Defining and developing geoscience expertise at the introductory level

Anne E. Egger
School of Earth Sciences
Stanford University

Oct. 19, 2009
GSA Annual Meeting
Some general principles we can probably agree on
**Principle #1:**
Geoscientists are different
Principle #2: Geoscience introductory courses are different
Principle #2:
Geoscience introductory courses are different

- Chemical Principles
- Structure and Reactivity
- Mechanics
- Magnetism and Electricity
- Light and Heat
- Genetics, Biochemistry, and Molecular Biology
**Principle #2:**
Geoscience introductory courses are different

- Chemical Principles
- Structure and Reactivity
- Mechanics
- Magnetism and Electricity
- Light and Heat
- Genetics, Biochemistry, and Molecular Biology
- Dynamic Earth
- Evolution and Extinction
- Energy and the Environment
- Earthquakes and Volcanoes
- The Oceans
- The Water Course
Principle #2: Geoscience introductory courses are different
Principle #3: Geoscience expertise ≠ ability to identify every rock

- Learning to be an expert really means learning the process of science, how we know what we know.
Principle #3: Geoscience expertise ≠ ability to identify every rock

• Learning to be an expert really means learning the process of science, how we know what we know

• For many students, how geoscientists know things is very different from their experiences in other science courses
Principle #3: Geoscience expertise ≠ ability to identify every rock

- Learning to be an expert really means learning the process of science, how we know what we know
- For many students, how geoscientists know things is very different from their experiences in other science courses
- Introductory geoscience courses are therefore critical places to emphasize real geoscience expertise
How does these grand ideas translate to reality?

(at least in this case)
A bit of background...

• **1891** John Casper Branner, a geologist, is the first professor hired at Stanford in the Department of Geology
A bit of background...

• **1891** John Casper Branner, a geologist, is the first professor hired at Stanford in the Department of Geology

• **1947** School of Mineral Sciences, with degrees offered in geology, geochemistry, geophysics, mining, metallurgy, and petroleum engineering
A bit of background...

- **1891** John Casper Branner, a geologist, is the first professor hired at Stanford in the Department of Geology.

- **1947** School of Mineral Sciences, with degrees offered in geology, geochemistry, geophysics, mining, metallurgy, and petroleum engineering.

- **Today** School of Earth Sciences, with undergraduate degrees in:

  - *Earth Systems*
  - *Energy Resources Engineering*
  - *Geological and Environmental Sciences*
  - *Geophysics*
A bit of background...

enrollment trends

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>456</td>
<td>400</td>
<td>316</td>
<td>398</td>
<td>311</td>
<td>409</td>
<td>381</td>
<td>360</td>
<td>321</td>
<td>419</td>
<td>513</td>
<td>645</td>
</tr>
<tr>
<td>Students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Courses:
- Esys 10
- Energy 101
- Energy 102
- GP 3/113
- GES 1
- GES/EESS 2
- GES 4
- GES 8
A bit of background... enrollment trends

Believe it or not, this created problems.
Proposal:
A New Approach to Introducing the Earth Sciences
Proposal: A New Approach to Introducing the Earth Sciences

**Goal:** To enhance our existing introductory courses (and develop new ones where necessary) to engage students in active learning to introduce the nature of scientific investigation and the broad range of topics and disciplines within the Earth and environmental sciences.
Proposal:
A New Approach to Introducing the Earth Sciences

Goal: To enhance our existing introductory courses (and develop new ones where necessary) to engage students in active learning to introduce the nature of scientific investigation and the broad range of topics and disciplines within the Earth and environmental sciences.

Goal: Within these courses, clearly articulate how they serve as entry points for all of our majors.
Proposal: A New Approach to Introducing the Earth Sciences

Goal: To enhance our existing introductory courses (and develop new ones where necessary) to engage students in active learning to introduce the nature of scientific investigation and the broad range of topics and disciplines within the Earth and environmental sciences.

Goal: Within these courses, clearly articulate how they serve as entry points for all of our majors.

• Students will be actively engaged ... in order to develop an understanding of the nature of scientific inquiry in the earth sciences.
Proposal: A New Approach to Introducing the Earth Sciences

Goal: To enhance our existing introductory courses (and develop new ones where necessary) to engage students in active learning to introduce the nature of scientific investigation and the broad range of topics and disciplines within the Earth and environmental sciences.

Goal: Within these courses, clearly articulate how they serve as entry points for all of our majors.

• Students will be actively engaged ... in order to develop an understanding of the nature of scientific inquiry in the earth sciences.

• Students will gain the scientific literacy skills necessary to understand and evaluate the science behind complex socioscientific issues.
Proposal: A New Approach to Introducing the Earth Sciences

Goal: To enhance our existing introductory courses (and develop new ones where necessary) to engage students in active learning to introduce the nature of scientific investigation and the broad range of topics and disciplines within the Earth and environmental sciences.

Goal: Within these courses, clearly articulate how they serve as entry points for all of our majors.

- Students will be actively engaged ... in order to develop an understanding of the nature of scientific inquiry in the earth sciences.

- Students will gain the scientific literacy skills necessary to understand and evaluate the science behind complex socioscientific issues.

- Students ... will see both what makes a major unique and what similarities are shared between all of the earth sciences.
**Proposal:**
A New Approach to Introducing the Earth Sciences

**Goal:** To enhance our existing introductory courses (and develop new ones where necessary) to engage students in active learning to introduce the nature of scientific investigation and the broad range of topics and disciplines within the Earth and environmental sciences.

**Goal:** Within these courses, clearly articulate how they serve as entry points for all of our majors.

- Students will be *actively engaged* ... in order to develop an understanding of the nature of scientific inquiry in the earth sciences.

