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# Transforming the Teaching of Geoscience and Sustainability

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## Transforming the Teaching of Geoscience and Sustainability

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The geosciences have an important role to play in addressing whether humans can live sustainably on Earth. From water to energy, from climate change to natural hazards, geoscience is central to solving a wide range of problems.

Two projects funded by the National Science Foundation (NSF) support faculty in incorporating aspects of sustainability in their teaching: the Interdisciplinary Teaching of Geoscience for a Sustainable Future (InTeGrate) Center in the Geosciences and the On the Cutting Edge Faculty Development Program in the Geosciences. The former is funded by NSF's Science Technology, Engineering, and Mathematics (STEM) Faculty Development Program, and the latter is funded by NSF's Transforming Undergraduate Education in STEM Program. These programs, led by faculty across the country, engage members of the geoscience community and their colleagues in allied disciplines in sharing their existing teaching materials and strategies and in collaboratively developing new materials to meet recognized needs.

For example, materials currently in development address human dependence on mineral resources, environmental justice, and freshwater resources, among other topics. Together, the On the Cutting Edge and InTeGrate projects provide instructors with online access to several resources that support the teaching of geoscience and sustainability, both within geoscience courses and across the undergraduate curriculum.

### *Goals of InTeGrate and On the Cutting Edge*

Sustainability is a strong organizing principle for modern liberal arts and technical education programs, requiring systems thinking, synthesis, and contributions from all disciplines—geoscientists, natural/ physical scientists, social scientists, humanists, and engineers. InTeGrate fosters this interdisciplinary framework in undergraduate education, helping students bridge the gap between global and local issues and vice versa. It has the potential to raise the value placed on faculty engagement with local resources and research questions and to bring community-based stakeholders outside of academia into the classroom.

One primary goal of the 5-year project, which started in 2012, is to develop curricula that will dramatically increase geoscience literacy of all undergraduate students. At the same time, the program is devoted to increasing the number

of majors in the geosciences and associated fields across the country, teaching students to be able to work with other scientists, social scientists, businesspeople, and policy makers to develop viable solutions to current and future environmental and resource challenges. These goals complement those of the On the Cutting Edge program, which aims to improve teaching and learning in undergraduate geoscience courses.

Both projects employ a community-based approach. On the Cutting Edge uses workshops to collect examples of teaching practices within the geosciences and to produce syntheses of research and experience to enhance teaching. InTeGrate uses a similar approach to understand current practices across disciplines. In addition, InTeGrate supports the development of teaching materials and model programs designed to incorporate geoscience throughout the curriculum.

### *InTeGrate and Cutting Edge in Action*

Incorporating sustainability topics into coursework can be a stimulating and powerful mechanism for linking course content to real-world issues. Participants in three On the Cutting Edge and InTeGrate workshops in 2012 documented how sustainability and geoscience are currently brought together successfully in undergraduate education. The results are four online resources that help faculty integrate sustainability in their courses.

The first describes undergraduate courses that have significant components of both geoscience and sustainability (see <http://serc.carleton.edu/integrate/workshops/sustainability2012/courses.html>). Users of the Web site will find descriptions of upper-level and introductory courses—for instance, an introductory course developed by Brooke Crowley at the University of Cincinnati called “Humans and Nature: Living in the Anthropocene” focuses on current social and environmental issues and emphasizes the links between raw materials, waste, and products used in day-to-day life. An upper-division course entitled “Hydrotopia: Toward a Hydraulic Society in the American West,” developed by Ed Barbanell of the University of Utah, addresses a range of physical, historical, conceptual, cultural, legal, and technical aspects of water in the western United States. Other courses listed include Washington State University's “Sustainable Watersheds and Communities,” Kansas State University's “Sustainability Science,” and the University of the Pacific's “It's Not Easy Being Green.” Along with each course

listed is a course description, content overview, course format (lecture, lab, online, etc.), course goals, assessment strategies, a syllabus, and examples of teaching materials.

The second resource is a collection of teaching activities, including classroom activities, lab exercises, problem sets, and more. Faculty teaching environmental geology will be most interested in the collection of 400 peer-reviewed teaching activities recommended for use in this common introductory course (see <http://serc.carleton.edu/NAGTWorkshops/environmental/index.html>). This Web site includes examples of ways in which faculty have used strategies from analysis of geoscience data to role-playing to help students understand the role of geoscience in pressing environmental issues. The InTeGrate project Web site hosts a smaller collection of activities for use in interdisciplinary courses (see <http://serc.carleton.edu/integrate/workshops/sustainability2012/activities.html>).

Advice and tips can be found in InTeGrate's collection of essays, written by instructors (see <http://serc.carleton.edu/integrate/workshops/sustainability2012/essays.html>). There participants share approaches to teaching sustainability in an interdisciplinary context and ideas for exploring opportunities to enhance the integration of geoscience and sustainability.

For those interested in bringing sustainability into courses in disciplines other than geosciences, an InTeGrate resource (see <http://serc.carleton.edu/integrate/workshops/sustainability2012/keyconcepts.html>) highlights key sustainability concepts that students can learn in their biology, chemistry, economics, history, geography, and other classes. The resource helps discipline-based instructors find opportunities to bring issues related to sustainability into their curricula and shows where teaching about sustainability may cross into their discipline. Beyond ties of subject matter, it also documents where concepts related to sustainability can be seamlessly slipped into skills taught in the classroom.

#### *Success Through Broad Participation*

InTeGrate and On The Cutting Edge both depend on active participation from faculty across the country for success. There are many avenues for participation, such as joining a curriculum development team, testing newly developed

materials, applying for a grant to make innovative use of curricular materials, or attending one of the many InTeGrate or On the Cutting Edge professional development workshops. Faculty are encouraged to submit additional examples of courses or teaching activities to the InTeGrate and Cutting Edge online resource collections or to sign up to help review the On the Cutting Edge teaching activity collection.

Faculty can apply to assist in the assessment effort by using InTeGrate's Geoscience Literacy Exam (GLE) to examine their students' understanding of sustainability. GLE probes concepts elucidated in recently released Earth, ocean, atmosphere, and climate science literacy documents. It includes a suite of questions that address whether students can understand and apply core content learned in introductory classes. The exam set also includes an equal number of more challenging questions that ascertain the depth to which students can critically analyze subject matter. Joining the InTeGrate or On the Cutting Edge e-mail lists keeps those interested informed of project announcements and news.

Preparing a workforce and citizenry that can meet the resource and environmental challenges society faces to create a sustainable future will require the concerted efforts of all geoscience faculty. More than 2000 geoscience faculty have participated in On the Cutting Edge's professional development program, now 12 years old, and tens of thousands of users make use of its online resources. The InTeGrate project, now in its second year, provides complementary opportunities to bring geoscience into courses across the curriculum and to develop new kinds of materials and programs focused on sustaining the future. To join these efforts, please visit the project Web sites: <http://serc.carleton.edu/NAGTWorkshops/index.html> and <http://serc.carleton.edu/integrate/index.html>

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