

# Knowledge structures and the vocabulary of engineering novices

Anita Coleman, SIRLS, University of  
Arizona, Tucson, USA  
[asc@u.arizona.edu](mailto:asc@u.arizona.edu)

# Science knowledge

- Three types of science knowledge
  - Declarative
  - Procedural
  - Structural
- Structural knowledge
  - Learners (novices)
  - Experts
- Representation of science knowledge
  - Concepts maps
  - Pathfinder networks

# Controlled vocabularies

- Controlled vocabularies have two main components:
  - Concepts (terms or phrases)
  - Relationships (facets, hierarchies)

# Types of controlled vocabularies

Simple

Complex

**Synonym  
Rings**

**Authority  
Files**

**Classification  
Schemes**

**Thesauri**

**Ontologies**

Equivalence

Hierarchical

Associative

(Roles)

*Relationships*

Source: Modified from Rosenfeld and Morville 2002

# Research Question

- What is the language used by learners and experts for *soil consolidation* concepts and relationships?

# Subjects

- Novices and Expert from a civil engineering, geo-technical laboratory class, at a major southwestern university in the United States were solicited for voluntary participation.
  - Novices (n=10)
  - Expert (n=1)

# Course

- The Geo-technical laboratory is a laboratory course that must be taken either with a three-unit Soils course or soon after it. There are approximately ten labs that must be completed over the course of the 16-week semester for a course value of one credit hour. The lab manual used was *Engineering properties of soils and their measurements*, Joseph E. Bowles, 4<sup>th</sup> edition, New York, McGraw-Hill.

# Laboratories

- From the list of ten laboratories, the experiment on primary consolidation titled “Consolidation,” was selected for further study. There are two delivery formats available: as a virtual test and as a physical test.



# Data Collection

- Novices first performed a virtual and a physical laboratory on the soils concept, *primary consolidation*. After completion of the labs, they engaged in three interviews with the research team of the investigator and the graduate research assistant.

# Data Analysis

- Concept maps were generated of the statements made by each student after each interview; thus, for each student there are three concept maps, one representing the state of their knowledge at the end of the virtual lab, one representing their knowledge at the end of the physical laboratory, and the third representing the categories that resulted from the card sort, all this resulting in a total of 30 concept maps.

# Data Analysis (contd.)

- Additionally, pathfinder networks were generated for each student's rating of relatedness among the statement and categories.
- Similarly, concept maps and pathfinder networks were also drawn for the expert's three interviews.
- Elsevier's Engineering Index Thesaurus was used to generate the concept map and pathfinder network for the primary term soil consolidation and all relationships.

