# Arguments Against the Convergent Evolution of Undergraduate Curricula in Geology, Ecology, and Civil Engineering

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## Convergent Evolution

Convergent evolution is the development of similar biological characteristics in two or more separate lineages that do not share a common ancestry. The similar evolutionary adaptations are driven by common environmental factors. Examples include the similarities in form and function of the placental flying squirrel and ground hog with the marsupial flying phalanger and wombat, which evolved on separate continents.

**Within the past 15 years geologists, ecologists, and civil engineers, three separate lineages, began to evolve similar curricula, particularly at the graduate level.** This, I believe, is in response to environmental pressure to perform interdisciplinary research and to acquire external funding for this type of research. As a result, civil engineering faculty are performing more basic research, which formerly was the domain of earth scientists and ecologists. To do this type of research, civil engineering faculty are offering fewer courses in engineering design and construction of public works structures and are offering more courses that compliment those in similar earth science disciplines in terms of the use and application of concepts and principles that are held in common. Geologists are expanding their scientific interests into astrobiology, geomicro-biology, sustainable resources, and river/wetland reconstruction, which overlap with some of the interests of ecologists. **This is a good thing, at the graduate level.**

At the undergraduate level, I am not in favor of the convergent evolution of the geologic, ecologic, and civil engineering disciplines. **Competing with civil engineers and ecologists for undergraduate students by designing and offering complimentary courses within B.A. and B.S. curricula will further diminish our undergraduate enrollments**, which in turn could plunge our graduate programs to lower depths.

## Ancestors and Lineages

Traditionally, geologists at all levels of study were educated as physical scientists to observe, identify, describe, experiment, and analyze the Earth to form and test concepts explaining natural phenomena. The most common degree obtained by practicing geologists was the Master's of Science. The amount of applied course work was minimal and a significant amount of training occurred on the job, especially with large oil companies, the major source of employment. In the past 20 years, this historical relation changed as employment with oil companies declined and employment with geotechnical and geo-environmental firms grew. At these smaller companies, new hires are expected to immediately contribute to the bottom line and require little additional training.

Ecologists also are trained as scientists. Practicing ecologists generally acquire a Master's of Science degree usually majoring in biology and taking courses at the graduate level in organismal biology, population sampling, and statistics. Job opportunities for ecologists, like geologists, have increased markedly as a result of federal and state regulations addressing the impact of human activities on the quality of Earth's environments. Because of these mandates, ecologists are hired by consulting firms to work on multidisciplinary projects with geologists and engineers.

Undergraduate civil engineers receive a traditional engineering education where scientific and mathematical principles are applied to practical problems dealing with the design and construction of public works projects such as sewer line excavation, surface water structures, dam construction, mining, slope stability, etc. In the past 20 years many civil engineering departments have added courses in environmental engineering to address the need for construction of environmental projects such as wetlands, rivers, and beaches. The highest degree sought by most practicing engineers is the bachelor's degree, as that degree and on-the-job-experience are needed to acquire a Professional Engineering license.

## Why Convergent Evolution Now?

For generations, geologists, ecologists, and civil engineers have taken divergent paths. Why are aspects of these formerly separate disciplines coalescing now? Part of the answer is the mandate by academic funding agencies for us to perform more interdisciplinary research. Another part of the answer is supply and demand economics aimed at capturing more student credit hours to prop up waning departmental budgets. This internal "butts-in-chairs" funding competition among departments on the same campus often focuses on the perceived attraction of the "E" word. **The word "Environmental" is believed by faculty in many departments to possess pheromone-like properties that will help stem the downward spiral of enrollments in science and engineering, whereas it is hoped by willing and anxious students to help provide employment.**

## Can We All Survive in the Same Niche?

By 'All' I mean all the faculty, all the departments, and all the students. I doubt all our departments can survive competing for the same students interested in the application of science to human environmental problems. Science is perceived by the vast majority of students to be the path of most resistance. As a result, geology, ecology, and civil engineering departments are largely competing for the same group of predisposed students. **Rather than compete with civil engineers, who have a well-established licensing structure, and ecologists, who have well-defined tasks within most regulatory guidelines, at an undergraduate level we geologists need to emphasize the skills that make our students unique.**

