Geospatial and Geosocial Education

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The following were my undergraduate courses at University College Dublin, Ireland:

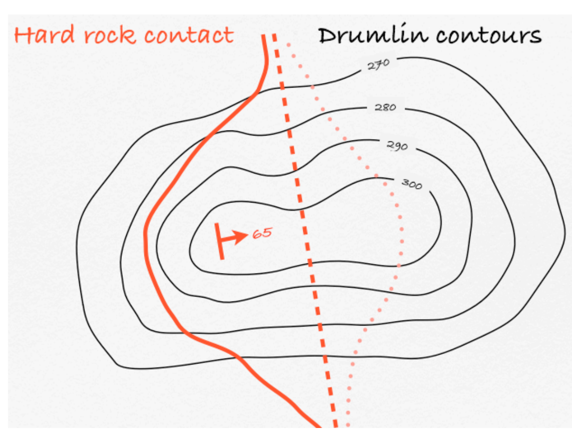
> 1969-70, 1st Year: geology, mathematics, physics, mathematical physics,
> 1970-71, 2nd Year: geology, mathematics, physics,
> 1971-72, 3rd Year: geology, mathematics,
> 1972-73, 4th Year: geology.

Of course, chemistry and biology were on offer, however in 1st year each required two afternoon labs whereas physics had one long lab and geology ran morning labs plus weekend field trips. I thus had four afternoons free for student life (protest marches, *etc.*)

After classes started, my motivation for studying geology changed from convenience to interest thanks to Dr. Pádraigh Kennan's lectures. Before class, he painstakingly covering blackboards with legible handwriting and multicolored chalk illustrations that shared the destiny of sand mandalas. I think we concentrated harder knowing his wisdom was about to be erased forever. Everything I learned in geology was new whereas physics and mathematics classes regurgitated the secondary school curriculum. Department Chair, Prof. Brindley, didn't permit the teaching of plate tectonics but our lecturers would meet us in the campus bar and subversively report on the unfolding geoscientific revolution (I particularly remember a demonstration of lithospheric thinning using Guinness froth). The geology program included many field trips and often we ended up in a pub discussing the day's work with instructors (or singing rugby songs, or both). The social aspect was central to our learning; there was no continuous assessment, but we studied in order to hold our own in these discussions. Geology labs also involved collaborative learning. Long before physicists designed SCALE-UP (www.ncsu.edu/per/scaleup.html), we gathered around specimen boxes or maps and exchanged observations peer-to-peer.

For my senior thesis, I mapped a contact aureole whilst my physics friends measured tracks in a Wilson Chamber. They weren't sure mapping was 'real' science and liked to quip that science was either physics or stamp collecting. But they envied geo students.

Geology did not come naturally to me. I had to work hard to see what was obvious to others, such as the mineralogy of fine-grained rocks or the justification for calling something *hornfels*. Prof. Brindley was interested only in solid geology and viewed anything younger than Carboniferous as 'cover.' I struggled to draw a hard rock contact across a drumlin. First, I used strike lines to trace the contact but Brindley said that was wrong, that I should draw it straight across. I considered this but



curved the contact in the opposite direction, arguing that ice had probably scoured the underlying bedrock into a spoon-shaped depression. Brindley responded: “Draw the contact straight across the drumlin, or is it that you think you’re the only student I have to supervise?” I decided I didn’t understand map making and resolved to research things I could measure, calculate, and be sure about.

After five years teaching in Galway, I moved to Johns Hopkins and offered mainly advanced courses. The audience for mathematical geology was not large, however, neither among students nor colleagues. I endeavored to make conference presentations about tensors entertaining and colleagues would respond “Loved your talk - didn’t understand a word of it - ha!” I decided the only way to promote my topics was to offer faculty workshops using lots of graphics. Visualizations helped folks grasp complex processes, while making and presenting them improved my own understanding.

My interest in computer graphics coincided with a ‘two-body’ career path ranging from contract-teaching a class of five majors at Harvard to team-teaching (with two physicists and two astronomers) in an auditorium filled with 425 students of Boston University’s Core Curriculum. Team-teaching with people Rutherford would have called scientists lead to many discussions on scientific method.

