Concept Mapping as a Meaningful Learning Tool to Promote Conceptual Understanding and Clinical Reasoning for Resident and Distance Learning Students

Gregory G. Passmore
Georgia Regents University, gpassmor@gru.edu

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Concept Mapping as a Meaningful Learning Tool to Promote Conceptual Understanding and Clinical Reasoning for Resident and Distance Learning Students

Gregory Passmore, Ph.D., CNMT
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Department of Medical Laboratory, Imaging, and Radiologic Sciences
Georgia Regents University
Augusta, Georgia
gpassmor@gru.edu
WORKSHOP ACTIVITIES

• Introduction
• Exploration
  – How to make and use C maps
• Explanation
  – Learning Theory, Research, and C maps
• Application
  – Practice making and using C maps
Introduction: Student Radiation Protection Concept Maps

Map with relationships and interconnectivity

Map as “flow diagram”: no relationships
INTRODUCTION: CONCEPT MAP WITH REMEDIATION COMMENTS/CORRECTIONS

- **Radiation Protection**
  - Leads to
  - **Reduced Exposures**
    - **3 Simple Steps**
      - **Time**
        - C
      - **Distance**
        - C
      - **Shielding**
        - C
  - **As time gets longer, activity of radioactive material reduces**
    - Def
    - **Half life**
  - **Inverse Square Law**
    - Radiation intensity at a distance is equal to the inverse square of the distance
      - ex
      - \( I_1 D_1^2 = I_2 D_2^2 \)
      - \( I_1 D_1 \frac{1}{2} = I_2 D_2 \frac{1}{2} \)
  - **Hinders exposure**
    - More shielding
    - Less exposure
  - **Attenuation**
    - C
    - **Scatter**
      - measured as
    - **Absorption**
      - measured as
  - **Half value layer or Thickness**
EXPLORATION: CONCEPT MAPPING

HOW DO YOU MAKE CONCEPT MAPS?

• Simplest Unit is a Concept Dumbbell
  - two concepts and their relationships in the form of two nodes and the link between them

INTENSIVE STUDYING Leads to GOOD GRADES

Gregory Passmore
EXPLORATION: CONCEPT MAPPING

HOW DO YOU MAKE SIMPLE CONCEPT MAPS?

• Linking Relationships

<table>
<thead>
<tr>
<th>DESCRIPTIVE</th>
<th>DYNAMIC</th>
<th>ELABORATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (T)</td>
<td>Leads to (L)</td>
<td>Example (EX)</td>
</tr>
<tr>
<td>Part (P)</td>
<td>Next (N)</td>
<td>Analogy (A)</td>
</tr>
<tr>
<td>Characteristic (C)</td>
<td>Influences (I)</td>
<td>Comment (CO)</td>
</tr>
</tbody>
</table>

(Dansereau & Cross, Knowledge Mapping. 1990)
EXPLORATION: CONCEPT MAPPING

HOW DO YOU MAKE CONCEPT MAPS?

• Novak (1984) : Ausubel/Hierarchical
  – Deductive
  – Good grasp of knowledge domain
  – Top to Bottom Approach most Efficient
    • Most Inclusive or General Concepts at Top
    • Narrow and Specific Concepts Underneath
    • Important to Identify Linking Relationships

EXPLORATION: Focus Question Mapping

Concept List Parking Lot with Focus Question

<table>
<thead>
<tr>
<th>Atoms</th>
<th>Universe</th>
<th>Focus question: What is the structure of the Universe?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecules</td>
<td>Mass</td>
<td></td>
</tr>
<tr>
<td>Matter</td>
<td>Energy</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>Heat</td>
<td></td>
</tr>
<tr>
<td>Chemical</td>
<td>Stored</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Elements</td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>Space</td>
<td></td>
</tr>
<tr>
<td>Transformations</td>
<td>State of Matter</td>
<td></td>
</tr>
<tr>
<td>Motion</td>
<td>Gases</td>
<td></td>
</tr>
<tr>
<td>Kinetic energy</td>
<td>Liquids</td>
<td></td>
</tr>
<tr>
<td>Potential energy</td>
<td>Solids</td>
<td></td>
</tr>
</tbody>
</table>

