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

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Professor
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: CONCEPT MAPPING

Introduction: Student Radiation Protection Concept Maps

Map with relationships and interconnectivity

- Characteristic: Radiation safety
  - Intensity of radiation falls off with square of distance
  - Inverse square law
  - Use tongs when handling isotopes
  - Example: The farther away, the less the rem/Sv dose

- Time: Characteristic
  - Less exposure time = less radiation exposure

- Part: Radiation decay
  - More time elapses = less activity

- Type: Characteristic
  - Lower activity = lower exposure

- Part: Shielding
  - Amount of shielding that reduces beam to 1/2 of its original intensity
  - Example: Syringe shields, vial Pb pigs, working with L-block
  - Attenuation of photons
  - Scatter
  - Absorption

- Example: Some energy stays, some energy leaves
- Characteristic: Energy stays in tissue

Map as “flow diagram”: no relationships

- Radiation protection
  - Time
    - Increase time
      - Decrease activity
  - Distance
    - Increase distance
      - Decrease activity
  - Shielding
    - Reduce exposure
    - Increase thickness
      - Decrease activity
    - Syringe shields
    - Lead plates
INTRODUCTION: CONCEPT MAP WITH REMEDIATION COMMENTS/CORRECTIONS

- **Radiation Protection**
  - Leads to
  - **Reduced Exposures**
    - **3 Simple Steps**
      - **Time**
      - **Distance**
      - **Shielding**
        - Hinders exposure
        - More shielding
        - Less exposure

- As time gets longer, activity of radioactive material reduces
- **Inverse Square Law**
  - Radiation intensity at a distance is equal to the inverse square of the distance
  - $I_1 D_1 = I_2 D_2$
  - $I_1 D_1 / D_1^2 = I_2 D_2^2$

- **Attenuation**
  - **Scatter**
  - **Absorption**
    - Half value layer or Thickness

- Def
- C
- ex
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

DESCRIPTIVE
Type (T)
Part (P)
Characteristic (C)

DYNAMIC
Leads to (L)
Next (N)
Influences (I)

ELABORATIVE
Example (EX)
Analogy (A)
Comment (CO)

(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

Atoms  Universe
Molecules  Mass
Matter  Energy
Light  Heat
Chemical  Stored
Chemical  Elements
Electrical  Space
Nuclear  Transformations
Transformations  State of Matter

Focus question: What is the structure of the Universe?

Focus question: What is the structure of the Universe?

The Universe contains

Matter transformed where $E=mc^2$

Usually Conserved is has may be

Particles used to make things can be

Energy comes in

Mass Organized Stored

Different Forms

Elements Space State of Matter Gases Liquids Solids
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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EXPLORATION: Fill in the blank concept and/or linking relationship.
EXPLORATION:
Fill in the blank concept and/or linking relationship

Diagram:
- INSECT - T - ANT
- FLU - C - FEVER
- EYE - An - CAMERA
- CAR - P - Tire
- PARTY!!! - L - POOR GRADES
- EAT MAIN COURSE - 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.
EXPLORATION:
Fill in the blank concept and/or linking relationship

Diagram:
- Physical Exam
  - Illness Diagnosis
    - Recovery
    - [Blank]
- Universities
  - Private
  - [Blank]
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:
- HOSPITAL
  - OPERATING ROOMS
  - EMERGENCY ROOM
- TRAUMA CENTER
  - WORK IN HOSPITALS
  - FLORENCE NIGHTINGALE
EXPLORATION:
Fill in the blank concept and/or linking relationship
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</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Include Eagles and Condors, a type of American Vulture</td>
<td></td>
</tr>
</tbody>
</table>

| 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.
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>
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<tbody>
<tr>
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<td>T</td>
</tr>
<tr>
<td></td>
<td>EAGLE</td>
</tr>
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| 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
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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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<td>AMERICAN VULTURE</td>
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<td>T or Ex</td>
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<tr>
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| FRONTAL DISPLAYS AND LATERAL ATTACKS ARE TWO KINDS OF AGGRESSIVE BEHAVIOR IN THE PARADISE FISH |
| 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
EXPLORATION: Construct a Concept Map from the statements provided.

**Raptors**
- Eagles
- American Vulture
- Condor

**Aggressive Behavior**
- Frontal Display
- Lateral Attack

**Paradise Fish**
- Aggressive Behavior
  - Frontal Display
  - Lateral Attack
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
EXPLORATION: Construct a Concept Map from the statements provided.

<table>
<thead>
<tr>
<th>CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES</th>
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<tbody>
<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

P

SENATE

P

HOUSE OF REPRESENTATIVES

PRINCIPLE OF VACCINATION
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
EXPLORATION: Construct a Concept Map from the statements provided.

CONGRESS IS COMPOSED OF THE SENATE AND THE HOUSE OF REPRESENTATIVES

PRINCIPLE OF VACCINATION
  from
  EXPERIMENTS
  with
  2 POX

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

PRINCIPLE OF VACCINATION
- from
  - EXPERIMENTS
    - with
      - 2 POX
        - COW
        - SMALL
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

CONGRESS
  \[ P \]
  SENATE
  HOUSE OF REPRESENTATIVES

EXPERIMENTS
  \[ 2 \text{ POX} \]
  \[ T \]
  COW
  L
  SMALL

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.
EXPLORATION: RGS – 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?

- Fever w/Flu
  - NOT Fever
    - characteristic
      - Common Cold
      - Head
      - Chest
      - Congestion
      - Cough

comment
EXPLORATION: RGS – COMMON COLD

What leads to a cold?

