A Survey of Introductory Soil Science Curricula

N.A. Jelinski\textsuperscript{1}, C.J. Moorberg\textsuperscript{2}, M.D. Ransom\textsuperscript{2}, J.C. Bell\textsuperscript{1}

\textsuperscript{1}Department of Soil, Water and Climate
University of Minnesota-Twin Cities

\textsuperscript{2}Department of Agronomy
Kansas State University

Image: S. Nordstrom
Survey Goals and Objectives

1. Improve knowledge of the diversity of materials, methods, and pedagogies utilized to teach Introductory Soil Science (or equivalent)
Survey Goals and Objectives

1. Improve knowledge of the diversity of materials, methods, and pedagogies utilized to teach Introductory Soil Science (or equivalent)

2. Assist instructors or institutions in the process of revising or reviewing their Introductory Soil Science courses
Survey Goals and Objectives

1. Improve knowledge of the diversity of materials, methods, and pedagogies utilized to teach Introductory Soil Science (or equivalent)

2. Assist instructors or institutions in the process of revising or reviewing their Introductory Soil Science courses

3. Identify opportunities for cross-institutional cooperation or the development of multi-user course materials and resources.
Survey Respondents

79 Institutions

- 36 U.S. Land Grant Institutions
- 40 Non-Land Grant Institutions
  - 12 Doctorate-Granting
  - 16 Master-Granting
  - 10 Bachelor-Granting
  - 2 Associate-Granting
- 3 Canadian Institutions
Class Size

- Average of 65 ± 29 students per course offering (< 20 to >100)
1. WHO are we teaching? – Class Size and Pre-Reqs

Class Size

- Average of $65 \pm 29$ students per course offering (<20 to >100)

Pre-Requisites

- Chemistry (63%)
- Math (24%)
- Biology/Plant Science/Crop Science (9%)
- Physics (5%)
- Geology/Earth Science (3%)
- None or HS (14%)
Introductory Soils Satisfies...

- Major or Minor Requirement (91%)
- General Science or Lab Requirement (53%)
Introductory Soils Satisfies...

- Major or Minor Requirement (91%)
- General Science or Lab Requirement (53%)

...and is taught in Departments that offer:

- Soil Science/Closely Related Major (32%)
- Soil Science Minor (34%)
- Soil Science Option (37%)
1. WHO are we teaching? – Class Year

Student Demographics by Class Year

- Juniors (33%)
- Sophomores (26%)
- Seniors (24%)
- Freshman (12%)
- Grad Students (3%)
- Non-Degree Students (2%)
Estimated Student Demographics by Requirement

- **Required (71%)**
- **General Ed (14%)**
- **Elective (12%)**
1. WHO are we teaching? – Requirements

Estimated Student Demographics by Requirement

- Required (71%)
- General Ed (14%)
- Elective (12%)

Land Grant institutions have a significantly lower proportion of students taking course as elective.
2. WHAT are we teaching? – Topical Categories

Condensed SSSA’s FSS Performance Objectives into 36 Topical Categories

- 1. Soil Particle Size Classes and Soil Texture
- 2. Bulk Density/Porosity/Particle Density
- 3. Soil Structure
- 4. Soil Color
- 5. Soil Water Concepts (Water Content, Potential, Retention, and Movement)
- 6. Components of Hydrologic Cycle
- 7. Soil Temperature and Factors Affecting Soil Temperature
- 8. Soil Gases and Aeration
- 9. Soil Mineral Structures and Behavior
- 10. Engineering Properties (Atterberg Limits, Strength, Shear Stress, etc.)
- 11. Soil Parent Material Types and Diversity
- 12. Horizon Forming Processes and Horizon Nomenclature
- 13. Soil Classification and Taxonomy
- 14. Soil Mapping and Map Unit Interpretations
- 15. Soil Geomorphology
- 16. Soil Forming Factors and Soil Development
- 17. Microorganism Diversity and Abundance in Soils
- 18. Plant Root/Microbial Interactions
- 19. Plant Root/Soil Interactions
- 20. Carbon Cycle
- 21. Nitrogen Cycle
- 22. Other Nutrient Cycles
- 23. Organic Matter Forms and Decomposition Processes
- 24. Bioremediation, Phytoremediation, and Waste Management
- 25. Erosion Types and Quantification
- 26. Soil Quality and Best Management Practices
- 27. Precision Agriculture
- 28. Water Quality and Management
- 29. Urban Soils
- 30. Integration of Soils Information and GIS
- 31. Plant Nutrients and Nutrient Deficiencies
- 32. pH and its Effects on Other Soil Properties
- 33. Cation Exchange Capacity
- 34. Soil Amendments and Chemical Management
- 35. Soil Testing, Analysis and Interpretation
- 36. Redox Processes and Hydric Soils
2. WHAT are we teaching? – Depth of Topics

