Known Knowns, Known Unknowns and Unknown Unknowns: Pushing students to identify gaps in their understanding

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Context:
I have used this method in an introductory, lecture based, biology course and a lab/lecture course at a community college. There is a wide range of ages, abilities, and socio/economic and ethnic backgrounds. The majors in each class were fairly uniform. The students resist in the beginning, but grow to appreciate them quickly.

The change I hope to achieve is to increase student understanding through increased communication, collaboration and the formation of arguments. I also want students to be more aware of their own thinking processes, and gaps in their understanding. In essence I want to model some of the nature of science.

Method:
• Every 10 to 15 slides, pose one or two thought provoking questions (or sometimes just questions to highlight the main points of the last few slides.)
• Ask the students to respond to the questions on a pre-printed sheet with the questions.
• Encourage them to identify gaps in their understanding - and write the questions on the right side of the sheet.
• After a set amount of time (3 minutes), tell them to turn to their neighbors (or, depending on the lay out of your class, walk around) and look at other peoples answers, discuss differences of answers, argue for what they think is true, attempt to come to consensus in their small groups.
• After a set amount of time (3 minutes), bring their attention back to you and review the answers as a whole class.
• Collect the sheets at the end of class, use the answers to formulate future lessons, connect and correspond with students, and as a class participation grade.

Findings:
In the first class, it dramatically increased in class communication and participation, creating a very collegial and fun environment in which EVERY student participated.

In my second, larger class, the same environment is building. In addition, I am pushing the students to come up with questions and reflections for me. This has been very successful as a formative assessment for me, but has also opened fairly personal lines of communication between me and the students. All of this effectively models the nature of science.

Resources:
Here are some articles about why lectures are not an effective way for most people to learn, and what some college professors are doing about it:

http://americanradioworks.publicradio.org/features/tomorrows-college/lectures/
### Examples:

<table>
<thead>
<tr>
<th>Concept:</th>
<th>Reflections (ah-ha's, points of confusion, pending questions, wonderings, opinions):</th>
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</table>
| What are the unifying characteristics of epithelial cells?  
  - Cellular have polarity, they are attached, a vasculature, regenerate.  
| Do epithelial cells ever use their ability to regenerate? For example, in age? |
| Why do epithelial cells in the small intestine have microvilli?  
  - To increase absorption.  
| Why do epithelial cells in the nasal cavity have cilia?  
  - To sweep our debris and keep your lungs clean.  
| Why is the urinary bladder lined with transitional epithelium?  
  - Because it tolerates repeated stretching from the filling, emptying of bowels.  
| Do you want to ask a question you answered it. It does not work. Now does it? |
| Why do we get wrinkles?  
  - As your skin ages, tissue no longer repairs.  
| Nevermind about question you answered it. It does not work. Now does it? |

Please fill in the concept map on the other side of your paper.

<table>
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<td>Describe a muscle contraction at the molecular, fiber, and muscle level.</td>
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What two ways do muscles make energy? When do they use them?

What would a muscle need before it could return to normal activity?

Why/how do muscles grow and shrink depending on how we use them? What changes occur?