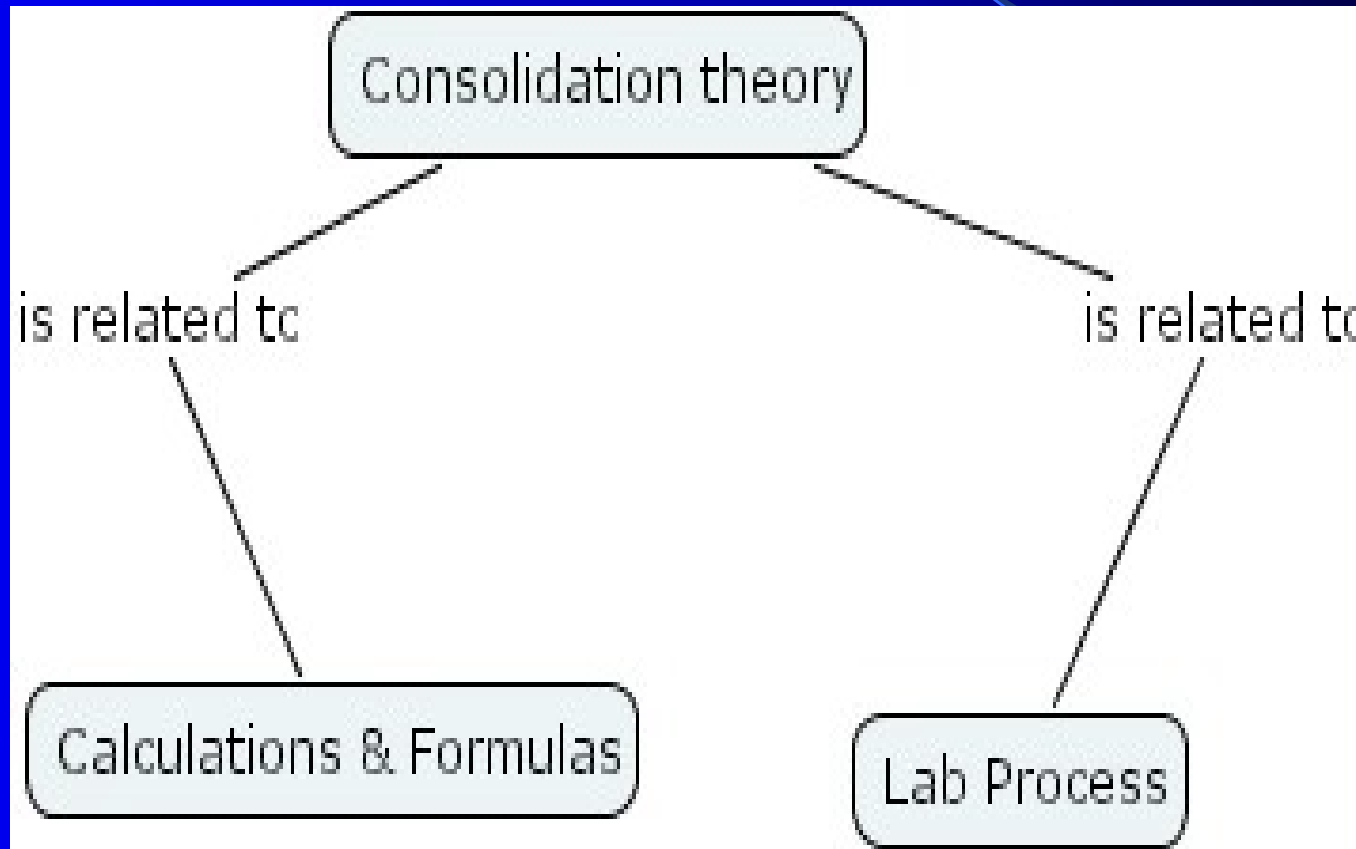
# Results

- Only the results of the comparison of the concept maps and networks which represent category labels (concepts and relationships identified in final interviews), among novices, expert, and tool is described here.