Focus Question, Concept List, and Hierarchical Skeleton

EXPLORATION: RELATIONSHIP-GUIDED SEARCH - RGS

• Start with a central concept and ask the following:
  – Can this concept be broken down into different types?
  – What are the characteristics of each type?
  – What are the important parts of each type?
  – What led to the starting concept? Or where does it lead to?
  – What influences the starting concept? Or what does it influence?
  – What happens next? Can I elaborate with an analogy or example?

(Dansereau & Cross, Knowledge Mapping, 1990)
EXPLORATION: RELATIONSHIP-GUIDED SEARCH - RGS
EXPLORATION: Fill in the blank concept and/or linking relationship.
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Diagram:
- INSECT to ANT with T
- FLU to FEVER with C
- EYE to CAMERA with An
- CAR to Tire with P
- PARTY!!! to POOR GRADES with L
- EAT MAIN COURSE to DESSERT with N
EXPLORATION: Fill in the blank concept and/or linking relationship
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EXPLORATION: Fill in the blank concept and/or linking relationship

Diagram:
- PHYSICAL EXAM
- ILLNESS DIAGNOSIS
- TREATMENT/THERAPY
  - RECOVERY
  - RIP
- UNIVERSITIES
  - PRIVATE
EXPLORATION: Fill in the blank concept and/or linking relationship
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EXPLORATION: Fill in the blank concept and/or linking relationship.

Diagram:
- "Emergency Room"
- "Operating Rooms"
- "Work in Hospitals"
- "Florence Nightingale"
EXPLORATION: Fill in the blank concept and/or linking relationship
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EXPLORATION: Fill in the blank concept and/or linking relationship
**EXPLORATION:** Construct a Concept Map from the statements provided.

<table>
<thead>
<tr>
<th>RAPTORIAL BIRDS INCLUDE EAGLES AND CONDORS, A TYPE OF AMERICAN VULTURE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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RAPTORIAL BIRDS INCLUDE EAGLES AND CONDORS, A TYPE OF AMERICAN VULTURE

RAPTORIAL BIRDS

EAGLE

AMERICAN VULTURE

FRONTAL DISPLAYS AND LATERAL ATTACKS ARE TWO KINDS OF AGGRESSIVE BEHAVIOR IN THE PARADISE FISH
EXPLORATION: Construct a Concept Map from the statements provided.

RAPTORIAL BIRDS include eagles and condors, a type of American Vulture.

Frontal displays and lateral attacks are two kinds of aggressive behavior in the Paradise fish.
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RAPTORIAL BIRDS INCLUDE EAGLES AND CONDORS, A TYPE OF AMERICAN VULTURE

FRONTAL DISPLAYS AND LATERAL ATTACKS ARE TWO KINDS OF AGGRESSIVE BEHAVIOR IN THE PARADISE FISH

RAPTORIAL BIRDS

EAGLE

AMERICAN VULTURE

CONDOR

PARADISE FISH

AGGRESSIVE BEHAVIOR

C

T or Ex
EXPLORATION: Construct a Concept Map from the statements provided.

Raptorial birds include eagles and condors, a type of American vulture.

Frontal displays and lateral attacks are two kinds of aggressive behavior in the paradise fish.

Paradise fish

Frontal display

Lateral attack

Eagle

American vulture

Condor

Aggressive behavior
EXPLORATION: Construct a Concept Map from the statements provided.

Raptorial Birds
Include Eagles and Condors, a type of American Vulture

Frontal displays and lateral attacks are two kinds of aggressive behavior in the Paradise fish

Paradise fish

Aggressive behavior

Frontal display Lateral attack

Eagle

American Vulture

T or Ex Condor

T T
EXPLORATION: Construct a Concept Map from the statements provided.