I also directed BU’s Field Camp at a time when GPS and GIS were revolutionizing mapping and came to the conclusion that mapping was key (pun intended). Geology describes places that change through time; it uses methods from Steno, Smith, Hutton, Walther, *etc*. The *Principles* in Lyell’s book are not derivable from Newton’s *Principia*. Earth cannot be reduced to physical particles bound by chemical bonds, because complexity emerges from their interaction and emergent complexity spawns chaotic patterns that require map making and map interpretation.

My Core Curriculum colleagues pointed to the role of prediction, *e.g*. Einstein’s 1915 prediction that starlight would be deflected by the Sun which was dramatically confirmed during a 1919 eclipse. However, that prediction then became an explanation of the past. Explanations of the past in geoscience are as valid as future predictions in physics.

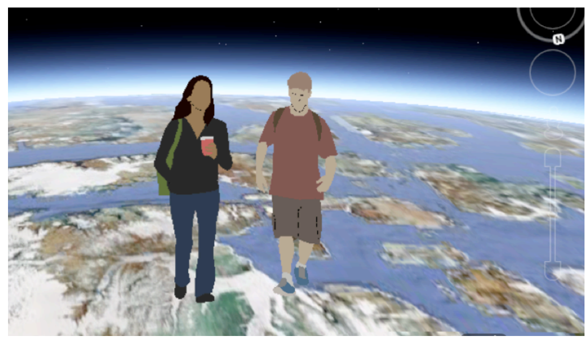
Another hot topic for discussion was Popperian Falsification – the notion that a hypothesis could never be proved by repeated tests but could be falsified by a single negative test. This is not what Karl Popper actually said, and is not how science works. When a test result is negative, the hypothesis may indeed be wrong, or the test may be flawed. Whether a result is positive or negative, the test may be tainted by fraud. And if you test whether a test is valid, the problem becomes recursive. So how can you know?

Consider an analogy with jigsaw puzzles – a hobby my spouse Carol Simpson and I occasionally found time for before e-mail. Some pieces fitted uniquely but in regions of blue sky, alternative fits seemed equally possible. We turned these pieces over and examined the cardboard fabric closely. If pulp matched across jigsaw-cuts, we knew the fit was right. A similar approach works in geoscience. Wegener noted general coastline correspondence, then Bullard matched continental shelves in detail. Problems with the

Bullard fit, such as Iceland and Iberia were resolved on even closer inspection – Iceland was young, Iberia had rotated, *etc*. Thus, the key to resolving at least some working hypotheses is pattern recognition across a range of length and time scales. The proof is in the zoom-in!

As Carol pursued the dark art of academic administration, I continue to move (with the onset of middle age, finding a new spouse-job seemed marginally easier than finding a new spouse). WPI had no geology department so, invoking *karma*, they put me in physics. From there, I taught planetary science and geology for engineers. To my surprise, some of the smartest engineers disliked graphical solutions; rather than find the intersections of two planes by using a stereonet, they preferred to calculate with direction cosines and cross products.

Now in ODU's physics department, I teach 375 non-majors (many from disadvantaged backgrounds) about the Solar System. Most have no understanding of the scientific, not to mention geoscientific, method. My research group creates, tests, and disseminates 3D models of specimens, block diagrams, *etc*., for use in Google Earth™. We've developed interactive virtual field trips and a mapping game in which students' avatars explore Google Earth at various scales (why not?) and communicate *via* text messages that pop-up in one another's placemark balloons.



I also teach with the Omniglobe™ and offer planetarium "field trips" to school children and the public. Digital full-dome projection of the planets and moons opens up new, immersive modes of both formal and informal education.

Geoscientists are not the only scientists who deal with places and patterns, but these are at the core of what we do. In today's world, few students can learn the methods of geoscience in the field-based, highly social environment that many of us experienced. Our new challenge is to bring that social-learning approach to the domains of general education, adaptive learning, distance education, and peer-to-peer instruction.

Links:

- www.digitalplant.org
- www.odu.edu/~ddepaor
- www.odu.edu/planetarium
- geosphere.gsapubs.org/content/8/2/491.abstract
- www.sciencedirect.com/science/article/pii/S0098300410001755
- www.geosociety.org/gsatoday/archive/20/4/article/i1052-5173-20-4-4.htm
- www.geosociety.org/penrose/10google.htm
- www.geosociety.org/meetings/2012/sessions/keynote.htm
- NE GSA Workshop, Bretton Woods NH, 2013. Building Google Earth Geologic Maps and Information Systems for Desktops, Laptops, and Mobile Devices.