SHALLOW

1: No Time Alloted

2: Mentioned Briefly, Not Explored

3: < ½ Lecture/Lab/Disc

4: > ½ Lecture, Lab, Disc

5: One entire Lecture/Lab/Disc

6: Multiple, Integrated Lectures/Labs/Discussions

DEEP
2. WHAT are we teaching? – Depth of Topics

**SHALLOW**

1: No Time Allotted
2: Mentioned Briefly, Not Explored
3: < ½ Lecture/Lab/Disc
4: > ½ Lecture, Lab, Disc
5: One entire Lecture/Lab/Disc
6: Multiple, Integrated Lectures/Labs/Discussions

**DEEP**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision Agriculture</td>
<td>2.22 ± 1.14</td>
</tr>
<tr>
<td>Urban Soils</td>
<td>2.36 ± 1.18</td>
</tr>
<tr>
<td>Engineering Properties [Atterberg Limits, etc.]</td>
<td>2.37 ± 1.48</td>
</tr>
<tr>
<td>GIS/Soils Info Integration</td>
<td>2.97 ± 1.53</td>
</tr>
<tr>
<td>Bioremediation/Waste</td>
<td>2.98 ± 1.43</td>
</tr>
</tbody>
</table>
2. WHAT are we teaching? – Depth of Topics

**Deepest:**
- Soil Water Concepts  
  \[5.43 \pm 0.94\]
- Classification/Taxonomy  
  \[5.17 \pm 1.03\]
- Horizon Genesis and Nomenclature  
  \[5.04 \pm 1.14\]
- Soil pH and Its Effects  
  \[5.03 \pm 0.98\]
- Soil Development/Factors  
  \[5.01 \pm 1.11\]

**Shallow:**
1: No Time Allotted
2: Mentioned Briefly, Not Explored
3: < ½ Lecture/Lab/Disc
4: > ½ Lecture, Lab, Disc
5: One entire Lecture/Lab/Disc
6: Multiple, Integrated Lectures/Labs/Discussions
2. WHAT are we teaching? — Texts

81% require a textbook

33%
2. WHAT are we teaching? — Texts

Textbooks — Required (Alternative)

5% Require Purchase of Course-Specific Lecture Notes
2. WHAT are we teaching? – Texts

39% recommend texts

10%

FIFTEENTH EDITION
THE NATURE AND PROPERTIES OF SOILS
RAY R. WEIL
NYLE C. BRADY

8%

ELEMENTS OF THE NATURE AND PROPERTIES OF SOILS
NYLE C. BRADY
RAY R. WEIL
THIRD EDITION
2. WHAT are we teaching? — Texts

Textbooks – Recommended (Alternative)
3. HOW are we teaching it? – Non-Lab Pedagogies

65% Lecture

49% Active Learning/Studio-Style

26% Online Learning Management

31% Peer Learning/Flipped Class

Images: (UL) University of Iowa, (UR) (BR) (BL): University of Minnesota
3. HOW are we teaching it? – Non-Lab Pedagogies

No significant relationship between class size and proportion taught as lecture vs. alternative styles.

No significant difference between Land Grant, Non-Land Grant, or Carnegie Classification Categories.
3. HOW are we teaching it? – Labs

92% Have Laboratory Component
- 27% Offer Lab as a Separate Course
- 97% Have Defined Lab Periods
- 3% (2 Institutions: Purdue and UMN) Have self-paced labs
Labs are led by:

- **Primary Instructor (70%)**
- Graduate TA’s (43%)
- Undergraduate TA’s (8%)
- Other (11%)
3. HOW are we teaching it? – Labs

Laboratory Activities

- Wet Lab (47%)
- Field (18%)
- Exhibits (16%)
- Digital (9%)
- Other (3%)
76% of Laboratory Sections have a field component

- Average of 2 field trips (1-6)
- Does not appear to vary by latitude!
3. HOW are we teaching it? – Lab Manuals

**Soils Laboratory Manual**

K-State Edition

What type of laboratory manual is used?