<table>
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<th>CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES</th>
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<tr>
<td>EXPERIMENTS WITH TWO DISEASES OF THE POX STRAIN, COW POX AND SMALL POX, RESULTED IN THE PRINCIPLE OF VACCINATION</td>
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CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES

CONGRESS

SENATE

P

P

HOUSE OF REPRESENTATIVES

EXPERIMENTS WITH TWO DISEASES OF THE POX STRAIN, COW POX AND SMALL POX, RESULTED IN THE PRINCIPLE OF VACCINATION
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PRINCIPLE OF VACCINATION
EXPLORATION: Construct a Concept Map from the statements provided.

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CONGRESS

P

SENATE

P

HOUSE OF REPRESENTATIVES

PRINCIPLE OF VACCINATION

from

EXPERIMENTS
EXPLORATION: Construct a Concept Map from the statements provided.

CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES

CONGRESS

P

SENATE

P

HOUSE OF REPRESENTATIVES

EXPERIMENTS WITH TWO DISEASES OF THE POX STRAIN, COW POX AND SMALL POX, RESULTED IN THE PRINCIPLE OF VACCINATION

PRINCIPLE OF VACCINATION

from

EXPERIMENTS

with

2 POX
CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES

EXPERIMENTS WITH TWO DISEASES OF THE POX STRAIN, COW POX AND SMALL POX, RESULTED IN THE PRINCIPLE OF VACCINATION
EXPLORATION: Construct a Concept Map from the statements provided.

CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES

EXPERIMENTS WITH TWO DISEASES OF THE POX STRAIN, COW POX AND SMALL POX, RESULTED IN THE PRINCIPLE OF VACCINATION
YOUR TURN:

Using the RGS questions and linking relationships listed in your handout, develop a simple concept map for the concept of COMMON COLD.
What are some types of colds?
What are some characteristics?
What leads to a cold?
What happens next?
EXPLORATION: RGS – COMMON COLD

What are some types of colds?

- Common Cold
  - Head
  - Chest

What are characteristics of a cold or types?

- Common Cold
  - Fever w/Flu
    - comment
  - NOT Fever
    - characteristic
      - Head
      - Congestion
    - characteristic
      - Chest
      - Cough
What leads to a cold?

What happens next with a cold?
Knowledge is built from experiences. Learning is a structuring process. Teacher facilitates student learning. Knowledge from objective measurements & discovery. Learn the inherent structure of the discipline. Teacher conveys structure to student. Behavior indicates learning. Teaching elicits behaviors.

**Passive Learning**
- Based on beliefs.
- Teacher conveys structure to student.
- Memory Schemes.
- Rote Memorization.
- Arbitrary Assimilation.
- Concept maps & Vee Diagrams.

**Active Learning**
- Based on beliefs.
- Student - active participant.
- Teacher facilitates student learning.
- Learning has to be elicited in some fashion.
- Teaching should help student make connections.
- Teaching elicits behaviors.
- Behavior indicates learning.
- Memory Schemes.
- Rote Memorization.
- Concept maps & Vee Diagrams.

**Constructivist Philosophy**
- Student - passive recipient.
- Teacher facilitates student learning.
- Learning has to be elicited in some fashion.
- Teaching should help student make connections.
- Teaching elicits behaviors.
- Behavior indicates learning.
- Non-arbitrary assimilation.

**Objectivist Philosophy**
- Teacher conveys structure to student.
- Concept maps & Vee Diagrams.
- Rote Memorization.
- Arbitrary Assimilation.

**Cognitive Learning Theory**
- Assimilation
- Accommodation
- Equilibrium
- Integration
- Differentiation
- Metacognitive Activity
- AUSUBEL

**Piaget**
- Conceptual
- Relational
- Hierarchical
- Uses
- Leads to

**Meaningful Learning Principles**
- Knowledge is stored in idiosyncratic cognitive structures.
- Prior knowledge influences new learning.
- Knowledge is constructed through meaningful learning.
- Knowledge can be elicited using.