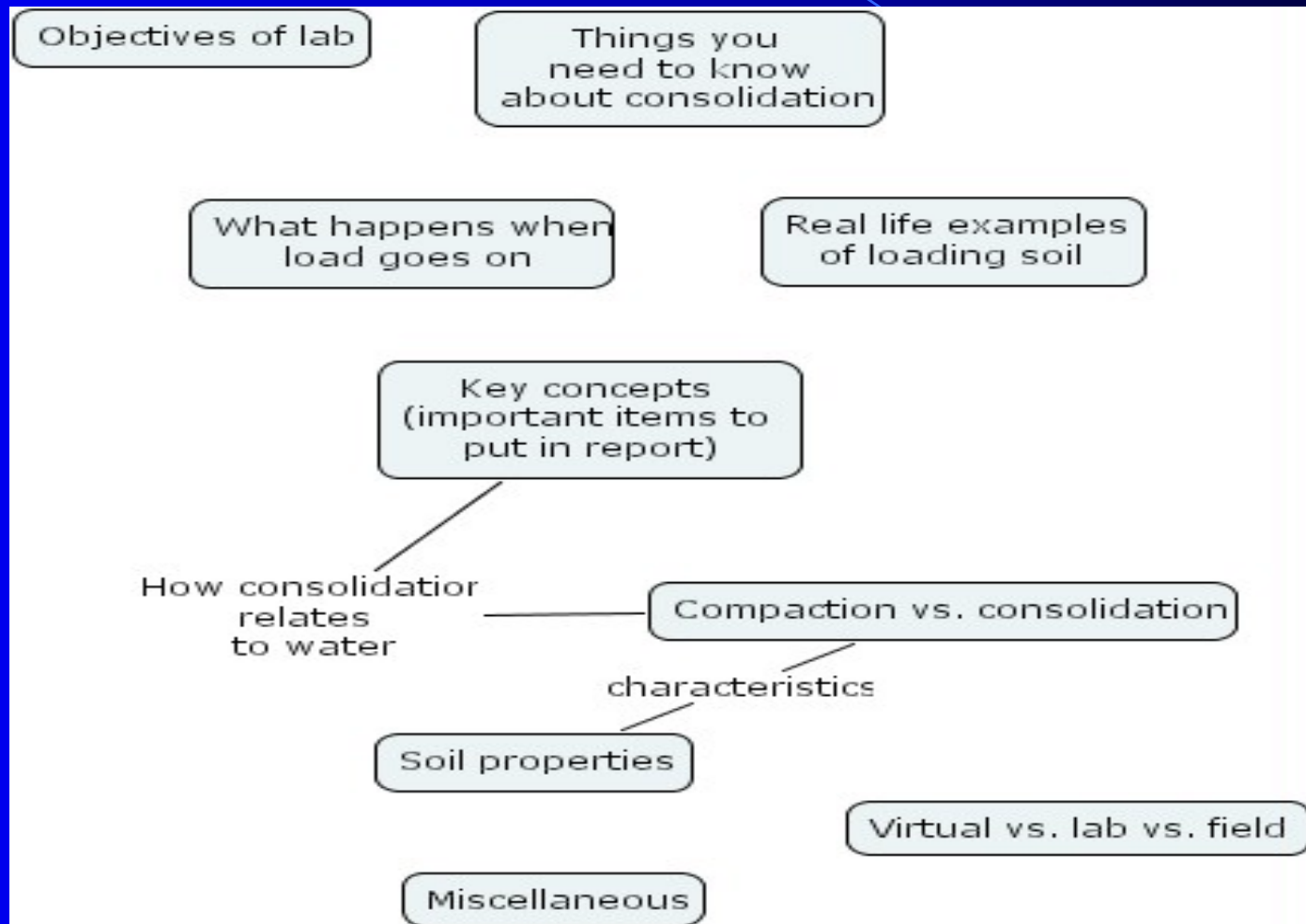
# Nature of concept maps

- The concept maps of the two novices and the expert show a preoccupation with learning/teaching, the organizational framework for the concept); structural knowledge about the concept (subject) is clearly interlinked in their minds to learning perspectives, such as how best to do it.