Fever w/Flu

NOT Fever

Common Cold

Head

Chest

Congestion

Cough

Exposure to Cold Virus

leads to

characteristic

type

What happens next with a cold?

Fever w/Flu

NOT Fever

Common Cold

Head

Chest

Congestion

Cough

Recovery

Bronchitis

Pneumonia

Sinusitis
EXPLANATION: LEARNING & TEACHING

LEARNING THEORY

ACTIVE LEARNING
- based on beliefs
  - Teacher facilitates student learning
- leads to beliefs
  - Student - active participant

CONSTRUCTIVIST PHILOSOPHY
- Knowledge is built from experiences
- Learning is a structuring process
- Teacher facilitates student learning
- Student - active participant

OBJECTIVIST PHILOSOPHY
- Knowledge from objective measurements & discovery
- Learn the inherent structure of the discipline
- Teacher conveys structure to student
- Student - passive recipient

COGNITIVE LEARNING THEORY
- PIAGET
  - Assimilation
  - Accommodation
  - Equilibrium

AUSUBEL
- Integration
- Differentiation
- Metacognitive Activity

BEHAVIOR LEARNING THEORY
- Teaching elicits behaviors
  - Rote Memorization
  - Arbitrary Assimilation
  - Memory Schemes

MEANINGFUL LEARNING PRINCIPLES
- Knowledge is stored in idiosyncratic cognitive structures
- Conceptual, Relational, Hierarchical

Prior knowledge influences new learning

Knowledge is constructed through meaningful learning

Knowledge can be elicited
- Concept maps & Vee Diagrams

TEACHING STRATEGIES
- Teaching should help student make connections
- Learning has to be elicited in some fashion
- Assimilation
- Accommodation
- Equilibrium
- Integration
- Differentiation
- Metacognitive Activity
- Teacher conveys structure to student
- Rote Memorization
- Arbitary Assimilation
- Memory Schemes

Misconceptions
Non-arbitrary assimilation
Meaningful learning continuum

Meaningful Learning Principles

- LTM = Computer Storage
  - Information processed and retrieved in chunks of 5-7 units

- IP = Computer Processor
  - Computer processor and storage as model for learning

- WM = Computer Processor
  - Information processed and retrieved in chunks of 5-7 units

PCK

- Help Student Organize Knowledge Structure
  - Similar to Discipline Knowledge Structure

Teaching Strategies

- FACILITATION
  - Elicit Student Knowledge Structure
  - Monitor & Control
  - Externalize & Modify
  - Ascertain what the student knows and teach accordingly

- PCK
  - based on
  - uses
  - characteristic

- Ausubel
  - by
  - using

- EXTERNALIZE & MODIFY

- CONCEPTUAL CHANGE

- PROBLEM SOLVING (IDEAL)
  - types include
  - def'n

- SHARE (Maps/Diagrams)
  - Identify the problem
  - Define the variables
  - Explore solutions
  - Apply solutions
  - Look for alternatives

- APPLY (Problem solving)
  - types include

- FOCUS (Analogy)

- CHALLENGE (Discrepant Event)

Meaningful Learning vs. Rote Learning Continuum

- Knowledge is constructed meaningfully through non-arbitrary assimilation

- Knowledge is stored in conceptual, relational, & hierarchical structures

- Knowledge can be elicited through maps and diagrams
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.
EXPLANATION: 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.
Note: results of applying Concept Map intervention to Radiation Physics w/Laboratory Course. Significant performance gains noted. Some interaction.

**EXPLANATION:** CONCEPT MAPPING EMPIRICAL EVIDENCE - RESIDENT STUDENT COMPARISONS

**ANCOVA**  
F=5.123; p=0.0340; N=24
EXPLANATION: CONCEPT MAPPING

EMPIRICAL EVIDENCE – DISTANCE STUDENT COMPARISONS

Note: comparison between mapping and non-mapping groups in Radiation Physics And Protection Course w/Laboratory

* Mann Whitney U Test:
  \[ Z = -2.0381, p = 0.0415, n = 25 \]
Explanation: Learning – Instruction Continuum

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

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 rotenly 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
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
- stimulus
- attention
- forgotten
- short-term memory (STM) conscious/working memory
- STM capacity limited
- 7 +/- 2 chunks
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- 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
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>
<td>26</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>
EVALUATION: VEE AND MEMORY
LEARNING TASKS

How many did you remember?

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

8  18
13  26
21  3
5  12
11  7
Ready, Set, Go
EVALUATION: VEE AND MEMORY LEARNING TASKS

C A V E
Q E P Y
V E P Y
M A Y T
A T O
How many did you remember?

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

C E
Q P
V Y
M T
A O
Ready, Set, Go
<table>
<thead>
<tr>
<th>pet</th>
<th>turtle</th>
</tr>
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<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>
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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

- pet
- dog
- cat
- mouse
- rabbit
- turtle
- animal
- house
- door
- toy
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

How many did you remember?

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

petunia

sunflower

gardenia

maple

marigold

sycamore

zinnia

cottonwood

goldenrod

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

tracheid  palisade
xylem     mesophyll
cambium  stomate
phloem  aperature
epidermis plastid
EVALUATION: VEE AND MEMORY LEARNING TASKS

How many did you remember?

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

tracheid    palisade
xylem      mesophyll
Cambium    Stomate
Phloem     Aperature
Epidermis  Plastid
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?