Concept Maps as Teaching, Learning, and Assessment Tools
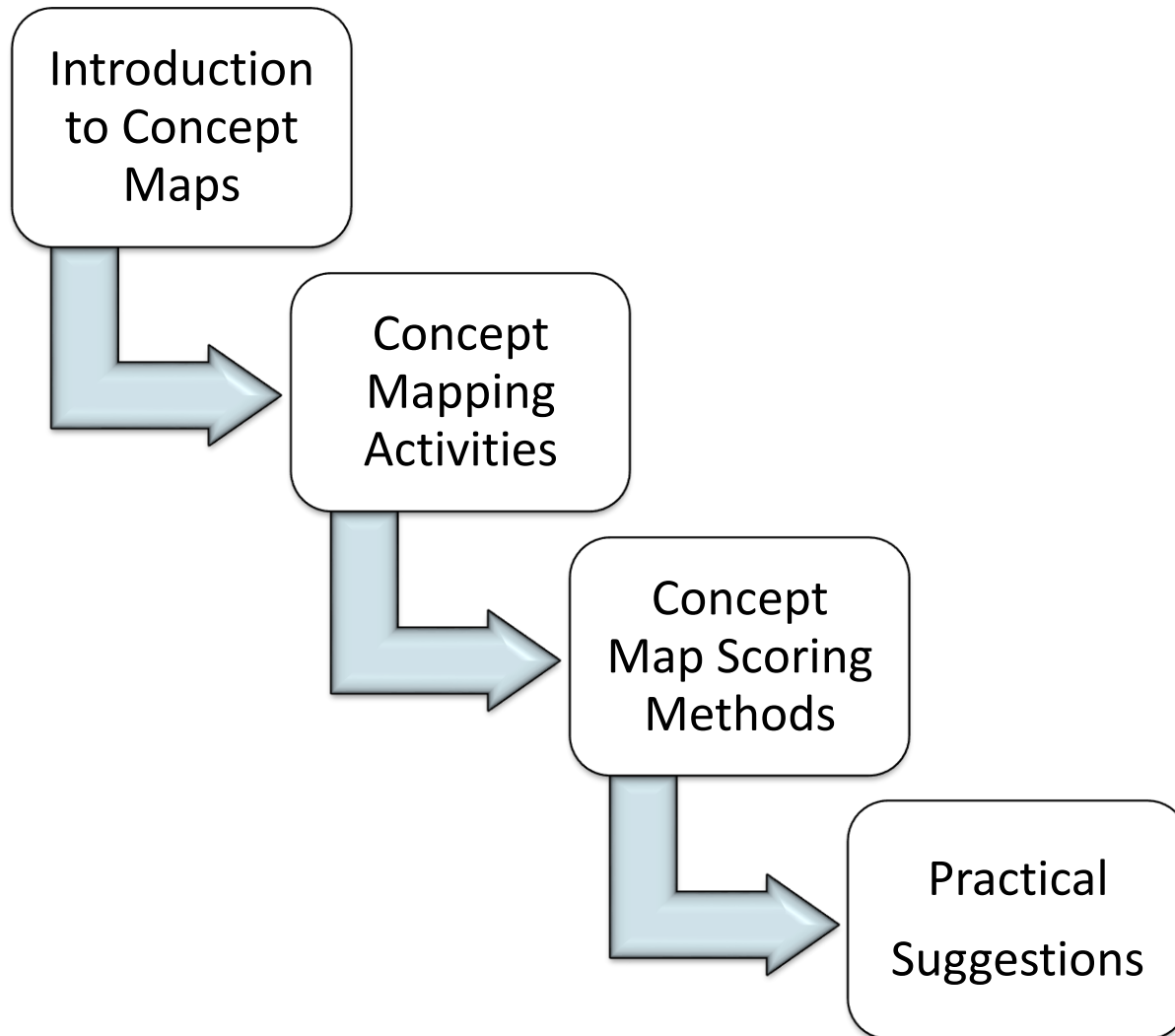
A Serve-Learn-Sustain Assessment Workshop

Presented at the Georgia Institute of Technology

Friday January 20, 2017

By:

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The Citadel

THE CITADEL
School of Engineering

Workshop Overview

Introduction to Concept Maps

Concept Mapping Activities

Concept Map Scoring Methods

Practical Suggestions

Serve-Learn-Sustain (SLS) Learning Outcomes:

Develop Skills & Knowledge

- *Identify* relationships among ecological, social, and economic systems.
- *Describe* how sustainability and community engagement relate to their civic lives.

Connect to Professional Practice

- *Describe* how sustainability relates to their professional practice.
- *Describe* the social and cultural impact of their professional practice.

Many outcomes target improving *conceptual knowledge.*

Introduction:
What is Conceptual Knowledge?

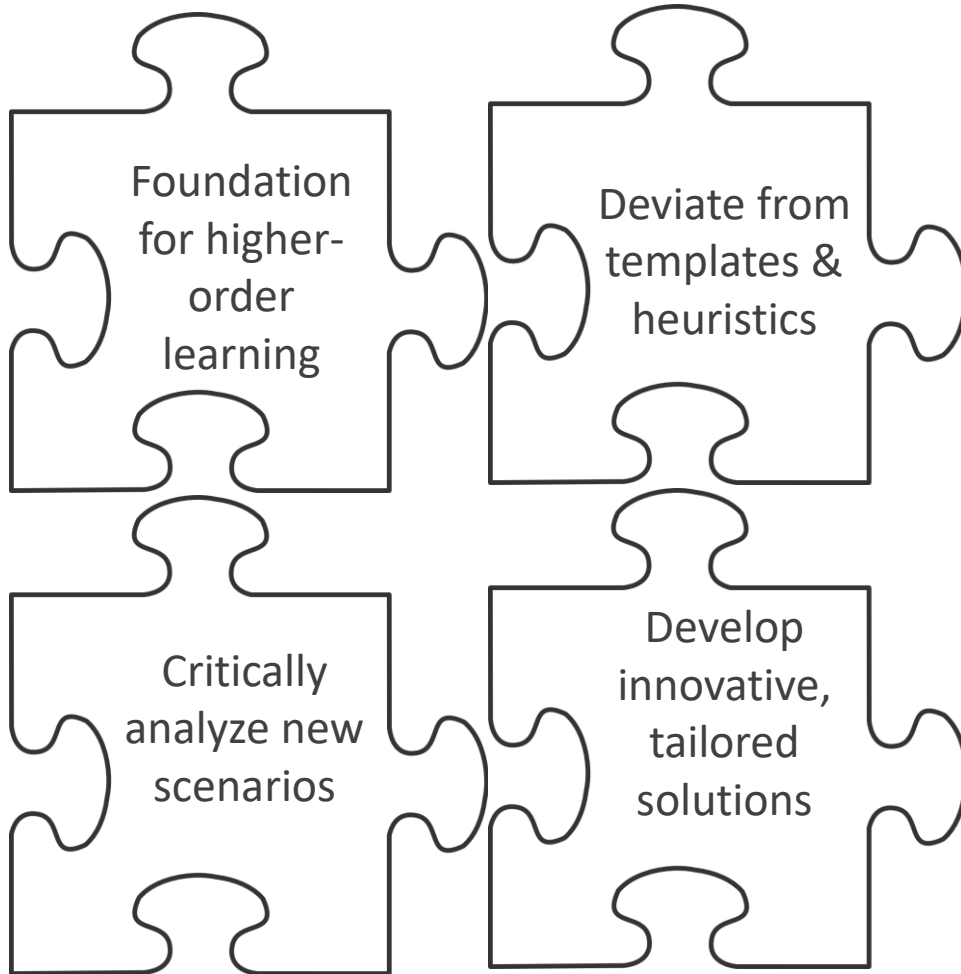Includes facts, generalizations, and principles.

