Rethinking STEM Graduate Education for Diverse Career Pathways at the Water-Energy Nexus
Syracuse University's NSF Research Traineeship Program

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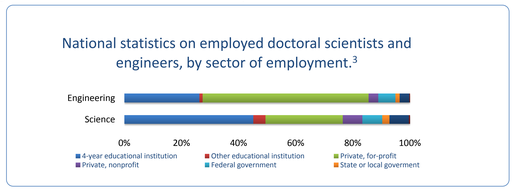
Background

Recent surveys show that only about half of PhD scientists find employment in academia; for engineering doctorate recipients, even fewer pursue academic positions.[1] Studies of STEM graduate education find that employer expectations of graduate degree holders extend beyond advanced content knowledge: employers want graduates to develop skills in professionalism and work ethic, oral and written communication, teamwork, and problem solving. Despite this, professional training opportunities in graduate school may be limited and offered outside of the academic departments, thus requiring students to independently seek out opportunities. In the geosciences, internship experiences have been seen by employers as essential for career preparation and professional skill development; however, less than 60% of graduate students have held internships.[2]

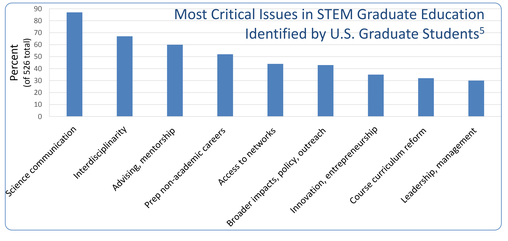


Given the range of career options for graduate degree holders in the STEM disciplines, the National Science Foundation created the NSF Research Traineeship (NRT) program to encourage the development of new approaches to STEM graduate training, preparing graduate students for careers within and outside academe.[4]

EMPOWER, or the Education Model Program on Water-Energy Research, at Syracuse University was one of the first funded NRT programs. Paying particular attention to the most critical issues in graduate education, as identified by U.S. graduate students, EMPOWER personnel have developed a series of training elements to:

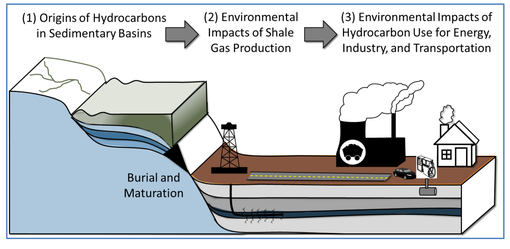
1) **Train** a cohort of students in the technical and professional skills needed for research and research-related careers in water and energy;
2) **Catalyze new collaborations** among faculty and students; and,
3) **Transform institutional culture** in graduate education.

EMPOWER was funded in 2015 and admitted its first cohort in Fall 2016.



Research Themes

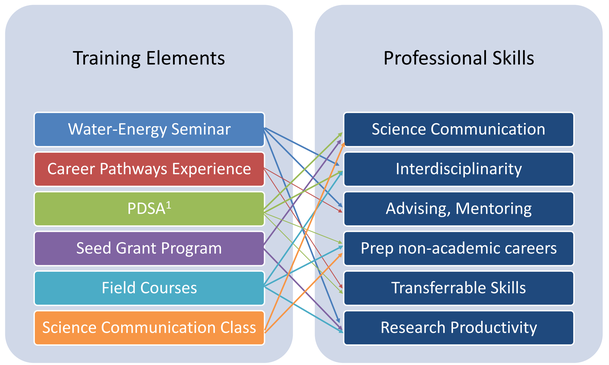
The EMPOWER NRT is focused on research at the interface of water and energy cycles. Research in this area is a priority nationally and is likely to produce graduates who will pursue careers in a range of sectors. Students in EMPOWER will develop advanced content knowledge on the formation, production, and effects of hydrocarbons and their interconnections with the water cycles.



Program Design

Graduates of the EMPOWER program are likely to pursue careers in four sectors: business, government, not-for-profits, or academia. Each career trajectory requires specialized professional skills. This program combines broad training across management, policy, communication, and law with in-depth training in a self-designed focus area most applicable to the trainee's career objectives.

Specific training opportunities are available to trainees throughout their graduate school career. The arrows indicate which professional skills are supported by each training element.

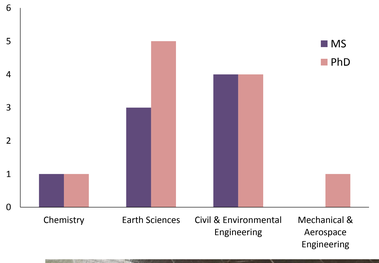


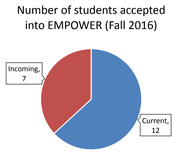
[1]PDSA: Professional Development Specialization Area

Participants

EMPOWER students are admitted to traditional disciplinary graduate departments, including Earth Sciences, Civil & Environmental Engineering, and Chemistry; yet, as trainees, participating students have access to the training elements of EMPOWER, which extend beyond the traditional departmental offerings.

To date, we have admitted 19 graduate students as trainees.





