in Nepal and is now a graduate student in Colorado's Engineering for Developing Communities program, says the local NGO "picks projects based on the community's needs. The board members of this NGO all grew up in the community." Lyons' says of her experience working in Nepal, "I stayed with the same family each time; everyone was crying when we left. It's nice to know I have family there."

Drew Turner, a PhD candidate in aerospace engineering, sought an outlet to provide direct help to people after an eye-opening personal travel experience in India. He hopes to go to Nepal with EWB this spring. Selection depends on each student's degree of involvement in the program and ability to raise funds. All of the EWB chapters raise their own funds from research

As part of the University of Colorado's Engineering for Developing Communities Program, in Nepal, James Diekmann, engineering professor, with students Tom Zearley and Amelia Lyons, cut galvanized pipe for the Spring Protection Projects as a Nepali watches.





Fabrication of a 'Merry Go Round' water pumping system in Nyeri, Kenya.

grants, private donations, engineering companies, professional associations, and campus fundraisers. "The biggest cost consistently is student travel," says Lyons, "and it's the hardest to get funded...if I were a traditional engineering student, I would know how to use CAD (computer-assisted design), not write a grant. We have learned to write grants, write reports, do technical drawings. It makes us more well-rounded"

James Diekmann, the civil engineering professor who agreed to be the faculty adviser for the Nepal project, noted the amazing degree of maturity among the students who volunteer for EWB projects. "One of the challenges here is how to make good use of really smart kids who have good technical training when they are in the U.S. so that when they go to Nepal they have appropriate solutions. There is a tendency for students to see all of these issues as needing a technical fix. We used very rudimentary technology. It's all about culture and people. Eventually they figure that out...they develop an understanding that an engineer's role in the world is not just making new bridges."

Not all the students who get involved in an EWB project are engineers or even scientists. University of Colorado education student Jessica Dehart is working with the NCDC in Nepal to expand the elementary school curriculum to include lessons on clean water, pollution, and personal hygiene. "I feel like I'm doing something valuable," says Dehart. "I consider myself

lucky to be involved." Two Israeli students worked with the Colorado team during the first summer and are now initiating their own EWB chapter.

For the Nepali NGO, "EWB is one of the major and most important ways we implement our activities successfully," says Madhu Shrestha, a Nepali engineer with NCDC. "The EWB team with the students' young spirit and the highly expert professor is a great opportunity for developing countries like Nepal."

Jordan Weisman, a University of Colorado alumnus and professional adviser, with Binod Bidari, a Nepalese volunteer, and a friend carry pipe through the village of Namsaling, Nepal.



Student Association for International Water Issues

In 2000 students in the Graduate Program of Hydrologic Sciences at the University of Nevada, Reno, developed their own version of EWB called the Student Association for International Water Issues. SAIWI sends students overseas for several weeks at a time to work on existing projects in developing countries. Annie Lassaline, a senior in environmental engineering, has traveled to Cameroon twice with three other students and three UNR mentors, including a local civil engineer. They learned to hand-drill a well, and shared their skills and equipment with local residents, who drilled at least three more wells on their own. The students also taught water hygiene at several large community meetings.” Lassaline found it rewarding, to give people the knowledge and tools to promote their own well-being.”

University of Dayton student Katie Burgei, Nweke Josephat (a local hardware businessman in Cameroon [who is originally from Nigeria]), and a welder work on the design for the construction of the bio-sand filter mold as part of the University of Dayton's Barambi Water project in 2008.



Water for Miramar

At the University of South Florida in Tampa, the EWB chapter has partnered with Columbia University's Center for Environment, Economy, and Society (CEES) to provide a source of clean water in the community of Miramar in the Dominican Republic. The first group of students to visit the community noticed that children were scooping up water leaking from a storage tank. Then students began meeting with the community to discuss possible solutions: rainwater harvesting, wells, an aqueduct system. USF engineering professor Daniel Yeh recalls one occasion when students built a household rainwater collection system on campus, but “after we were on the ground, people said, ‘We really don't like this idea because you can't create one for every household and that will create conflicts. We want a more centralized distribution for the water.’ That was a learning experience. The community may not want a textbook solution.” With the help of the local mayor's office, local workers drilled a well. If the water quality is acceptable, Yeh says students will help design a water distribution system. “The most important thing is teaching students to be resourceful in the local context.”