Contrary to this, in the past decade many geology departments have developed courses that do not develop or reinforce the geologic skills that our students will rely on during their professional careers to make them unique. Students today are savvier than we were several decades ago. Today, students are openly concerned about job prospects and know something about them, or the lack of them. If you were like me, you, too, were blissfully naïve about job opportunities as an undergraduate.

**So, while we are trying to help our budgets with larger enrollments, are we penalizing our undergraduate students?** I suspect we are. However, my opinion in this matter needs to be discounted because I do not work outside the hallowed halls. To get a reasonable answer to this question, we need to listen to the opinions of our alumni. Unfortunately, as a group, faculty usually don't listen well, especially to criticism about our courses. **What we need are data about where our recent graduates have obtained jobs and how well our courses prepared them for their jobs.**

**Illustrations by Matt Williams**

## What Skills Make Geologists Unique?

Two years ago, I asked our faculty what were the most important overall skills for our B.S. students to have upon graduation? As you can see below, some of these are general skills that all college graduates should possess and some are specific skills that set geologists apart from other science majors and engineers.

- ► **Time –** geologic history, evolutionary processes, correlation
- ► **Space –** map reading, map construction, paleo-environmental and structural framework analyses
- ► **Data Collection & Analysis –** observation, research design, resource searching, instrument operation, record keeping, statistics, Earth materials
- ► **Logic –** critical thinking, qualitative argumentation
- ► **Communication –** writing, data presentation, oral presentation
- ► **Professionalism –** organization, ethics, safety, teamwork, service, networking

Our faculty had difficulty separating the skills learned at the M.S. and Ph.D. levels from those introduced at a B.S. level. Nevertheless, the list suggests the skills that make geologists unique are **Time**, **Space**, and **Data Collection & Analysis** of geologic materials / processes. **Logic**, **Communication**, and **Professionalism** are skills shared with ecology, civil engineering, and others.

I also interviewed alumni (B.A., B.S., M.S., and Ph.D.) who worked for the U.S.G.S., Ohio EPA, Ohio DNR, Battelle Memorial Institute, and consulting firms, about 60 alumni in all, to find out (1) how they applied their geologic skills, (2) what skills we underemphasized, and (3) what skills we overemphasized. I have not performed an analysis of their responses, but several themes were repeated.

**Primary Applications of Geologic Skills**

- Groundwater resource exploration / evaluation
- Oil, gas, coal, aggregate exploration / evaluation
- Landfill siting and other waste disposal issues
- Toxic site characterization & remediation
- Construction of dewatering / depressurizing systems, highways
- Land stability, hazards, reclamation

Application of these geologic skills by practicing geologists is vastly different than for future academics. The reason I say this is because discussions in our department about undergraduate curriculum focus on getting students prepared for graduate degrees, not about getting students ready for the workforce. While providing this type of applied training is not popular among faculty, I believe it is a primary reason why our enrollments remain low. **We do not commonly inform our undergraduate students what types of jobs are available for them after they invest tens of thousands of dollars in their education and 4 to 5 years in our department.** Other departments do this well and benefit from it. Undergraduate students think about career opportunities. Without oil companies, we seem to be too inexperienced in industrial applications of our unique skills to make the curricular changes to assist our own students.

## What Are the Consequences?

The character to the left is a combination of the cartoon characterizations of all three disciplines. Just as a mule is an infertile hybrid between a donkey and a horse, an **Ecogeociveer** is an unemployable hybrid because he/she does not possess enough specific skills to compete for a job. To me, **our undergraduate curricula should strive to keep up with advances in technology, especially computer technology and software development, while emphasizing the skills that make geologists unique and our services needed by society. If we do this, students will come. If we don't...**