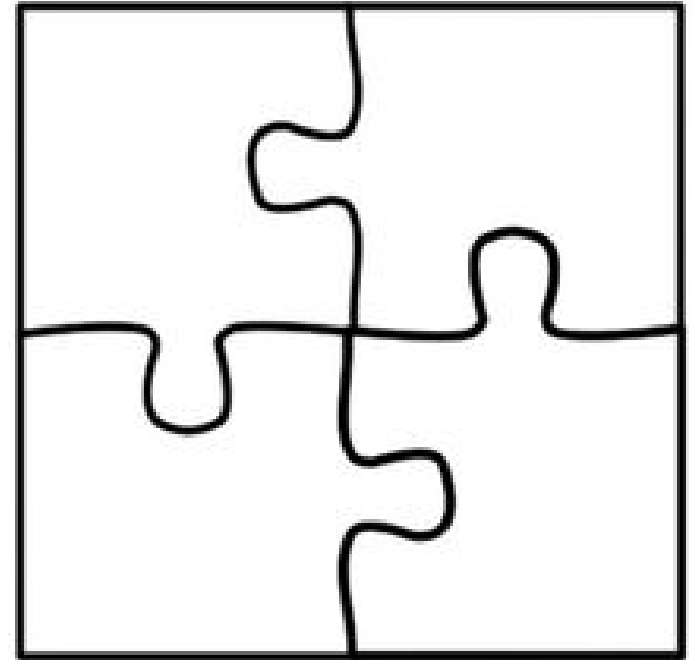Includes relationships between concepts.

Encompasses how facts are organized.

Should be deep and rich with connections.

Introduction:
Why is conceptual knowledge important?

Foundation for higher-order learning

Deviate from templates & heuristics

Critically analyze new scenarios

Develop innovative, tailored solutions

Conceptual Knowledge

[1]

Given the role of conceptual knowledge in professional competence, there is a need for appropriate:
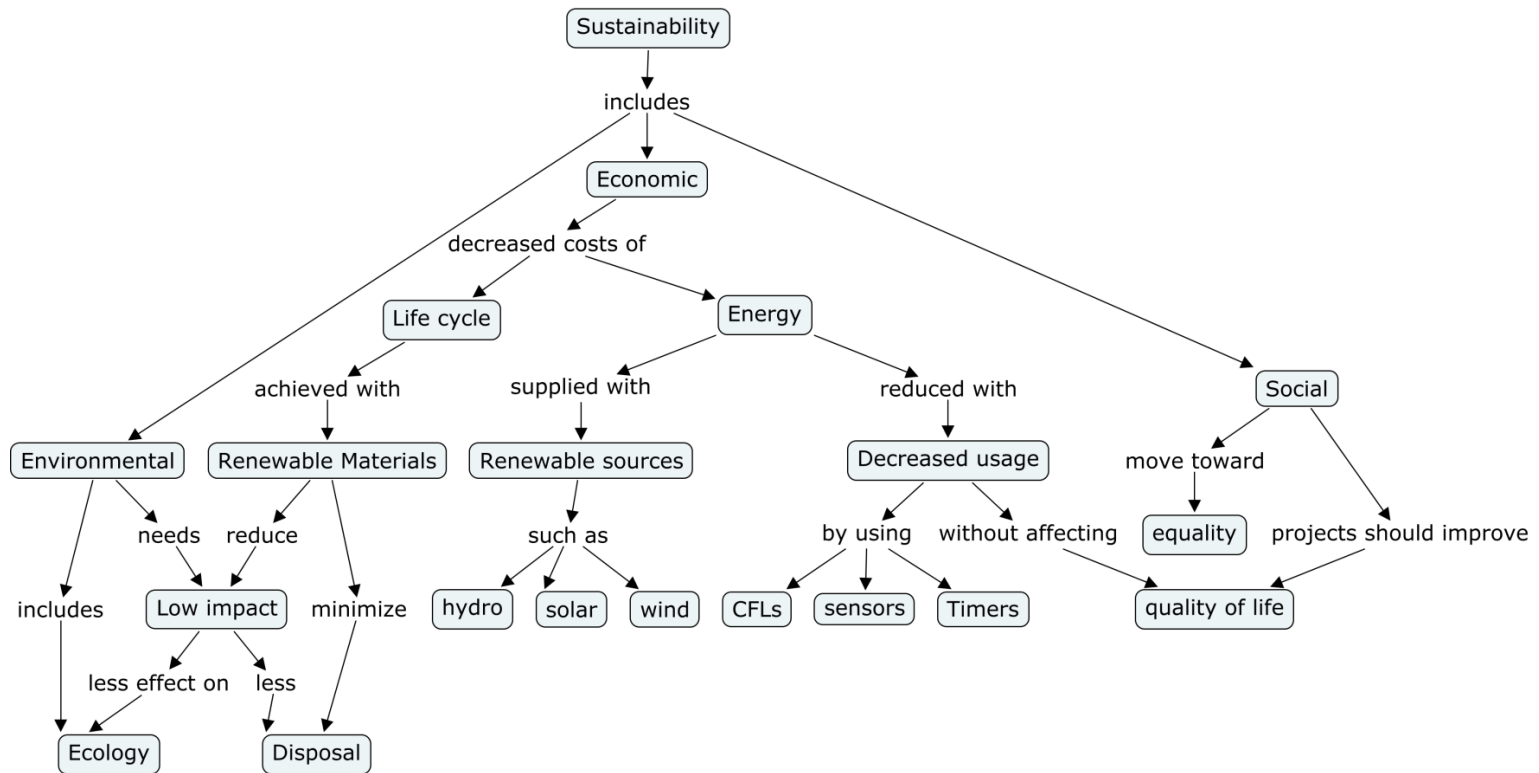
Teaching & Learning Tools

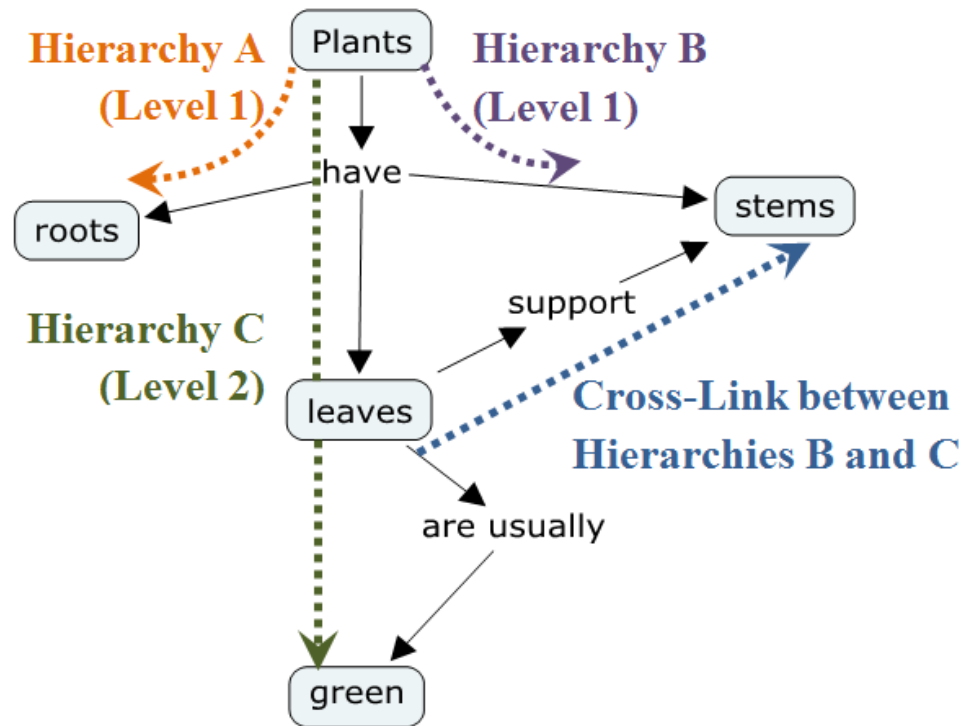Assessment & Research Tools

Introduction:
Concept Maps (Cmaps)

Cmaps are graphical tools for organizing and presenting knowledge.

Introduction:
Construction of a Concept Map

- Include concepts related to a central topic in boxes.