**Teaching Strategies**
- Encourages
- Beliefs
- Leads to
- Non-arbitrary assimilation
- Concept maps & Vee Diagrams
Meaningful learning ↔ Rote learning continuum

LTM = Computer Storage

IP = Information processed and retrieved in chunks of 5-7 units

PCK = Help Student Organize Knowledge Structure Similar to Discipline Knowledge Structure

Ausubel

EXPLANATION: LEARNING & TEACHING

Meaningful learning principles applied in IP

LTM = Computer Storage

information processed and retrieved in chunks of 5-7 units

TEACHING STRATEGIES

FACILITATION

Help Student Organize Knowledge Structure Similar to Discipline Knowledge Structure

Elicit Student Knowledge Structure

Misconception Identification & Remediation

EXTERNALIZE & MODIFY

Ascertain what the student knows and teach accordingly

by

USING

CONCEPTUAL CHANGE

EXPOSITORY L/L (with application)

APPLY (Problem solving)

FOCUS (Analogy)

CHALLENGE (Discrepant Event)

SHARE (Maps/Diagrams)

PROBLEM SOLVING (IDEAL)

def'n

types include

Identify the problem
Define the variables
Explore solutions
Apply solutions
Look for alternatives

knowledge is constructed meaningfully through non-arbitrary assimilation

knowledge can be elicited through maps and diagrams

knowledge is stored in conceptual, relational, & hierarchical structures

Meaningful learning → Rote learning continuum

Rote learning continuum

EXPOSITORY L/L (with application)

APPLY (Problem solving)

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SHARE (Maps/Diagrams)
Explanation: Concept Mapping

Concept Maps
- 2-Dimensional Space
  - draw in
- Organized Knowledge
  - made of
  - connected using
- Linking Words
  - used to form
- Relational Propositions
  - needed for
- Effective Teaching
- Meaningful Learning

Concepts
- Descriptive
- Elaborative
- Labeled
- Dynamic

Perceived Regularities or Patterns
- Events or Happenings
- Objects or Things
- Symbols
- Words

Hierarchically Structured
- Procedurally Structured
- Relationally Structured
- Creativity

Cognitive Structure
- Experts

Interrelationships
- Different Map Levels and Clusters
Explanation: Research Objective

- Advances and complexities in the field of Nuclear Medicine require that NMT students move away from dependency on memorization and learn with a meaningful understanding of the discipline's principles.
- Metacognitive learning strategies are based on instructional learning theory which promote deep, meaningful learning.
- Test both resident and distance learning NMT students to determine if students perform better when traditional instruction is supplemented with the non-traditional metacognitive learning strategy commonly known as concept mapping.
Explanatory: Concept Mapping

Empirical Evidence - Student Comparisons

- Quasi-experimental 2 group design: O X O: O _ O
- First study: 2 resident student groups separated by time but equalized on SAT scores
- Second study: 2 distance learning student groups separated by time but equalized on admissions scores
- Concept map used as metacognitive learning strategy
- Additional course content included the standard homework problem assignment, laboratory, and opportunity for question-answer sessions;
- Laboratory on Interactions of radiation, detection, stats and NM QC
- Concept mapping group used maps as the template for misconception identification and remediation interactions between the instructor and the student.
- The control groups relied on homework problems and question-answer sessions alone.
- The course final examination was used to facilitate a quantitative comparison between the performance of concept mapping students and non-mapping students.
EXPLANATION: CONCEPT MAPPING EMPIRICAL EVIDENCE - RESIDENT STUDENT COMPARISONS

Note: results of applying Concept Map intervention to Radiation Physics w/Laboratory Course. Significant performance gains noted. Some interaction.