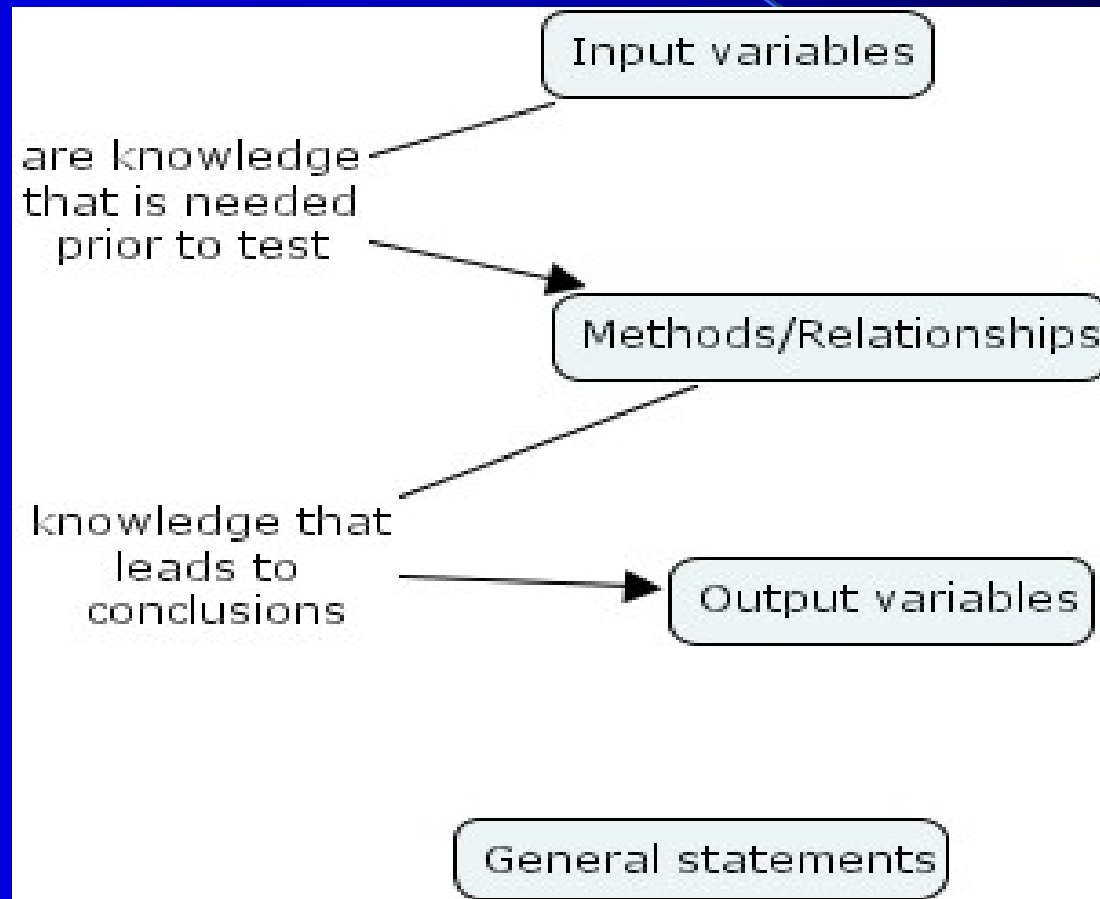
# Simple concept map



# Complex concept map

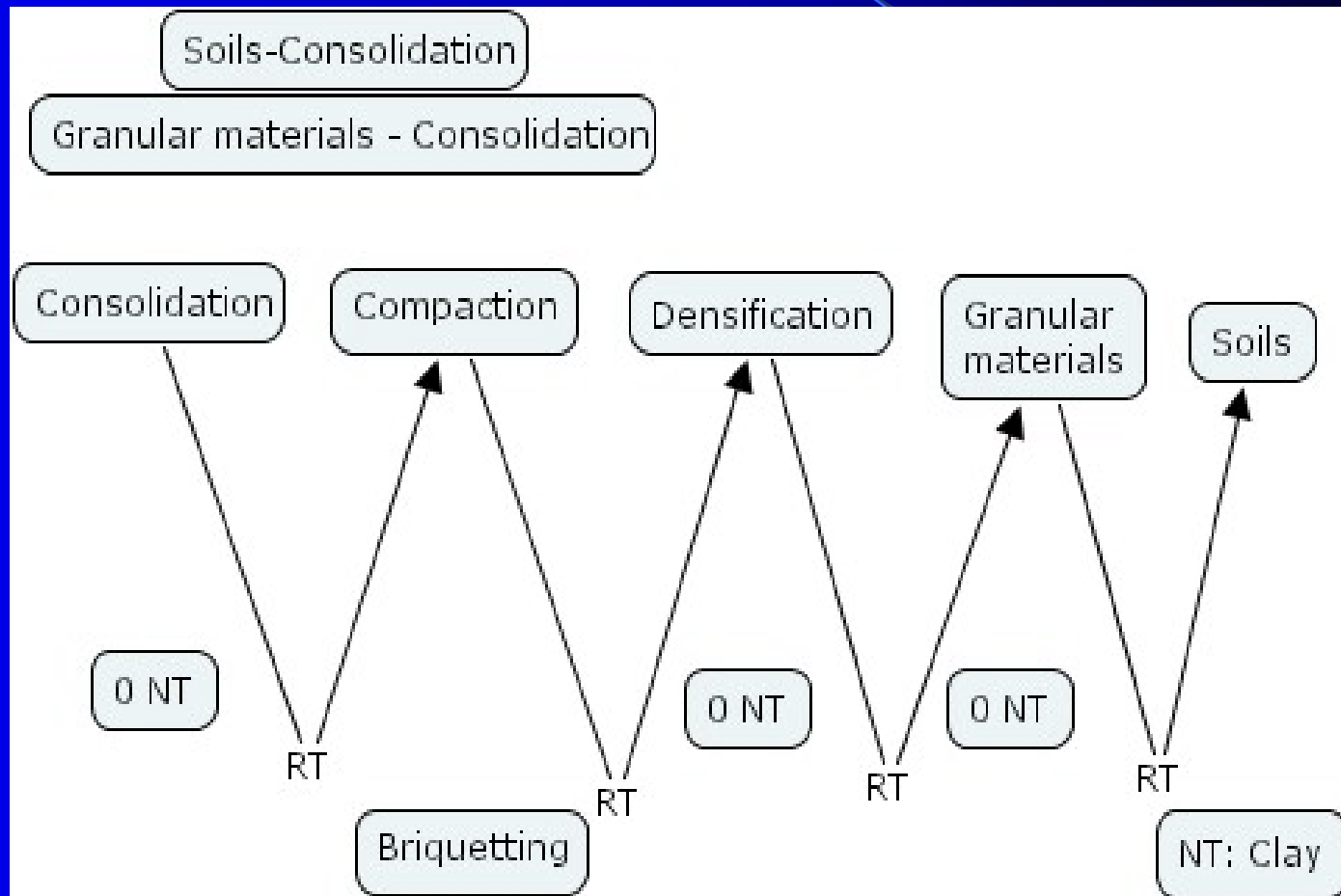


# Expert's concept map





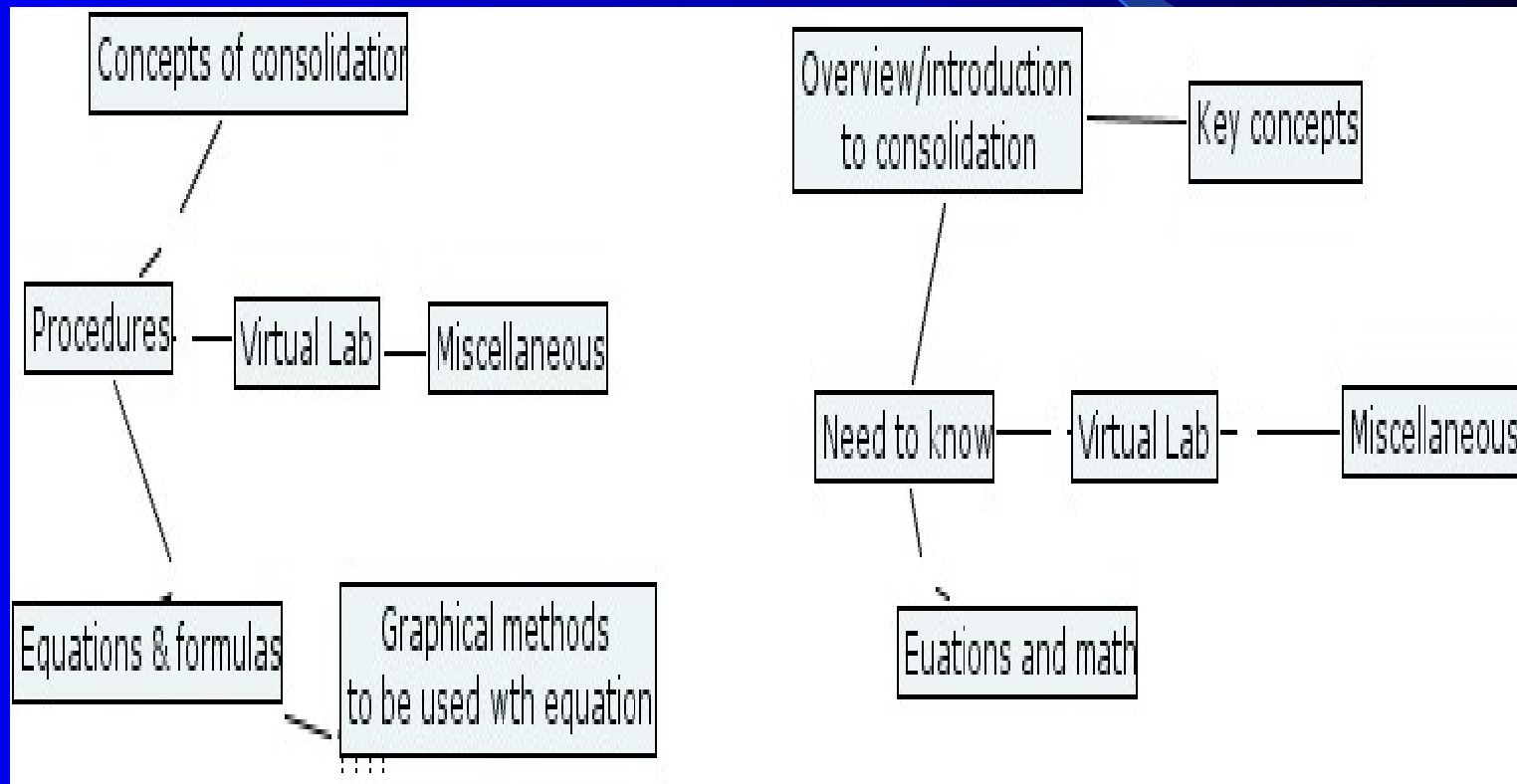
# EI Thesaurus concept map



# Similarities

- In pathfinder network analysis, the similarity rating examines the degree to which the same concept in two networks is surrounded by similar neighboring concepts.
- The networks of the novices were compared to the networks of the expert and used to calculate similarity.
- In general, the knowledge structures of novices exhibited higher similarity to each other. Novice networks showed little similarity and correlation to those of the expert and the tool.