- Connecting lines with phrases show concept relationships.

- Cmap Components
  - Propositions
  - Hierarchies
  - Cross-links

Introduction:
Examples of Concept Maps in Higher Education

Cmaps can be used to promote & assess knowledge in a variety of areas:

Ill-defined

Broad

Subjective

Disciplinary/
Technical

Introduction:
"Serve-Learn-Sustain" Context

Serve-Learn-Sustain (SLS) Learning Outcomes:

Develop Skills & Knowledge

- *Identify* relationships among ecological, social, and economic systems.
- *Describe* how sustainability and community engagement relate to their civic lives.

Connect to Professional Practice

- *Describe* how sustainability relates to their professional practice.
- *Describe* the social and cultural impact of their professional practice.

Concept maps can be used to promote *learning and assessment* of SLS outcomes.
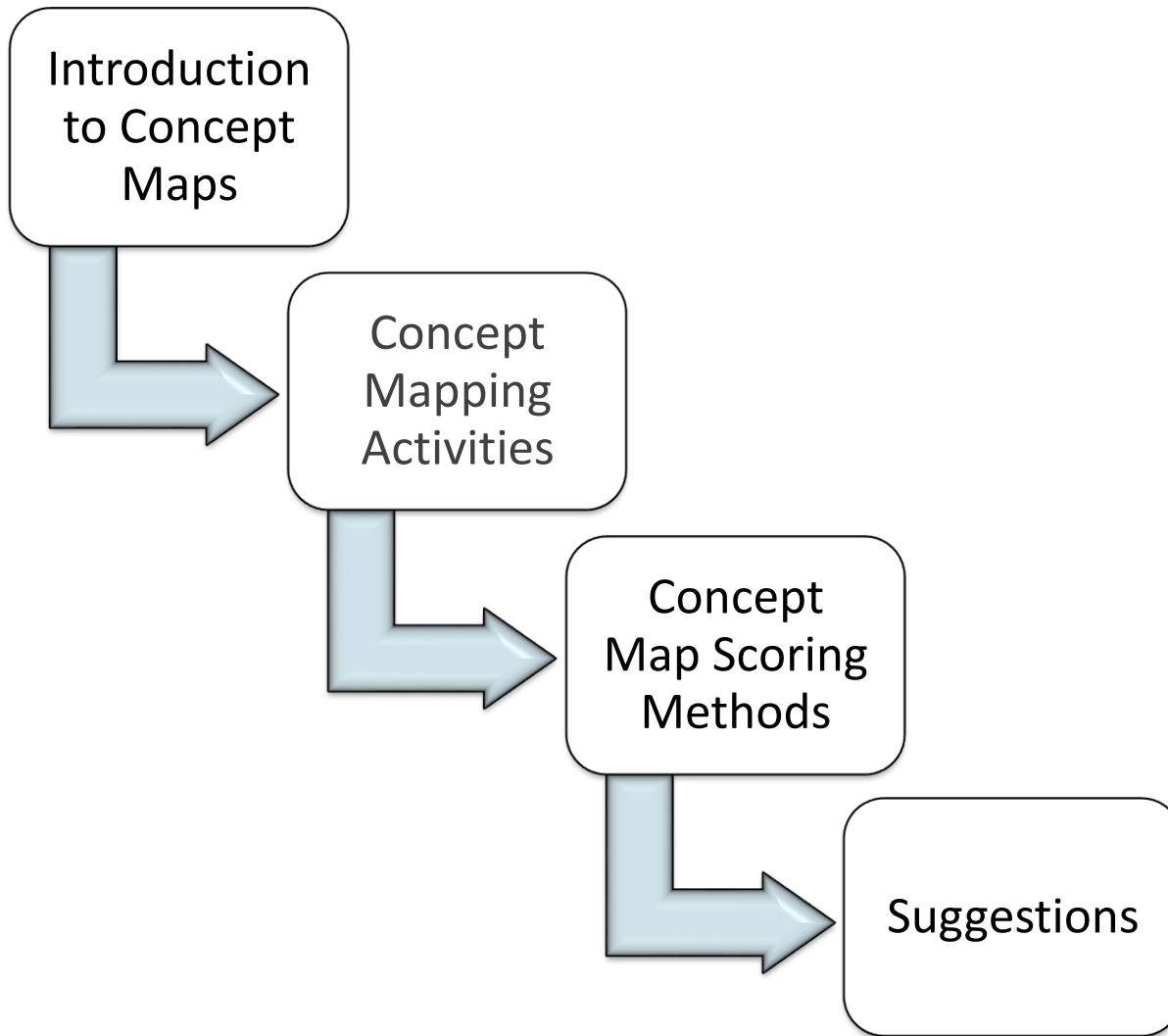
Activity #1:
Cmap Applications for "Serve-Learn-Sustain"

Brainstorm!

- Make a list of SLS topics that could be assessed using cmaps.

- Identify the SLS outcome associated with each topic.

Workshop Overview

Introduction to Concept Maps

Concept Mapping Activities

Concept Map Scoring Methods

Suggestions

Concept Map Activities:
Key Components

Three components of a concept mapping activity/assessment:

Task

Format

Scoring Method

Concept Map Activities:
## *Task*

Several levels of task directedness:

Low Directedness

Construct-a-Map:

Students structure their own maps using original concepts and linking phrases.

Intermediate:

Students create their own map structure using instructor-provided concepts and/or linking phrases.

High Directedness

Fill-in-a-Map:

Students fill in blank structure with instructor-provided concepts and linking phrases.

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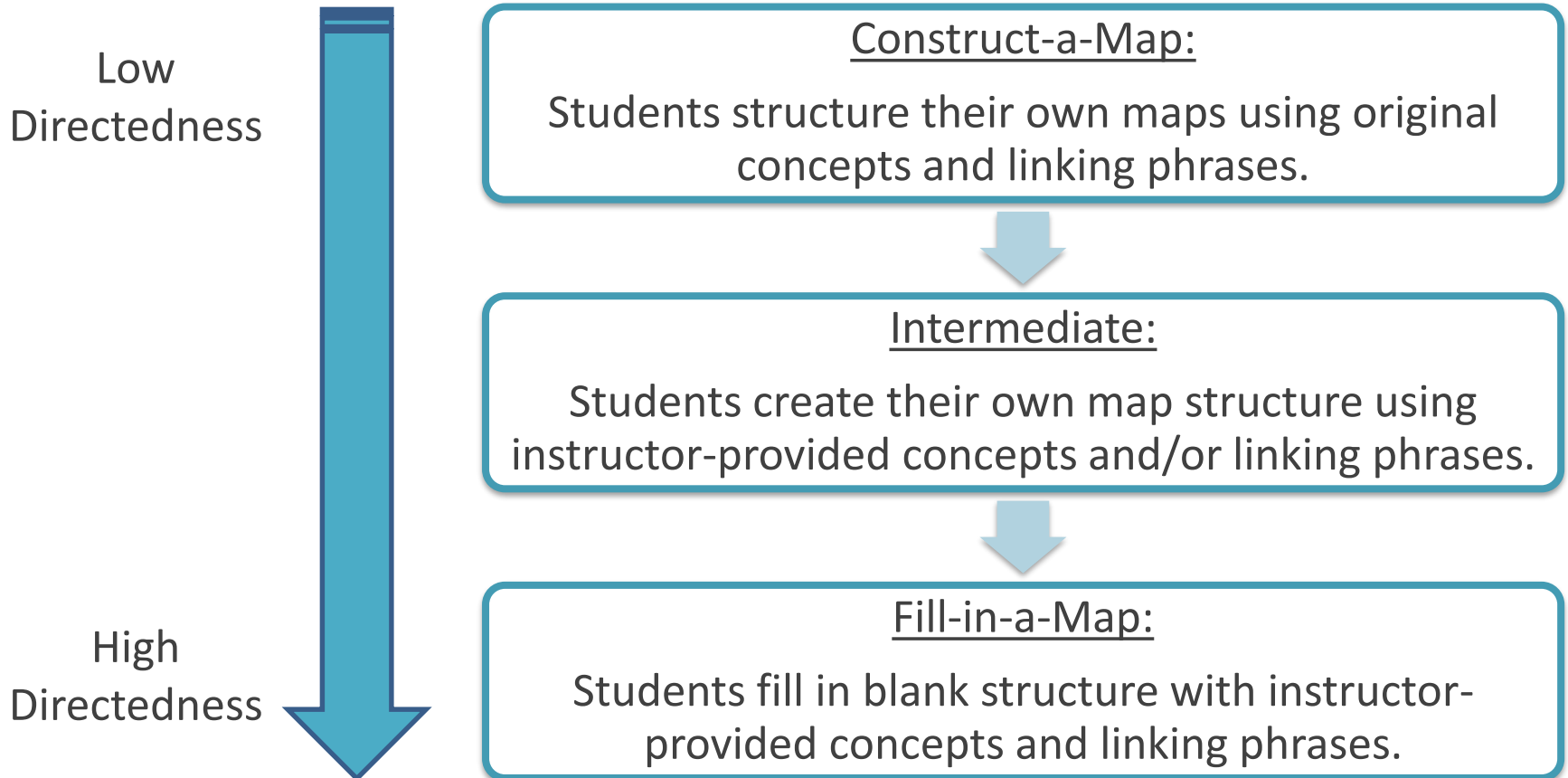
Concept Map Activities:
Format