Water for Ciudad de Dios, Peru

The University of North Carolina (UNC) and Duke University have a joint chapter of Engineers Without Borders for which Don Lauria, a retired professor of environmental sciences and engineering, is the adviser. The group's work in Ciudad de Dios, Peru had an interesting beginning. UNC associate anthropology professor Brian Billman contracted with community members to guard his anthropological dig site in return for funding for local development projects. Billman asked the UNC/Duke Engineering Without Borders chapter to help the community develop a regular supply of water. Lauria led several technical workshops in the United States for students who traveled to Peru in 2008, built a water main, and organized a local water committee to operate the distribution system.

Lauria and many of his colleagues working in international development insist on the importance of sustainability. “We are not in the Band-Aid business. Building stuff is a vehicle to strengthen the local community and help local institutions be self-sufficient without foreigners.” So when a small group of graduate students—proficient in Spanish and Latin American culture—returned to Peru in 2009, their primary task was building consensus in the community and helping the water committee adopt efficient business practices. “The transmission system is still working,” says Lauria, “and the committee is now ad-



dressing structural risks like the hilly, rocky terrain.” Lauria continues to provide advice from afar.

Using Technology for Clean Water

The University of Dayton’s Engineers for Technical Humanitarian Opportunities for Service-Learning (ETHOS) program begins to bridge the gap between student-directed projects and credit- or degree-granting programs. ETHOS is based on five principles: appropriate technology, cultural sensitivity, personal transformation, cultural immersion, and partnership. In 2009, 27 ETHOS students traveled to 11 locations in nine countries, working on a wide variety of appropriate technology projects, from wood stoves in Bolivia to solar panels in Nicaragua and water purification systems in Bangladesh and Cameroon. ETHOS also offers competitive Sustainable Engineering Scholarships to minority and women students, which is sponsored by the National Science Foundation and worth up to \$25,000 over four years.

Graduate student Mark Ewalt has been to Cameroon three times with ETHOS. In 2007 he and several other students met village elders who were concerned

that their community was literally dying for lack of clean water. The student team returned to Dayton with a plan and a proposal: they wanted to help and they also needed credit for a technical elective. Denise Taylor, assistant professor of civil environmental engineering, helped the students design a class with enough technical content to be accepted for credit by a review board of consulting engineers. Each of the eight students had to identify how this class would build on previous coursework, lead one class session, and contribute to a professional proposal as if it were a bid on an actual contract.

The students received credit, but “it would not have worked if I had initiated it,” says Taylor. “It fed on their motivation to get a job done. They took skills they learned in class and applied them in a completely different situation.” Taylor believes that connecting the coursework to the project helped students realize more technical benefit than if they had simply been told what to do.

“It was one of the best classes I’ve taken,” concluded Ewalt. “We were solving a problem. Everyone was passionate about it because we were going to build something we were designing. It wasn’t a teacher lecturing. When we had a problem, we could ask a faculty member.”

University of Dayton student Kaitlyn Burge teaches women in Cameroon about construction, maintenance, proper use, and benefits of bio-sand filters.



Sharon Jones (left), professor of civil and environmental engineering at Lafayette College, and student Lindsay Weir work with residents of Blantyre, Malawi, to help develop locally sustainable drinking water resources within the city.

But not all the problems could be solved in Dayton. “We thought we were prepared,” recalls Ewalt. “We had to adapt.” Transporting materials to the village was the trickiest: first loaded on motorcycles, then driven on dirt roads, and finally canoed across a lake to the village. But in two months, the students and the villagers had built a catchment to collect water, a two-kilometer pipeline to get the water to the village and three taps to distribute water. Every household received its own water filter. When the Dayton students returned in 2009, the children were resting their buckets on the spigots, causing them to break. So there were lessons for the children in handling buckets—and lessons for the adults in finding supplies and making repairs.

Portions of this project can be applied to any engineering situation I could be in,” says Ewalt. “It’s at the top of my resume.”

Degrees and Credits

The University of South Florida partners with Columbia University for its EWB projects and it partners with UNESCO-IHE in the Netherlands to provide U.S. students an overseas experience in a country whose entire

existence has been about reclaiming land from water. Each year, USF sends six students (graduate and undergraduate, sometimes including one or two foreign students) to the UNESCO-IHE Institute for Water Education to conduct research for 10 weeks. UNESCO-IHE focuses on every topic related to water: treatment technology, water policy, social policy, and economics. “The solutions are not always technical,” notes USF Professor Daniel Yeh. “Our students pick up out-of-the-box ideas. Out-of-the-box for us, but not for Holland.” In return, students from UNESCO-IHE—typically mid-level water managers from developing countries—visit USF’s Patel Center for Global Solutions to see the biggest desalination plant in North America. The Patel Center hosts annual programs for students from developing countries, using Tampa Bay as a laboratory to learn best practices in confronting water and sanitation issues.