- **Custom (62%)**
- Commercially Published (8%)
- Other (8%)
3. HOW are we teaching it? – Lab Manuals

Is there a cost to the student?
Yes: 49%  No: 51%

Soils Laboratory Manual
K-State Edition

Image: open.soilscience.info
14% (11 institutions) offer completely online/distance learning format.

Average Class size: 39.5 ± 34 (< 10 to > 100)

Audience: Predominantly Undergraduates (79%)
3. HOW are we teaching it? – Distance Learning

2 Programs tailored heavily to graduate students, professionals, continuing Ed

45% (5 institutions) have lab section in conjunction with distance learning.
Outcomes

1. Manuscript (*in prep*) containing detailed results will be submitted to Natural Resources Education
Outcomes

1. Manuscript (*in prep*) containing detailed results will be submitted to Natural Resources Education

2. First step in understanding state of soil science education and potential high-payoff collaborative tasks. Move to open source?
Outcomes

1. Manuscript \((in \ prep)\) containing detailed results will be submitted to Natural Resources Education

2. First step in understanding state of soil science education and potential high-payoff collaborative tasks. Move to open source?

3. 42% of surveyed instructors interested in connecting with other introductory soils instructors to explore new approaches.
Opportunities to connect and share: open.soilscience.info

Welcome

The goal of Open Soil Science is to provide instructors with the resources they need to effectively teach the world about soils and soil science. The soil science resources made available on this website are open access, and in some cases, open-source. All materials are licensed under a Creative Commons BY-NC-SA 4.0 International License unless stated otherwise. Please use what you would like. Also, please note that this site is under development, so come back often as we post new materials, and incorporate new features and community involvement into this endeavor.
An Open-Source Laboratory Manual for Introductory, Undergraduate Soil Science Courses

Colby J. Moorberg* and David A. Crouse

Abstract
High textbook cost is a major obstacle to affordable higher education. Open textbooks present one solution, but open laboratory manuals must be developed for lab-based courses to successfully reduce overall textbook costs. Here, we present the Soils Laboratory Manual, an open-source lab manual for undergraduate, introductory soil science courses. The manual facilitates the ability for instructors to develop their own...
Acknowledgement

➢ Over 80 instructors of Introductory Soil Science from across the country. Thank you for sharing your thoughts and opinions!

➢ Minnesota Agricultural Experiment Station, SSSA, NACTA

➢ Dr. J.D. Walker – UMN Center for Educational
79 Institutions
- 36 U.S. Land Grant Institutions
- 40 Non-Land Grant Institutions
  - 12 Doctorate-Granting
  - 16 Masters-Granting
  - 10 Bachelor’s-Granting
  - 2 Associate’s-Granting
No significant relationship between class size and proportion taught as lecture vs. alternative styles. No difference between LG/NLG and Carnegie Categories.
Are performance objectives from the SSSA or your state board of professional soil scientists “Fundamentals of Soil Science” exam incorporated into the learning objectives of the class?

Yes: 49%  No: 51%
3. HOW are we teaching it? – Lab Manuals

Soils Laboratory Manual
K-State Edition

What type of laboratory manual is used?
- Custom (62%)
- Commercially Published (8%)
- Other (8%)
- None/Notes (15%)
Results will be published in Natural Sciences Education (Journal)

First step in understanding state of soil science education and potential high-payoff collaborative tasks. Move to open source.

42% of surveyed instructors interested in connecting with other introductory soils instructors, and exploring new pedagogical techniques.
3. How are we teaching it? - Delivery

**Hybrid**: 16%

**Classroom**: 87%
2. How are we teaching it?

Average Number of Primary Instructors: $1.4 \pm 0.9$ (1-6)
Outline/Agenda

1. Survey Goals and Objectives
2. Respondent Statistics
3. Who Are We Teaching?
4. What are We Teaching?
5. How are We Teaching It?
6. Opportunities for X
1. WHO are we teaching? – Class Size and Pre-Reqs

Class Size

- Average (All) 65 ± 29 students per course offering (Min – Max)

Pre-Requisites

- Chemistry (63%)
- Math (24%)
- Biology/Plant Science/Crop Science (9%)
- Physics (5%)
- Geology/Earth Science (3%)
- None or HS (14%)