By Hand:

Easy to administer

No program to learn

Difficult to organize cmap

Can be harder to score
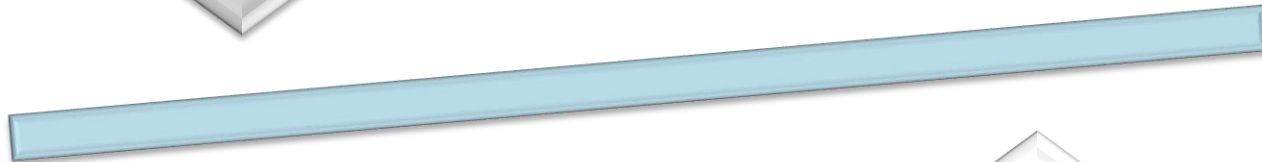
CmapTools:

Easy to organize cmap

Can be easier to score

Program easy to learn

Requires computers to administer

[10]

Concept Map Activities:
Scoring

Scoring methods needed to:

Provide formative feedback.

Capture changes over time.

Detect differences between groups.

Scoring is the major bottleneck in use of concept maps.

Concept Map Activities:
Activity #2

Create a cmap!

- Choose an SLS topic and create a concept map using the poster board.

- You can work individually or in groups.

- Post your concept map at the front when you are done!

Concept Map Activities:
Ready to Try in Your Classroom?

Before Pre-Assessment

- Watch training video
- Download CmapTools
- Construct practice cmap

Pre-Assessment

- Quick (5 min or less) cmap refresher
- Provide focus topic/question
- Allow at least 20 – 30 min for cmap activity
- For CmapTools, submit .cmap file
- For paper, provide large 11 x 17 paper

Post-Assessment

- Quick (5 min or less) cmap refresher
- Provide focus topic/question
- Allow the same amount of time as pre-assessment
- Use the same format (CmapTools or paper) as pre-assessment

Sample resources available in workshop folders.

Workshop Transition

Introduction to Concept Maps

Concept Mapping Activities

9:15 to 10:15 AM Session

Concept Map Scoring Methods

Practical Suggestions

10:30 – 11:30 AM Session

Questions?

Thank you!

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Introduction to Concept Maps

Concept Mapping Activities

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Practical Suggestions

Concept Map Activities:
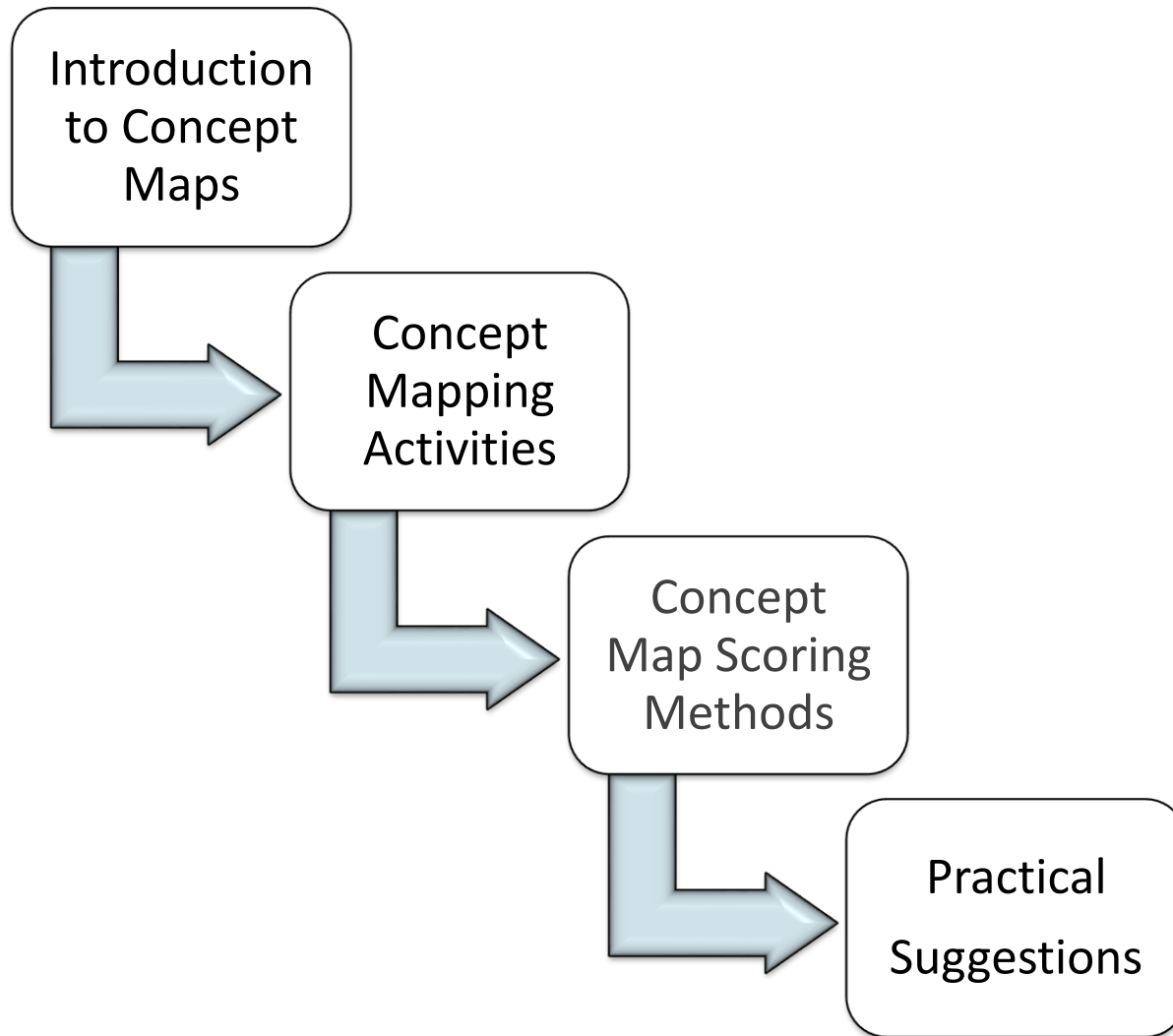## *Key Components*

Three components of a concept mapping activity/assessment:

Task

Format

Scoring Method

Concept Map Scoring:
Overview of Methods

Structure	Content	Hybrid (Structure & Content)
Counting Components (Traditional Method)	Qualitative Concept Coding	Interlinks & Complexity
		Analytic Rubric

[11]