USF’s Patel Center also allows students to earn credit doing research on campus that they then apply in a developing country. It was through this program that the EWB project in the Dominican Republic was initiated. “Because of this applied research component,” says assistant academic director Rebecca Harris, “students

feel they have an impact and this makes the university better as well. It enhances the university's reputation."

A Core Interest in Water

Water is a core interest of the Global Environmental Management Education Center (GEM) at the University of Wisconsin Stevens Point, where the stated mission since 2000 has been "applying practical learning to solve natural resource problems by linking faculty, students, and citizens worldwide." GEM is a discipline within the Department of Natural Resources, offering international seminars on campus as well as grant-based funding for graduate student projects and thesis research, and a GEM Student Ambassador program in developing countries.

On his way to a degree in forestry, Andrew Van Natta spent a summer as a GEM Ambassador in Bhilwara, India, earning credit for an internship and discovering that "some principles I had assumed were universal really weren't, like random sampling and removing human bias from statistical analysis." Van Natta worked with the Indian Foundation for Ecological Security, whose goal was to empower local villagers not to rely on the government to manage their natural resources. Van Natta and his student colleagues were gathering baseline data about the watershed to be used in creating a watershed management plan. "The Foundation was expecting a management plan but we wrote a manual for how to develop a management plan."

What did Van Natta learn from the experience? *Dahili*. An Indian word for patience. "Not just in the scientific process but life in general. You won't get done what you thought you would [projects took longer than anticipated]," said Van Natta. And yet, "the learning and growing and working were extremely beneficial to me."

Tiffany Short was a GEM Student Ambassador in Todos Santos, Guatemala in 2005, where she mapped land and water use next to a local river that was heavily contaminated by agriculture and livestock. Short came home feeling "very lucky to be in a country with water quality and land use laws," but pleased "to put a seed in everyone's mind that the local water quality was bad and here's how to start planning improvements."

Humanitarian Engineering and Social Entrepreneurship

There is no lack of acronyms with a common thread and mission—ETHOS, GEM, and at Pennsylvania State University, Humanitarian Engineering and Social Entrepreneurship (HESE)—with humanitarian engineering defined as "research and design under constraints to directly improve the well-being of mar-

ginalized communities," while social entrepreneurs are "solution-minded pragmatists who are not afraid to tackle some of the world's biggest problems." Tom Colledge, assistant professor of engineering, led a shift in the whole paradigm of engineering education at Penn State over the last 25 years, in which sustainable technology moved from student endeavors to projects embedded in established classes to dedicated courses and now a vertically integrated certificate.

"This is not just engineering students doing technical problem solving," explains Colledge. "Our goal is to empower and engage students to use their academic training to make a difference with marginalized communities; this is not just an international experience, it is service learning." Students need to be able to figure out how to do a community assessment, what is the engineer's role on a multidisciplinary team, and how to make a project economically sustainable. "We need students who are better prepared in social sciences as well as have appropriate technology dirt-under-the-fingernails experience," says Colledge.

HESE offers credit for such courses as "Projects in Community Service Engineering," which is connected to actual projects in Kenya and Appalachia, and "Design for Developing Communities," in which students write structured reflective blogs and make

Molly Diekmann, an epidemiologist and daughter of James Diekmann, professor of construction management engineering, looks at the water at Kammar Dhara in Nepal before it was protected.





Construction of a bridge in El Salvador to permit farmers access to farmland during the rainy season

YouTube video clips on how they applied concepts from the seminar series to their HESE ventures.

One HESE venture is a partnership with Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Nairobi, Kenya. Students at Penn State and JKUAT communicate regularly online with Skype technology, sharing designs for a low-cost, well-drilling rig to access water for irrigation. The goal is a collaborative design, explains Colledge.

Currently, 42 Penn State students are working on eight projects in Kenya in partnership with JKUAT and the Kenyan government's Children and Youth Empowerment Center in Nairobi. Other students who may never get to Kenya still have a chance to become knowledgeable about international development issues by taking a technical writing course in which they write literature reviews on the eight projects, a paper on the expected user experience, and a construction or operations manual that can be understood overseas.

Water for People

At Lafayette College in Easton, Pennsylvania, Sharon Jones, associate professor of civil engineering, is developing a long-term relationship with the nonprofit organization Water for People to educate students in rural water and sanitation issues. With funding from the National Science Foundation, Water for People is pairing Lafayette undergraduate students with students in Honduras where

they will collect field data on sustainable water infrastructure: Are water users getting what they need? Do local residents know how to use and maintain the infrastructure, both technically and financially? Is there a need for hygiene education? Jones says her goal is to "get students interested in rural infrastructure issues and help them realize that engineering is a service-oriented profession."