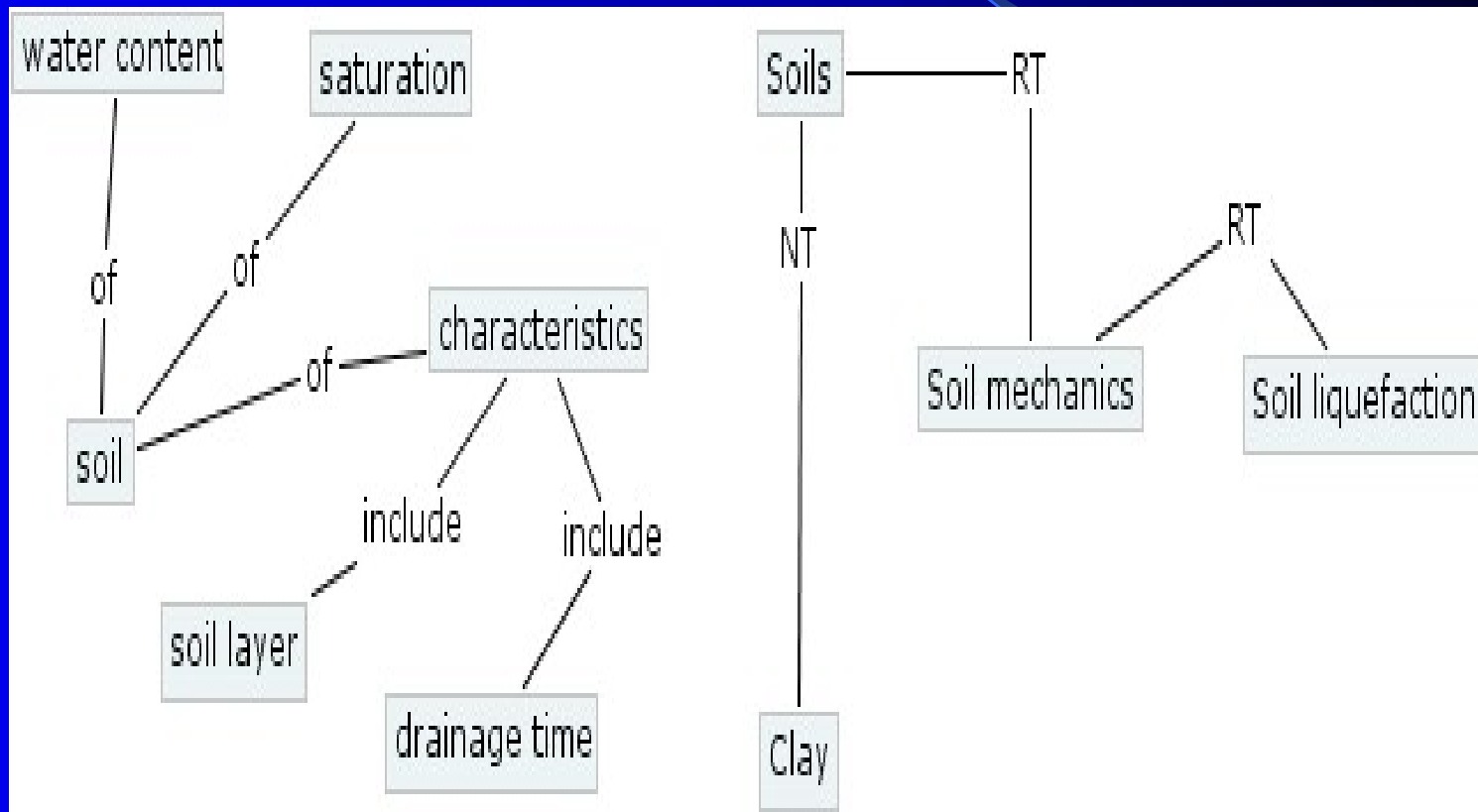
# High similarity between novice networks



# Differences

- The networks of the expert and the thesaurus also showed little similarity and correlation to each other.
- In order to ensure that the structural knowledge representation is typical of the field, the expert's map and network is currently being compared with other experts.

# Low similarity between experts



# Organizing frameworks

- Knowledge organization tools and digital libraries may want to consider adding learning schemas and organization frameworks in the representation of concepts and relationships.
- Implications for browse structures and navigation tools

# Acknowledgments

- Engineering Information Foundation
- Dept. of Civil Engineering, University of Arizona
- Dr. M. Budhu, Prof. University of Arizona
- Susan Irwin, SIRLS
- Study volunteers

**Thank you!**

ISKO 8, London, July 13-16, 2004