Concept Map Scoring:
Overview of Methods

Structure

Counting Components (Traditional Method)
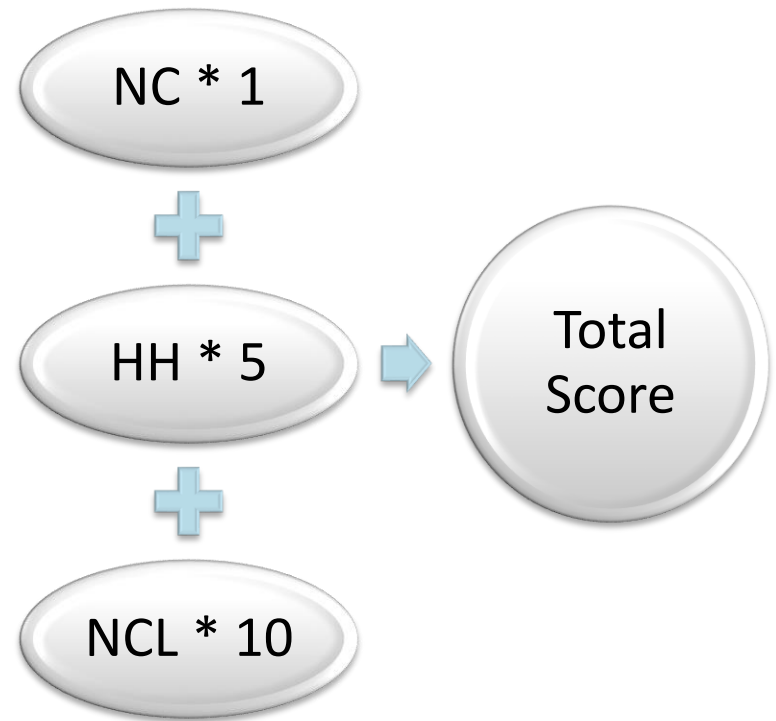
Content

Qualitative Concept Coding

Hybrid (Structure & Content)
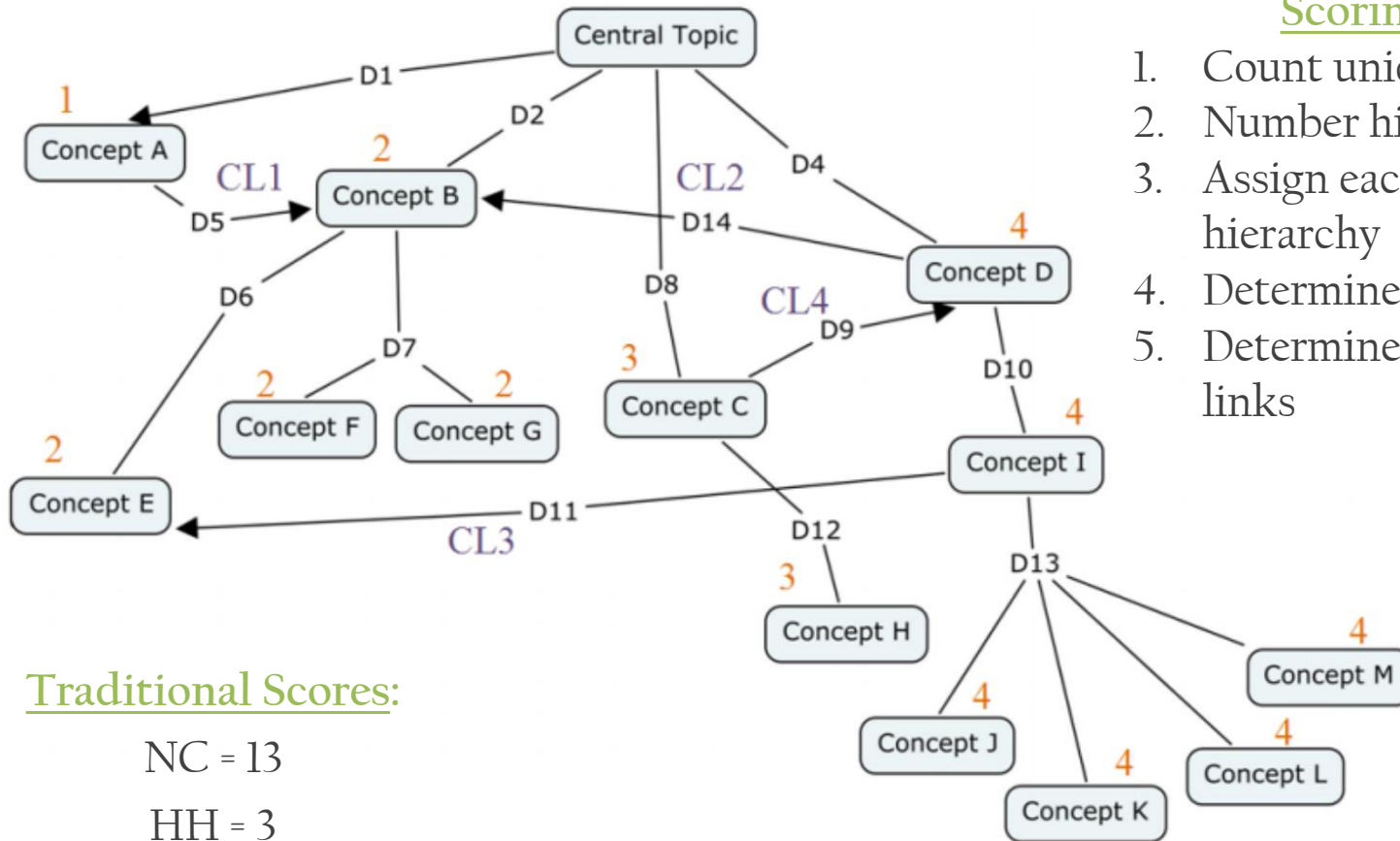
Interlinks & Complexity

Analytic Rubric

Concept Map Scoring:
Traditional Scoring Method

- Number of concepts (NC) represents knowledge breadth sub-score.

- Highest level of hierarchy (HH) represents knowledge depth.

- Number of cross-links (NCL) represents knowledge connectedness.

NC * 1

+

HH * 5 → Total Score

+

NCL * 10

Concept Map Scoring:
Traditional Scoring Method

Scoring Method:

1. Count unique concepts
2. Number hierarchies
3. Assign each concept to a hierarchy
4. Determine highest hierarchy
5. Determine number of cross-links

Traditional Scores:

NC = 13

HH = 3

NCL = 4

Total = 68
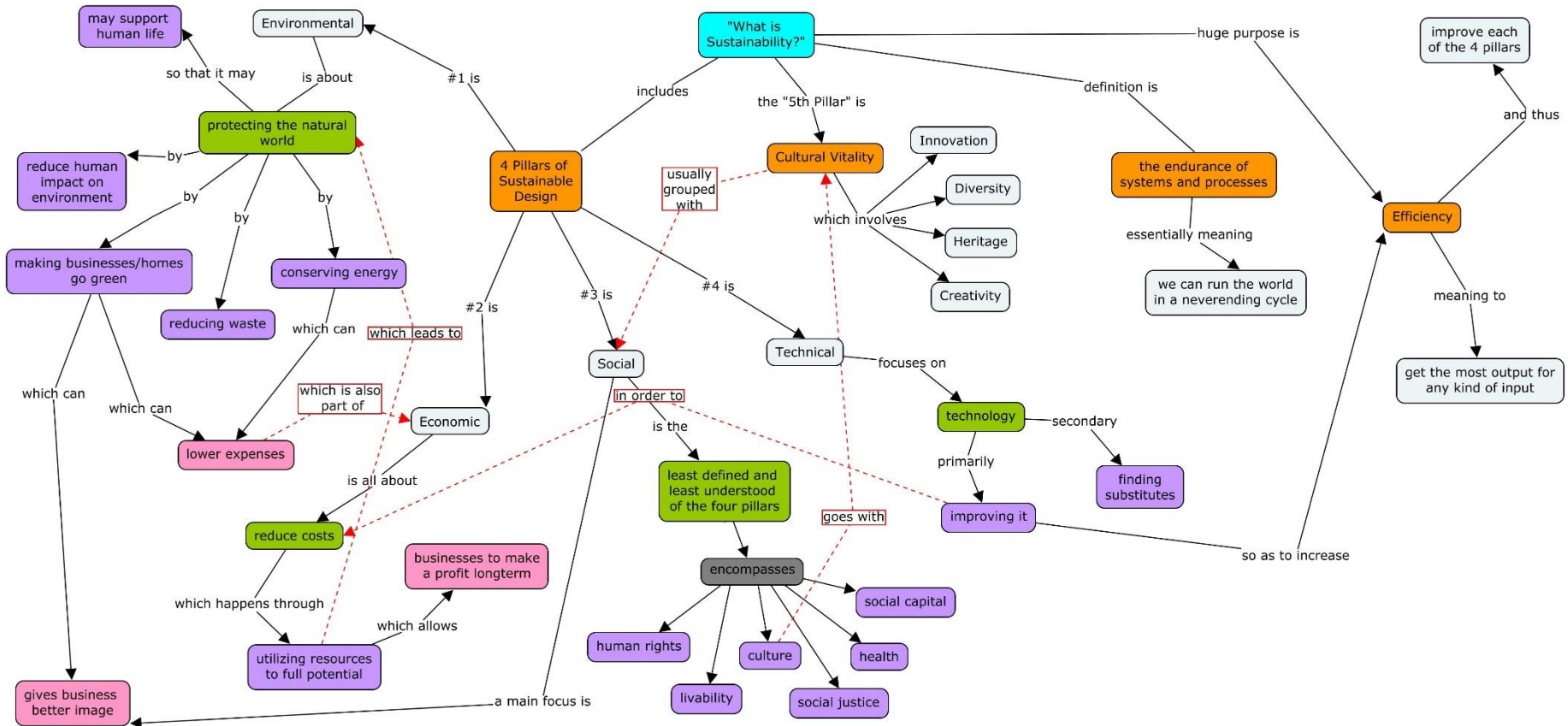
[8]

Concept Map Assessments:
Activity #3

Score a cmap!

- Count unique concepts
- Number hierarchies
- Assign each concept to a hierarchy
- Determine highest hierarchy
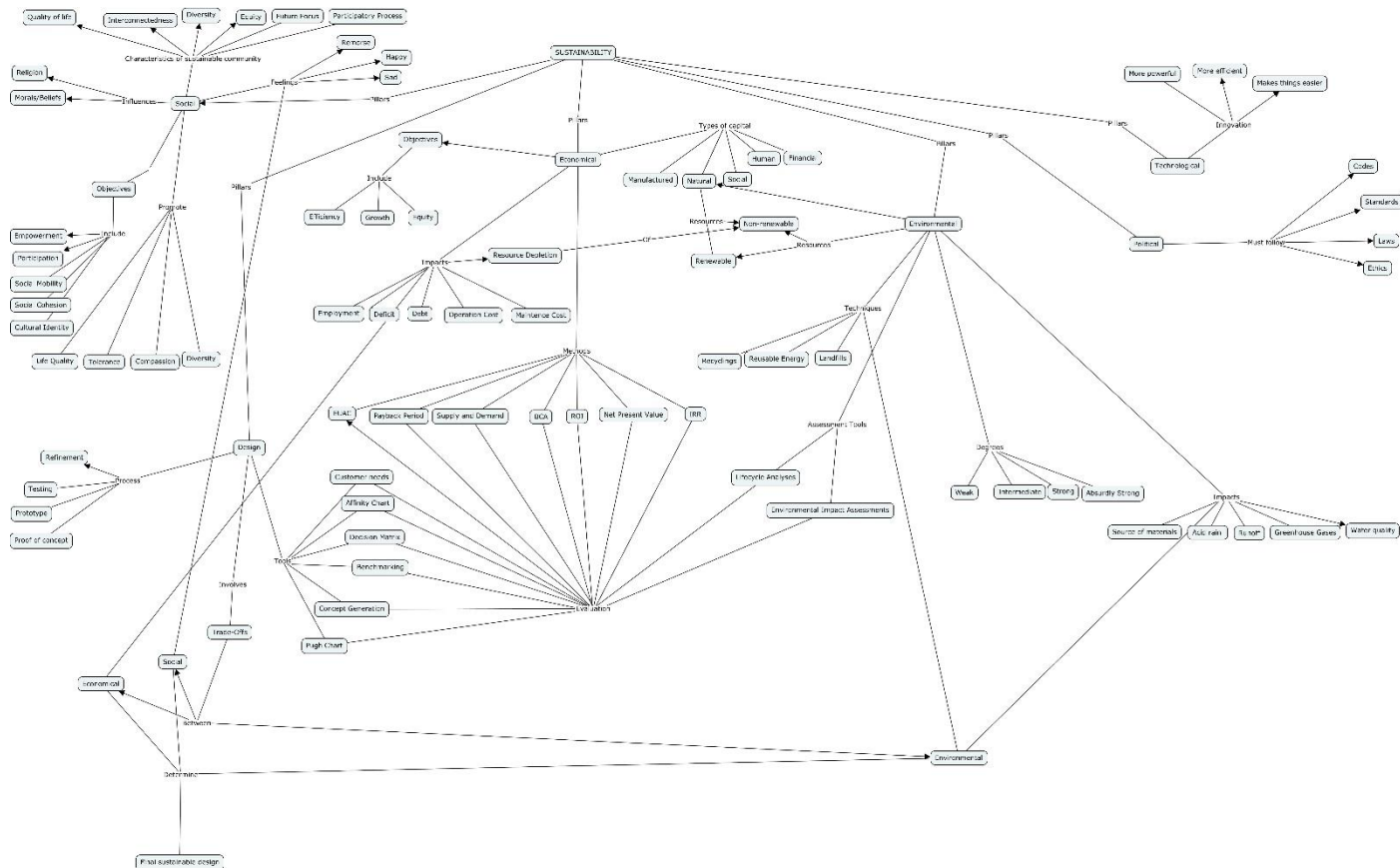- Determine number of cross-links

The traditional method seems easy...

But what about this one???

Or this one???

A concept map scoring program is available!

Concept Map Scoring:
Overview of Methods

Structure	Content	Hybrid (Structure & Content)
Counting Components (Traditional Method)	**Qualitative Concept Coding**	Interlinks & Complexity
		Analytic Rubric

Concept Map Scoring:
Qualitative Concept Coding

A study conducted in CEE at Georgia Tech:

Environment	Future
Resource scarcity	Unbalances (spatial)
Social impact	Technology
Values	Economy
Education	Actors/ Stakeholders

C
Pre Scores
Intervention Cohort

Natural Resources (22.6%)
Econ (13.8%)
Stkhldrs (4.0%)
Other (2.7%)
Environment (25.1%)
Tech (15.3%)
Temporal (5.4%)
Social Impacts (11.3%)

D
Post Scores
Intervention Cohort

NatRes (12.8%)
Econ (15.7%)
Temporal (3.7%)
Other (6.2%)
Stkhldrs (4.6%)
Environment (23.2%)
Tech (16.3%)
Social Impacts (17.6%)

Environment   Economic   Social

[8]

Concept Map Scoring:
Qualitative Concept Coding

A study conducted in an SLS course:

Ecological	Technical
Social	Temporal
Economic	Balance

PRE

Balance 3%
Temporal 1%
Technical 16%
Economic 12%
Ecological 46%
Social 22%

POST

Balance 2%
Temporal 5%
Technical 12%
Economic 16%
Ecological 25%
Social 40%

You can choose any categories that are of relevance to your concept maps.

Concept Map Scoring:
Qualitative Concept Coding

PRE

POST

Word clouds can provide quick, easy qualitative analysis.

Try Wordle!