EMPOWER trainees pose for photograph after attending Water-energy seminar

Participating faculty, drawn from several departments, make program admissions decisions, approve coursework, review student seed grant applications, and teach the field courses. EMPOWER is further supported by an **External Advisory Committee (EAC),** which is comprised of PhD professionals in non-academic careers, including energy, advocacy, government research, environmental consulting, and STEM education.

Training Elements

Water-Energy Seminar

This 1-cr interdisciplinary seminar, offered every semester, is open to all graduate students. Trainees are expected to enroll every semester. In addition to discussing research papers and hosting visiting speakers, professional development opportunities are offered.

Sample Activities and Guests:

1) Mock NSF panel
2) Panel on publishing in *Science*
3) Breakfast with NSF Earth Sciences Division Director, Dr. Carol Frost
4) Dr. Fred Schroeder, AAPG Visiting Geoscientist Presentation
5) "Status of the Geoscience Workforce, 2016" discussion

Career Pathways Experience

Each trainee is required to participate in an off-campus experience aligned with the individual's career goals.

To date, four students have career pathways experiences: a visiting instructor at local college, a AAAS Mass Media Fellow, an intern at an environmental consulting firm, and a GeoFORCE summer instructor.

Laura Demott, center, leads GeoFORCE group at Grand Teton National Park.

Professional Development Specialization Area (PDSA)

Students take coursework outside of the STEM disciplines that are related to the student's professional interests. PhD students are required to take 12 credit hours; MS students take 6.

	Communication	Policy Studies/Law	Business & Management	Entrepreneur-ship
Academia	X			
Industry	X		X	X
Government	X	X		
Not-for-Profit	X		X	X
Consulting	X	X	X	X

Potential career paths in water-energy research, and professional development area coursework applicable to those careers.

Seed Grant Program

The seed grant program supports research and professional activities that are aligned with the goals of EMPOWER and may not necessarily be supported through traditional funding sources. Trainees submit a proposal, and, if funded, they manage the award budget and write a final report.

We have designed three lines of funding:

1) Professional Network Grants
2) Professional Development Training Grants
3) Emerging Interdisciplinary Research Grants

Science Communication Course

This 3-credit course will be offered once per year, starting in Spring 2017. This course will cover the principles, practices, and processes of journalism, documentary, and new media and the communication of complex scientific research to the public.

*EMPOWER has offered additional professional development opportunities in science communication, including a **AAAS Science Communication Workshop,** a **networking workshop**, and a **webpage development seminar**.*

Field Courses

These are 3-credit collaborative, interdisciplinary capstone team experiences. Our **domestic** (northeastern US) course will be offered in summer 2017; the **international** (Lake Kivu, Rwanda) course will be in summer 2018.

EMPOWER offered a short field course led by an energy industry scientist. This course was open to all STEM graduate students.

Program of Study

The table below outlines the suggested program of study for students participating in EMPOWER. The exact program is determined individually for each student in consultation with EMPOWER's leadership team and the student's faculty advisor.

	PhD Trainees	MS Trainees
Year1	Water-energy seminar (F, Sp.) Start PDSA coursework Science Communication Course Field Experience Course (optional)	Water-energy seminar (F, Sp.) Complete PDSA coursework Science Communication Course Field Experience Course (optional)
Year 2	Water-energy seminar (F, Sp.) Complete PDSA coursework Field Experience Course (optional)	Career Pathways Experience Water-energy seminar (optional) Field Experience Course (optional)
Year 3	Career Pathways Experience Water-energy seminar (optional)	
Year 4	Complete dissertation research	

Takeaways

An **outside independent evaluation team** is assessing the implementation and effectiveness of the program. EMPOWER has received valuable feedback from faculty, students, and the External Advisory Committee (EAC) that is guiding programming.

Successes:

1. **EMPOWER's EAC** has identified skills that should be acquired as a part of graduate training to ensure high-level performance in the workplace. These skills include problem-solving flexibility, systems thinking, communication skills, ability to interact with a range of stakeholders and colleagues, proficiency in foundational STEM classes, and aptitude in practical application of quantitative skills and tools.

2. Positive responses from **students**:

"*I enjoy reading papers and then meeting the authors…I also enjoy the opportunity to have lunch and interact with the visiting lecturers.*"

"*This event [orientation] made me really excited about professional development-I really hope we can integrate some of these skills through EMPOWER*"

3. **Strong university support** including (1) office and program space renovation and (2) additional funds to support students and EMPOWER activities.

4. High levels of **faculty** engagement:

"*I see a lot of collegiality between the different faculty when I go to these [EMPOWER] meetings; they show up, they talk, they contribute.*" (from a faculty member)

Challenges:

1. Requirements may **increase time to degree** for trainees
2. Building **cross-disciplinary collaborations** across the university
3. **Providing broad experiences** for the trainees

"*I think the biggest challenge for the program is and will continue to be having a broad enough experience for the students outside of their home discipline.*" (from a faculty member)

4. Developing a pool of **internship opportunities** for students
5. **Recruiting** new trainees to the program

Acknowledgements

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SYRACUSE UNIVERSITY EMPOWER Education Model Program on Water-Energy Research