![Course performance graph as a function of SAT scores and Mapping intervention]

- **High SAT**: 91.8 (Control), 95.1 (Concept-Map)
- **Moderate SAT**: 88.3 (Control), 91.3 (Concept-Map)
- **Low SAT**: 73.4 (Control), 88.5 (Concept-Map)

**ANCOVA** F=5.123; p=0.0340; N=24
Note: comparison between mapping and non-mapping groups in Radiation Physics And Protection Course w/Laboratory

*Mann Whitney U Test:
Z = -2.0381, p = 0.0415, n = 25
Meaningful Learning from Concept Mapping

Novak & Canas, 2006
EXPLANATION: MEANINGFUL LEARNING FROM LABORATORY

From the Theory/Continua: A student who learns by….

– Rote Learning + Reception Instruction
  • Memorize clinical protocol
  • Unable to work with new protocol/change/modification/variation

– Meaningful Learning + Guided Discovery (Problems w limits)
  • Know protocol and Understand protocol
  • Able to work with new protocol/change/modification/variation

– Meaningful Learning + Autonomous Discovery (Problems w/o limits)
  • Understand protocol
  • Creates new protocol for each application
  • Process not suitable for clinical education/application
EXPLANATION: LEARNING AND LABORATORY

- Students need to be helped to recognize
  - What concepts they already know that relate to the observed events or objects
  - What events or objects they are observing
  - What records are worth making

- Bridge the gap: the “doing” or procedural part of the laboratory needs to be related to the conceptual or “thinking” part of the laboratory for meaningful learning to come from a laboratory activity

- “Knowledge is not discovered like gold or oil, but rather is constructed like cars or pyramids” - Novak & Gowin (1984)
EXPLANATION: CONCEPT MAPPING
LEARNING AND ASSESSMENT TOOL

• Used as a comprehension/misconception check
• Can be assessed using a scoring rubric according to accuracy, depth, and degree of integration or synthesis of knowledge
  – 1 point each valid relationship
  – 5 points each valid level of hierarchy
  – 10 points each valid and significant cross link between different segments in the map as evidence of synthesis of knowledge

Novak & Gowin, Learning How to Learn. 1984
EXPLANATION: LEARNING, ASSESSMENT, AND REMEDIATION

Display Resistance

APPLICATION: CONCEPT MAP

YOUR TURN!

• Construct a concept map from the paragraphs on memory that follow
THE INFORMATION PROCESSING MODEL OF MEMORY

- Information processing begins with the stimulus from the external environment. If we do not pay attention to the new information coming in, it’s forgotten; if we do pay attention to it, it moves to the short-term memory (STM) storage system. Short term memory is conscious/working memory - all that we are aware of at one time. The capacity of this store is limited to about 7 +/- 2 chunks of information. Information in STM can be bumped out by new information (forgotten).

- Information in STM, if rehearsed or encoded, remains the focus of attention and is passed along to the long-term memory (LTM). Information that is encoded without attention to prior knowledge is rotemly learned. Information that is encoded with attention to prior knowledge is meaningfully learned. This is accomplished via concept assimilation: integration or differentiation.

- The capacity of LTM is probably unlimited. The information stored in LTM is rarely forgotten, although we may have difficulty in retrieving it because of the way we search for it.
HOW DO WE REMEMBER ACCORDING TO THE INFORMATION PROCESSING MODEL OF MEMORY?

- Information processing
- stimulus
- attention
- forgotten
- short-term memory (STM) conscious/working memory
- STM capacity limited
- 7 +/- 2 chunks
- bumped out (forgotten).

- rehearsed
- encoded
- focus of attention
- long-term memory (LTM)
- prior knowledge
- meaningful learning
- Assimilation
- Concept integration
- Concept differentiation
- rote learning.
- LTM capacity unlimited
- rarely forgotten
- difficulty retrieving
MAP SKELETON: INFORMATION PROCESSING MODEL

FOCUS QUESTION: How do we remember according to the IPM of memory?
HOW DO WE REMEMBER ACCORDING TO THE INFORMATION PROCESSING MODEL OF MEMORY?