Concept Map Scoring:
Overview of Methods

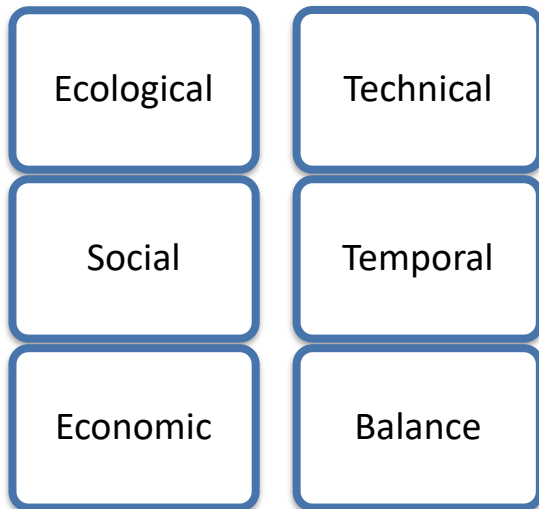| Structure	Content	Hybrid (Structure & Content)
Counting Components (Traditional Method)	Qualitative Concept Coding	**Interlinks & Complexity**
		Analytic Rubric

Concept Map Scoring:
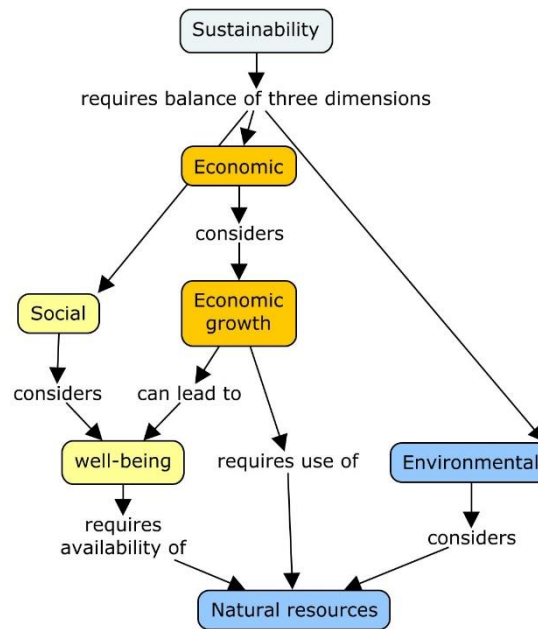## *Interlinks and Complexity*

STEP 1: Categorize each concept in the concept map.

STEP 2: Count "interlinks" between concepts from different categories.

STEP 3: Calculate complexity for each concept map.

Ecological	Technical
Social	Temporal
Economic	Balance

$$CO = NC * \frac{NIL}{N_{CAT}}$$

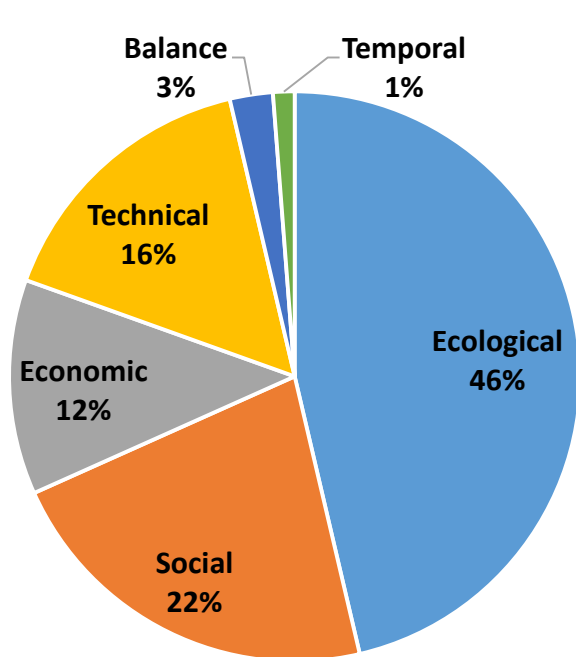CO = Complexity
NC = No. Concepts
NIL = No. Interlinks
NCAT = No. Categories

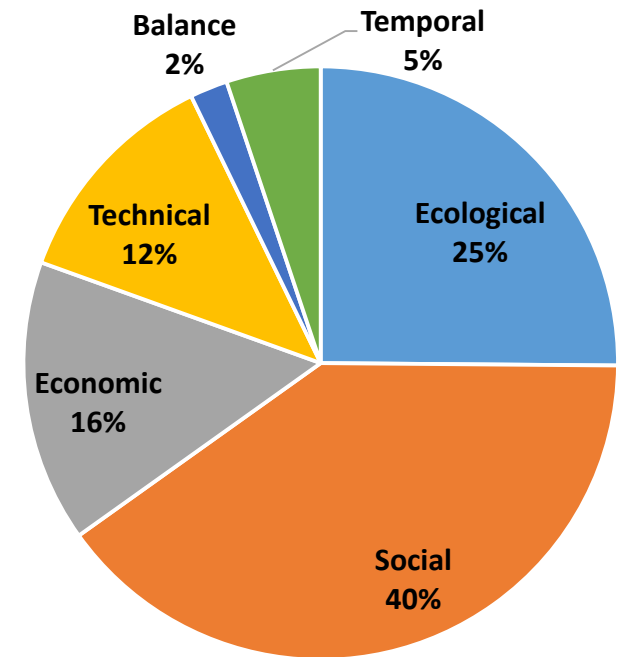Captures *content and structure* of concept maps.

Concept Map Scoring:
Qualitative Concept Coding

A study conducted in an SLS course:

PRE
Avg. NIL = 5.2
Avg. CO = 23.4

POST
Avg. NIL = 14.7
Avg. CO = 137.8

PRE pie chart: Balance 3%, Temporal 1%, Technical 16%, Economic 12%, Social 22%, Ecological 46%

POST pie chart: Balance 2%, Temporal 5%, Technical 12%, Economic 16%, Social 40%, Ecological 25%

Concept Map Scoring:
Overview of Methods

Structure	Content	Hybrid (Structure & Content)
Counting Components (Traditional Method)	Qualitative Concept Coding	Interlinks & Complexity
		Analytic Rubric

