Teaching for Understanding: The Importance of Developing a Conceptual Framework

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Outline

• What is meant by understanding?

• What is a concept?
  – Definitions

• Why is it important to articulate key concepts in life sciences courses?
  – What often happens?
  – What should happen?
  – How do we articulate concepts?

• What is a conceptual framework?

• How can you develop a conceptual framework for your own course?
Why are we here?

“Underpinning science education reform movements in the last 20 years – at all levels and within all disciplines – is an explicit shift in the goals of science teaching from students simply creating a knowledge base of scientific facts to students developing deeper understanding of major concepts within a scientific discipline.”

Tanner and Allen, 2005
What is understanding?
Student Learning: Knowing vs. Understanding

- **Knowing** is associated with facts, memorization, and superficial knowledge

- **Understanding** is associated with a more complex, multidimensional integration of information into a learner’s own conceptual framework

- *Knowing the facts and doing well on tests of knowledge does not mean we understand.*

From Understanding by Design (Wiggins and McTighe, 1998)
Student Learning: Knowing vs. Understanding

<table>
<thead>
<tr>
<th>Knowing</th>
<th>Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>The facts</td>
<td>The meaning of the facts</td>
</tr>
<tr>
<td>A body of coherent facts</td>
<td>The “theory” that provides the coherence and meaning to those facts</td>
</tr>
<tr>
<td>Verifiable claims</td>
<td>Fallible, in-process theories</td>
</tr>
<tr>
<td>Right or wrong</td>
<td>A matter of degree or sophistication</td>
</tr>
<tr>
<td>I know something to be true</td>
<td>I understand why it is, what makes it knowledge</td>
</tr>
<tr>
<td>I respond on cue with what I know</td>
<td>I judge when and when not to use what I know</td>
</tr>
</tbody>
</table>

From Understanding by Design (Wiggins and McTighe, 1998)
What is a concept?

• Merriam-Webster
  – *Something conceived in the mind: thought, notion*
  – *An abstract or generic idea generalized from particular instances*

• Samuel M Scheiner
  – *Facts: confirmable records of phenomena*
  – *Concepts: labeled regularities in phenomena*

• Teaching 100 Quarter Course
  – *A generalized idea that connects a set of facts together because they share a relationship to one another.*
  – *Often capture the physical principles of systems*

• Carl Wieman
  – *An idea that can be applied in multiple contexts to explain and/or predict outcomes*
What actually happens in many courses in the life sciences (example: biology)

• There is a strong tendency to teach biology as a long list of facts

• Sometimes those facts are called concepts, but in reality they are often taught (and assessed) as an extensive laundry list of details

• There is an assumption (perhaps unconscious?) that students will induce important generalizations from the details

• This implies that there is an expectation for students to make sense of the all the information and put it into context
Concepts are important because they provide a road map

• Teaching from a well-articulated set of concepts can change the way we approach the material in our courses

• Give the big picture ideas (the concepts) up front, and then fit in the smaller facts and details

• Provide the context for the student

• This sounds simple in theory, but in reality it is not – it requires a certain amount of effort and foresight on the part of the instructor
An example of a curriculum redesigned to focus on concepts: Revised AP Biology Curriculum

- Challenge: How do you balance breadth of content coverage with depth of understanding?

- Shift from traditional content coverage model to a focus on enduring conceptual understandings and the content that supports them

- Students spend less time on factual recall and more time on inquiry-based learning of essential concepts

- Focus on development of skills: reasoning skills, designing experiments, analyzing data, connecting concepts

AP Biology: Curriculum Framework 2012-2013
A Few Examples of Concepts:

• “Competition and cooperation are important aspects of biological systems.”

• “Cells communicate by generating, transmitting and receiving chemical signals.”

• “Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.”

AP Biology: Curriculum Framework 2012-2013

Identifying/articulating concepts – Activity/Discussion
What is a conceptual framework?

- Organizational structure for the concepts
- Hierarchical

- Benefits:
  - classification of concepts (organization)
  - emphasizes connections between concepts
  - provides the context for the student
  - important tool for course design
How do you generate a conceptual framework?

In developing any curriculum, an educator should prioritize the material into three levels of desired student understanding:

1. knowledge worth being familiar with
2. important knowledge and skills
3. enduring understanding

Khodor et al, 2004
Levels of the Conceptual Framework:

- **Top Level (Big Picture Concepts)**
  - Enduring Understanding

- **Mid-level (Concepts/Information)**
  - Important knowledge and skills

- **Bottom level (Information)**
  - Knowledge worth being familiar with (essential facts and details)

Khodor et al, 2004
Basic Steps in Developing the Framework

• Identify concepts covered in the course
  – sort through the information
  – related to goals of course – what should students understand and remember?

• Develop hierarchy
  – formulate top-level concepts
  – formulate supporting concepts
  – formulate facts and details
  – organize

• Framework Organization – Activity/Discussion
The instructor’s conceptual framework vs. the student’s conceptual framework – not the same thing?!

• Students are not blank slates

• They bring a significant amount of prior knowledge with them

• Can also have significant misconceptions about the subject

• Students must consider new information in context of their prior knowledge, and resolution of differences must occur for true understanding to take place

• Instructors have to support students in integrating new knowledge with existing knowledge for effective learning

Tanner and Allen, 2005
A conceptual framework has the potential to impact all major areas of course design

• Planning of course objectives and goals
  – what will be accomplished?
  – major concepts?
  – what should students walk away with?

• Planning of assessments
  – how will you measure learning and understanding?
  – what will you test on?

• Planning of lectures and other activities
  – how will you organize the concepts and content?
Some Important Closely-Related Topics

• Backwards Course Design

• Concept Maps

• Concept Inventories
Resources


Table 1. Top-level concepts in the BCF

1. Biology is based on observational and experimental science.
2. At the molecular level, biology is based on three-dimensional interactions of complementary surfaces.
3. The cell is the basic unit of life.
4. All cells share many processes/mechanisms.
5. Cells interact with other cells.
6. Cells are created from other cells.
7. DNA is the source of heritable information in a cell.
8. A gene is the functional unit of heredity.
9. The structure of DNA dictates the mechanism of the production of nucleic acids and proteins.
10. Sexual reproduction is a powerful source of variation.
11. Life processes are the result of regulated chemical reactions.
12. Proteins perform many varied functions in a cell.
13. Recombinant DNA technology allows scientists to manipulate the genetic composition of a cell.
14. The expression of genes is regulated.
15. All carbon-containing biomass is created from CO₂.
16. Populations of organisms evolve because of variation and selection.
17. Organisms and the environment modify each other.
18. In multicellular organisms, multiple cell types can work together to form tissues which work together to form organs.

Numbering is for practical purposes and does not indicate relative importance. Natural language is used to formulate the organizing concepts.

BCF = Biology Concept Framework

Khodor et al, 2004
A Hierarchical Biology Concept Framework: A Tool for Course Design
Cell Biology Education 3: 111-121