- Information processing
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- Concept differentiation
- rote learning.
- LTM capacity unlimited
- rarely forgotten
- difficulty retrieving
CONCEPT MAP for the FOCUS QUESTION: How do we remember according to the Information Processing Model of Memory Chunking Rule?
APPLICATION: IPM MEMORY LEARNING TASKS

- What follows is an application/test of the IPM of memory, specifically “chunking”. Your map on memory will serve as the conceptual understanding for what you will experience next.
- To participate, you will need a clean area in which to write.
- You will be exposed to items to memorize for 30 seconds, you will then have 30 seconds to write them down.
- You will then be able to review how many items you could put in STM and score yourself.
- A show of hands will tell us if chunking is being used.
- Ready… Set… Go!
## EVALUATION: VEE AND MEMORY LEARNING TASKS

<table>
<thead>
<tr>
<th>8</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
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<tr>
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<td>5</td>
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</tr>
<tr>
<td>11</td>
<td>7</td>
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EVALUATION: VEE AND MEMORY LEARNING TASKS

How many did you remember?

Write them down now!
# EVALUATION: VEE AND MEMORY LEARNING TASKS

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Ready, Set, Go
EVALUATION: VEE AND MEMORY LEARNING TASKS

C
Q
V
M
A
E
P
Y
T
O
EVALUATION: VEE AND MEMORY
LEARNING TASKS

How many did you remember?

Write them down now!
EVALUATION: VEE AND MEMORY LEARNING TASKS

C Q V M A E P Y T O
Ready, Set, Go
<table>
<thead>
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<th>pet</th>
<th>turtle</th>
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</tr>
<tr>
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<td>door</td>
</tr>
<tr>
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EVALUATION: VEE AND MEMORY
LEARNING TASKS

How many did you remember?

Write them down now!
### EVALUATION: VEE AND MEMORY LEARNING TASKS

<table>
<thead>
<tr>
<th>pet</th>
<th>turtle</th>
</tr>
</thead>
<tbody>
<tr>
<td>dog</td>
<td>animal</td>
</tr>
<tr>
<td>cat</td>
<td>house</td>
</tr>
<tr>
<td>mouse</td>
<td>door</td>
</tr>
<tr>
<td>rabbit</td>
<td>toy</td>
</tr>
</tbody>
</table>
Ready, Set, Go
EVALUATION: VEE AND MEMORY LEARNING TASKS

petunia  sunflower

gardenia  maple

marigold  sycamore

zinnia  cottonwood

goldenrod  walnut
EVALUATION: VEE AND MEMORY LEARNING TASKS

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EVALUATION: VEE AND MEMORY LEARNING TASKS

petunia  sunflower  maple  cottonwood  walnut

gardenia  marigold  sycamore  walnut

zinnia  goldenrod
Ready, Set, Go
## EVALUATION: VEE AND MEMORY LEARNING TASKS

<table>
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<tr>
<th>tracheid</th>
<th>palisade</th>
</tr>
</thead>
<tbody>
<tr>
<td>xylem</td>
<td>mesophyll</td>
</tr>
<tr>
<td>cambium</td>
<td>stomate</td>
</tr>
<tr>
<td>phloem</td>
<td>aperature</td>
</tr>
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CONCLUSIONS/DISCUSSION

- Concept maps allow the teacher to
  - Expose/change learner’s knowledge structure
  - Identify and remediate misconceptions
  - Help student move from rote learner to meaningful learner
  - Help student move from algorithm memorization to problem solving
- The quantitative analyses support the use of concept mapping as a metacognitive learning strategy suitable for use by both resident and distance learning students in the Nuclear Medicine Technology program.
- Meaningful learners are more adept problem solvers/critical thinkers and should be more adaptive technologists
In Closing…Questions?