Concept Map Scoring:
Analytic Rubric

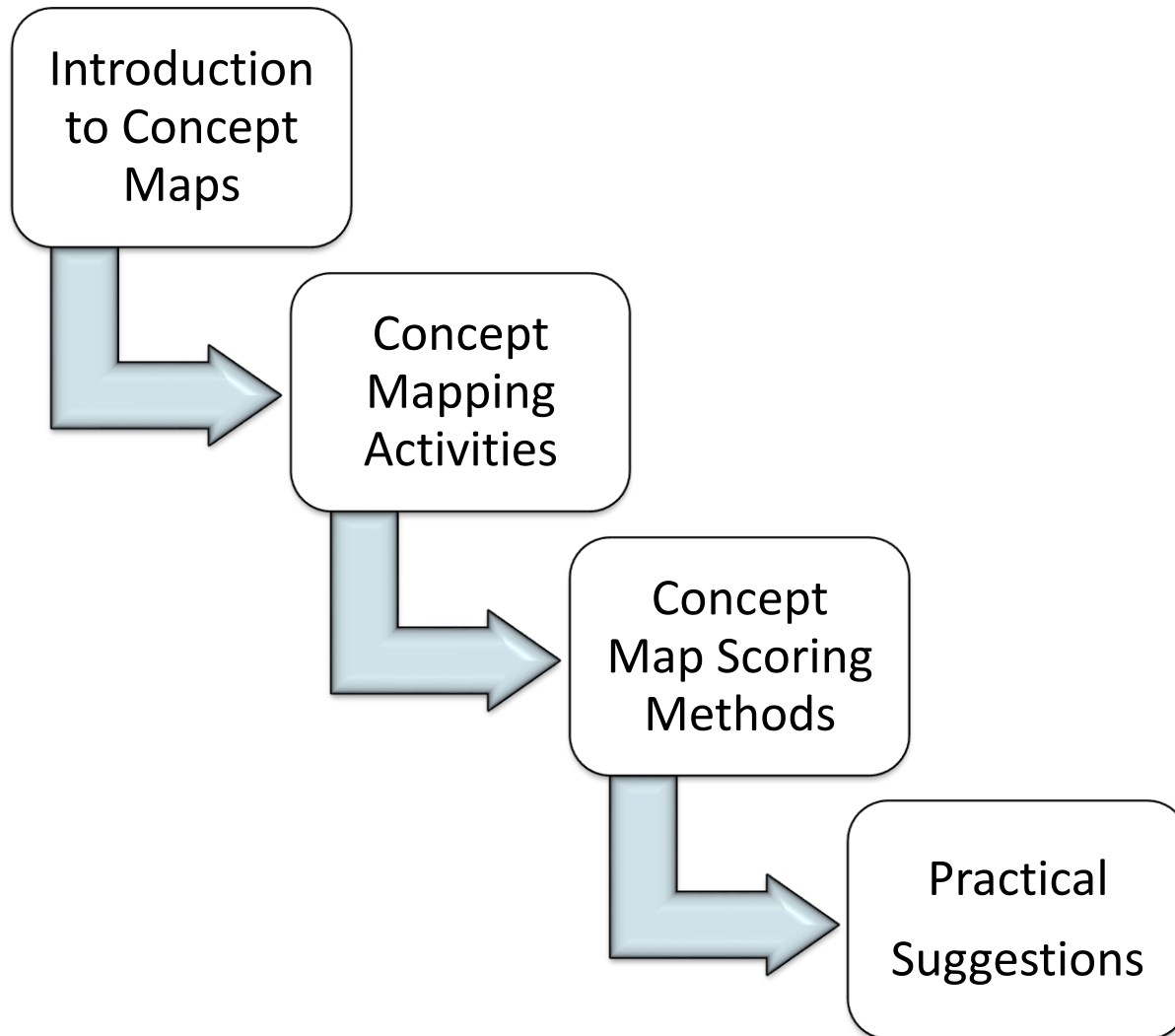## Besterfield-Sarce et al. 2004 Rubric

	1	2	3
Comprehensiveness – covering completely/broadly	The map lacks subject definition; the knowledge is very simple and/or limited. Limited breadth of concepts (i.e. minimal coverage of coursework, little or no mention of employment, and/or lifelong learning). The map barely covers some of the qualities of the subject area.	The map has adequate subject definition but knowledge is limited in some areas (i.e., much of the coursework is mentioned but one or two of the main aspects are missing). Map suggests a somewhat narrow understanding of the subject matter.	The map completely defines the subject area. The content lacks no more than one extension area (i.e., most of the relevant extension areas including lifelong learning, employment, people, etc. are mentioned).
Organization – to arrange by systematic planning and united effort	The map is arranged with concepts only linearly connected. There are few (or no) connections within/between the branches. Concepts are not well integrated.	The map has adequate organization with some within/between branch connections. Some, but not complete, integration of branches is apparent. A few feedback loops may exist.	The map is well organized with concept integration and the use of feedback loops. Sophisticated branch structure and connectivity.
Correctness - conforming to or agreeing with fact, logic, or known truth	The map is naïve and contains misconceptions about the subject area; inappropriate words or terms are used. The map documents an inaccurate understanding of certain subject matter.	The map has few subject matter inaccuracies; most links are correct. There may be a few spelling and grammatical errors.	The map integrates concepts properly and reflects an accurate understanding of subject matter meaning little or no misconceptions, spelling/grammatical errors.

Considers content

Considers structure

Adaptation for sustainability-focused cmaps is available in workshop folder.

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Workshop Overview

Introduction to Concept Maps

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Concept Map Scoring Methods

Practical Suggestions

Concept Map Scoring:
Practical Considerations

Impact of Format on Scoring

CmapTools makes scoring easier!

Cmaps are more organized & legible.

Allows for use of automated scoring.

Easy export of concepts for coding

Choice of Scoring Method(s)

Two methods can support validity of results.

Capture aspects of content and structure.

Consider whether multiple raters are needed.

Student Grades vs. Assessment Scores

Assessment scores may not be appropriate as grades.

There is often no right or wrong answer.

Scoring methods may not provide timely, meaningful feedback.

Serve-Learn-Sustain (SLS) Learning Outcomes:

Develop Skills & Knowledge

- <u>Identify</u> relationships among ecological, social, and economic systems.
- <u>Describe</u> how sustainability and community engagement relate to their civic lives.

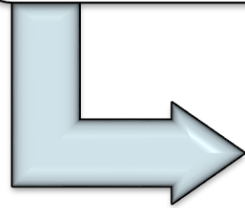**Connect to Professional Practice**

- <u>Describe</u> how sustainability relates to their professional practice.
- <u>Describe</u> the social and cultural impact of their professional practice.
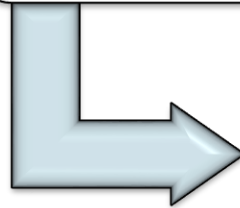
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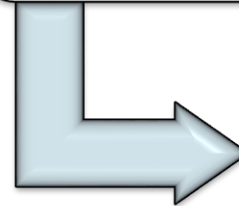
Workshop Overview

Introduction to Concept Maps

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Thank You!

Questions?

References

1. Montfort, D., S. Brown, and D. Pollock, *An Investigation of Students' Conceptual Understanding in Related Sophomore to Graduate-Level Engineering and Mechanics Courses.* Journal of Engineering Education, 2009. **98**(2): p. 111-129.
2. Baroody, A.J., Y. Feil, and A.R. Johnson, *An alternative reconceptualization of procedural and conceptual knowledge.* Journal for Research in Mathematics Education, 2007. **38**: p. 115-131.
3. Rittle-Johnson, B., *Promoting Transfer: Effects of Self-Explanation and Direct Instruction.* Child Development, 2006. **77**(1): p. 1-15.
4. Star, J.R., *Reconceptualizing procedural knowledge.* Journal for Research in Mathematics Education, 2005. **36**: p. 404-411.
5. Novak, J. D. and A.J. Cañas, *The theory underlying concept maps and how to construct and use them*, 2008. Available at: <http://eprint.ihmc.us/5/2/TheoryUnderlyingConceptMaps.pdf>.
6. Besterfield-Sacre, M., et al., *Scoring Concept Maps: An Integrated Rubric for Assessing Engineering Education.* Journal of Engineering Education, 2004. **93**(2): p. 105-115.
7. Turns, J., C. Atman, and R. Adams, *Concept maps for engineering education: A cognitively motivated tool supporting varied assessment functions.* IEEE Transactions on Education, 2000. **43**(2).
8. Watson, M.K., et al., *Assessing Conceptual Knowledge Using Three Concept Map Scoring Methods.* Journal of Engineering Education, 2016. **105**(1): p. 118-146.
9. Tulving, E., *Episodic and Semantic Memory*, in *Organization of Memory*, E. Tulving and W. Donaldson, Editors. 1972, Academic Press: Oxford, England
10. Ruiz-Primo, A., *On the use of concept maps as an assessment tool in science: What we have learned so far.* Revista Electrónica de Investigación Educativa, 2000. **2**(1): p. 29-53.
11. Watson, M.K., E. Barrella, and J. Pelkey, *Assessment of conceptual knowledge using a component-based concept map scoring program*. Computers & Education, In submission.
12. Ruiz-Primo, M.A. and R.J. Shavelson, *Concept-Map Based Assessment: On Possible Sources of Sampling Variability*. 1997, Center for Research on Evaluation, Standards and Student Testing: Los Angeles, CA.
13. Barrella, E.M. and M.K. Watson, *Comparing the outcomes of horizontal and vertical integration of sustainability content into engineering curricula using concept maps* in *New Developments in Engineering Education for Sustainable Development*, W.L. Filho and S. Nesbit, Editors. 2016, Springer International Publishing: Cham, Switzerland.
14. Barrella, E., Henriques, J. Gipson, K. (2016). Using concept maps as a tool for assessment and continuous improvement of a first year course. Proceedings of the 2016 ASEE Annual Conference & Exposition, Atlanta, GA, June 26-29, 2016.