Water for People also offers a new Fellowship in Innovation and Sustainability to support graduate students pursuing original research. The first fellow, Stephanie Ogden, is studying water resources in Rwanda, where she recently filed this blog: "I spent most of my time in the field, walking through two small watersheds in different parts of the country, talking to families, surveying where they get their water...how much water they use in the home. This is the part of the job that I love most—perhaps because it seems like such an incredible liberty to be able to visit folks that live in some totally different way than I do, accept their generosity in stopping in the middle of their day to answer a few questions and help me understand."

Training the Trainer

In Central America, about 80 percent of the water supply comes from groundwater, as opposed to surface water (rivers, lakes, reservoirs). David Bethune is a hydrogeologist at the University of Calgary, combining skills in engineering and geology with a passionate belief in the importance of studying and monitor-

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ing groundwater. When Bethune first began working in Central America in the 1980s, there were only three local people who had a master's degree in hydrogeology, despite the huge dependence on groundwater. In 1995 Bethune and his wife, Cathryn Ryan, an engineer, helped start the first hydrogeologic training program in Central America at the University of Costa Rica. Now a network called CARA links six Central American universities, one university in Bolivia, and the Universities of Calgary and Waterloo in Canada. "They wanted their own network, not just north-south," explains Bethune, "because they can assist each other."

The CARA network places a strong emphasis on training Latin American professors, and over the years, several have obtained master's of science degrees from either the University of Calgary or Waterloo. In 2005 all but one of 74 degree holders were working in their home countries, mostly for government departments or national water agencies. There are now more than 120 master's-level hydrogeologists in Central America. Valeria Delgado, who teaches at the National Autonomous University of Nicaragua and earned her graduate degree from Calgary, has high praise for the continuing value of the program: "I have been able to keep in touch with my professors and CARA staff. We are a community in which everyone helps the other with their expertise and advice. Professionally speaking, my degree has allowed me to work in an important subject as water, one of the main concerns for our government and the world."

John Ssempebwa is similarly pleased with his connection to the State University of New York at Albany. Ssempebwa received his PhD under the tutelage of David Carpenter, who directs SUNY Albany's Institute for Health and the Environment. Now Ssempebwa is contributing to the revision of the undergraduate curriculum in environmental health science at Makerere University in Kampala, Uganda. "Although not a lot has been achieved by me in the way of policy changes (yet)," says Ssempebwa modestly, "significant contributions have been made in terms of realizing good practice guidelines within communities."

Carpenter says one key to success when educating professionals like Ssempebwa is to make sure their training has practical value back home. He recalls a Kenyan student who was trained to use sophisticated technology that did not exist in Kenya—and the student is still in the United States. "We talked with John at great length about environmental health issues in Uganda and what kind of research could be done there. Even planning for that, it has been very difficult for him."

Ssempebwa also believes that collaborating institutions—like Makerere University and SUNY Albany—must have shared goals, with lead investigators whose fields of expertise are complimentary and products or conclusions are scalable and adaptable not only in the host country but internationally.

The success and sustainability of these overseas development projects depend largely on the quality of planning, degree of commitment (both overseas and in the United States), and funding.

Carpenter advises universities to go slowly. "We always had one student from the partner country who trained here. The next contact was the student's teacher or mentor in his home country. When the student goes back, there is a possibility of collaboration and it grows like a mushroom." Ron Tschilda at the University of Wisconsin Stevens Point also emphasizes the importance of building a network slowly, finding people to work with locally to give credibility to your presence. "Don't grow too fast. Don't just throw a dart at the map."

James Diekmann at the University of Colorado recommends finding a practicing engineer who is willing to be a technical mentor to students. "Often engineering faculty do their research far out on the fringe. They're not out there doing low-tech development." Tom Colledge at Penn State found it was important to elevate the academic importance of sustainable technology by embedding such issues in existing courses and eventually creating an Engineering and Community Engagement Certificate.

Daniel Yeh at the University of South Florida cautions that "getting a project off the ground with a potential for success takes tremendous time and energy for faculty and students. The Dominican Republic involves real people and real people's lives. This is not just a project for a class. They are counting on you for a solution. That's a tremendous responsibility. Don't get involved lightly." **IE**

KAREN LEGGETT is a freelance writer in Washington, D.C. Her last article for *IE* was "Teaching Medicine Without Borders" in the May/June 2009 issue.

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