- Students will gain the *scientific literacy* skills necessary to understand and evaluate the science behind complex socioscientific issues.

- Students ... will see both *what makes a major unique* and what similarities are *shared between all of the earth sciences*.
How it worked

Fall 2007

• Selection of course development assistants (CDAs)
• Workshop with faculty teaching intro courses to launch the project
• Development of broad learning outcomes for intro courses

Winter 2007, Spring 2008

• CDAs work one-on-one with faculty
• Weekly meetings with CDA group to workshop activities
• Revisiting the connections between courses

Academic year 2008-2009

• New CDAs, new courses
How it worked

Fall 2007

• Selection of course development assistants (CDAs)
• Workshop with faculty teaching intro courses to launch the project

• Development of broad learning outcomes for intro courses

Winter 2007, Spring 2008

• CDAs work one-on-one with faculty
• Weekly meetings with CDA group to workshop activities
• Revisiting the connections between courses

Academic year 2008-2009

• New CDAs, new courses
Developing learning outcomes

• Started with faculty teaching introductory courses (~5 people)
Developing learning outcomes

• Started with faculty teaching introductory courses (~5 people)

• Brought the list to the entire faculty (~45 people) and solicited feedback on the following questions:
Developing learning outcomes

• Started with faculty teaching introductory courses (~5 people)
• Brought the list to the entire faculty (~45 people) and solicited feedback on the following questions:

* Have we missed something critical as a broad objective for an introductory Earth Sciences course?

* If you teach a mid-level undergraduate course, are these the skills and knowledge you expect your students to have?

* How do these learning outcomes and courses fit into the bigger curriculum picture? How do we build on these skills and carry them through into upper-level course?
Developing learning outcomes

• Started with faculty teaching introductory courses (~5 people)
• Brought the list to the entire faculty (~45 people) and solicited feedback on the following questions:

  Have we missed something critical as a broad objective for an introductory Earth Sciences course?

  If you teach an mid-level undergraduate course, are these the skills and knowledge you expect your students to have?

  How do these learning outcomes and courses fit into the bigger curriculum picture? How do we build on these skills and carry them through into upper-level course?

• Allowed everyone to voice their opinions, and generalized out to...
Broad learning outcomes (there are 6)
Broad learning outcomes  (there are 6)

Over the extent of the course, activities in introductory courses should include
Broad learning outcomes  (there are 6)

Over the extent of the course, activities in introductory courses should include

• An introduction to the interconnectedness of earth systems and processes and the complexity of natural systems, including the role of humans in influencing earth processes and responding to hazards
Over the extent of the course, activities in introductory courses should include

- An introduction to the interconnectedness of earth systems and processes and the complexity of natural systems, including the role of humans in influencing earth processes and responding to hazards

- An introduction to the time scale of earth processes, including how the earth and its composition and biological components have changed over time
Broad learning outcomes (there are 6)

Over the extent of the course, activities in introductory courses should include

• An introduction to the interconnectedness of earth systems and processes and the complexity of natural systems, including the role of humans in influencing earth processes and responding to hazards

• An introduction to the time scale of earth processes, including how the earth and its composition and biological components have changed over time

• Active use of the observational tools of the earth sciences, whether those tools are found in the field, the laboratory, or the computer
Broad learning outcomes (there are 6)

Over the extent of the course, activities in introductory courses should include

• An introduction to the interconnectedness of earth systems and processes and the complexity of natural systems, including the role of humans in influencing earth processes and responding to hazards

• An introduction to the time scale of earth processes, including how the earth and its composition and biological components have changed over time

• Active use of the observational tools of the earth sciences, whether those tools are found in the field, the laboratory, or the computer

• Addressing problems in a quantitative fashion appropriate to the Earth sciences, including estimating uncertainty, scaling relationships, and using models
Broad learning outcomes (there are 6)

Over the extent of the course, activities in introductory courses should include

• An introduction to the interconnectedness of earth systems and processes and the complexity of natural systems, including the role of humans in influencing earth processes and responding to hazards

• An introduction to the time scale of earth processes, including how the earth and its composition and biological components have changed over time

• Active use of the observational tools of the earth sciences, whether those tools are found in the field, the laboratory, or the computer

• Addressing problems in a quantitative fashion appropriate to the Earth sciences, including estimating uncertainty, scaling relationships, and using models

• Reflection upon the unique aspects of the earth sciences
Over the extent of the course, activities in introductory courses should include

• An introduction to the interconnectedness of earth systems and processes and the complexity of natural systems, including the role of humans in influencing earth processes and responding to hazards

• An introduction to the time scale of earth processes, including how the earth and its composition and biological components have changed over time

• Active use of the observational tools of the earth sciences, whether those tools are found in the field, the laboratory, or the computer

• Addressing problems in a quantitative fashion appropriate to the Earth sciences, including estimating uncertainty, scaling relationships, and using models

• Reflection upon the unique aspects of the earth sciences

• Communication of Earth science concepts, from fundamental knowledge to complex relationships between research and issues of societal concern
Benefits of process
Benefits of process

- Guided new course development - where were we missing courses?
Benefits of process

- Guided new course development - where were we missing courses?
- Focused design of activities for existing courses - what aspects were missing?
Benefits of process

• Guided new course development - where were we missing courses?

• Focused design of activities for existing courses - what aspects were missing?

• Demystified courses in other departments, amount of overlap decreased
Benefits of process

• Guided new course development - where were we missing courses?

• Focused design of activities for existing courses - what aspects were missing?

• Demystified courses in other departments, amount of overlap decreased

• Created multidisciplinary community around introductory courses