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

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Context:

This study takes place over the course of two semesters at Finger Lakes Community College (FLCC). It therefore necessarily has two different subjects and two different groups of students. The first was a much more conceptual course on evolution and ecology for non-majors. The second semester course is an introductory anatomy and physiology course. The first course had 9 students (2 of whom have been omitted from the analysis because they showed up so rarely). The second course has approximately 20 students. A more detailed description is below. FLCC is a community college in the Finger Lakes region of Western New York. The population is diverse in age, background, ability and motivation.

This introductory college biology course is a lecture course with a weekly 2 hour lab. It is designed for non-majors who are required to take a year of science. Most of the students have completed the first half of the biology series, and therefore have a background in molecular/cellular biology. This course focuses on ecology, evolution and biodiversity.

I had nine students. Four business majors, four education majors, and one new media major. Two were returning students in their 50s with varying amounts of prior college education. They shared maturity, study skills and motivation. The other six students were between the ages of 18 and 23. There were four males and five females. Most were from the Canandaigua area, one was a graduate of Franklin HS in Rochester. They were mostly in their second year at FLCC and all were fairly focused on their major.

They varied in background from the child of a teacher to the child of a farmer. I do not know their socio-economic status, but generally they were middle to working class. Transportation was an issue for the Franklin HS graduate, who was also the only African American in the class.

The labs are determined by the course co-ordinator and set up on the assigned day by the lab-preparer. The text book and general syllabus outline was also determined by the course co-ordinator, but I was given a lot of freedom as to how to present the lecture material. The course co-ordinator strongly encourages the use of case studies (http://sciencecases.lib.buffalo.edu/cs/) and small group work. I used at least one case study for each unit. In addition, I used stations once and a lot of think.pair.shares followed by discussion and my lecturing on the topic at hand. Due to the small size of the class, there was a comfortable and collegial atmosphere and everyone seemed to feel comfortable sharing by the middle of the semester. I also incorporated movies, humor and songs into the presentations as much as possible.
There was a variety of assessment. Labs write ups, class participation (“check for understanding” sheets), a final project (they chose from 5 different formats and any topic), current events, case studies and tests. Tests were generally 3/5 multiple choice and 2/5 short answer by point value. The tests account for 20% of the final grade.

The introductory anatomy and physiology course is significantly larger, with approximately 20 students. Of these, 3 are returning students, 3 are of African American descent, one is pregnant, at least two raise pigs, one is a volunteer fireman, and the vast majority have jobs. Most live in the greater Canandaigua area, but a few commute from Rochester. Almost all of the students are pre-nursing and will continue from this course on to two semesters of anatomy and physiology. While I am doing my best to focus on concepts, anatomy and physiology is inescapably vocabulary heavy. I am focusing on big picture ideas so that they students enter anatomy and physiology with a broad framework onto which they can hang the details.

My previous education and identity is as a biology researcher. But I have been thinking about how to teach since 2006. This is my fourth (non-calendar) year teaching (depending on how you count). I did not do any teaching while completing my master of science in Aquatic and Fisheries Sciences at the University of Washington. However I did work as a graduate student instructor while a PhD student in Evolution at the University of Rochester in 2006. I followed this with working as an adjunct at Finger Lakes Community College in 2008.

I had some instincts about inquiry and keeping it relevant to students lives that I was able to really flesh out and turn into practice by completing my MS in education through the University of Rochester, Get Real! Science Program. I completed my student teaching in Rochester City schools and have since returned to Finger Lakes Community College. For this class, it was important to me to keep the students interested, to make it relevant to their lives, and to get them to understand the nature of science.

Problem:

My students did not do well on the first exam. It was a completely bi modal distribution with a couple As and a bunch of Ds and Fs. This was despite me giving them all the questions that were going to be on the test, a list of terms to review, and reviewing all of it in class the class before the test. I asked April for advice and she suggested I use these “Checks for Understanding” that the students fill out during pauses in the lecture, than turn to their neighbors and look at their answers and discuss them (and modify their own answer). Then the whole class discusses the answers. There is also a space on the sheet for “questions, reflections, a-has.”

During the Fall semester I focussed just on getting them to answer the questions and have discussions. The students almost never asked anything in the “questions, reflections, a-has” column. In the Spring semester I am focusing on getting more thoughtful responses. This has shifted my focus slightly from construction of knowledge by the students to metacognition (the students recognizing gaps in their own understanding).
In both cases, the pauses for independent writing, and small group discussion are also meant to increase participation in and knowledge construction during the large group discussion.

**Literature Review:**

This project incorporates a few different concepts. One is that people don't learn as much from straight lectures as they do from lectures with pauses. Second, that students learn by constructing knowledge together more than by passively absorbing knowledge. Third, that "we do not learn from experience...we learn from reflecting on experience" (Dewey 1933). While these ideas are connected, they are not the same.

Students sitting in lectures can develop “cognitive indigestion,” as described by Bena Kallick, author of Learning and Leading with Habits of Mind: 16 Essential Characteristics for Success. Heather Rader, editor of Choice Literacy described this phenomena and how to avoid it:

> The top symptom of indigestion is bloating, and that's how my brain felt in the curriculum presentation. In response, I tuned out. I simply couldn't take in more information until I had time to process what I'd already heard.

> After just a few minutes of her keynote, Bena said, "I'm going to give you two to three minutes to talk with the person next to you so you don't get cognitive indigestion." I felt relieved and connected. She had us turn and talk several times as we responded to research, video clips, and her thinking. (Rader, 2012)

Lecture has been shown to be ineffective in physics. "Students have to be active in developing their knowledge," he says. "They can't passively assimilate it" (Hanford, 2012). Physicists have found that having the students answer questions, discuss the answers with their neighbors (including arguing to convince their colleagues why they have the right answer) improves their understanding significantly over a straight lecture (Hanford, 2012).

Through these discussions and problem solving exercises, the students construct knowledge together, rather than absorbing it from me. Carpenter (1986, p. 868) stated the fact bluntly: "The research shows that learning proceeds through construction, not absorption" (as cited in Schoenfeld, 1992). This perspective argues that learning is a social act and it takes place in a social context (Schoenfeld, 1992). By encouraging (forcing?) my students to speak to each other and solve problems together, I aim to create a collaborative social environment that models the true nature of science.

However, the students are not only discussing the questions at hand. Before they speak, they must write on their own. This allows them to clarify their own thoughts before being influenced by others, but it also allows them to feel more articulate in the discussion because they have had time to think about the question. In addition, “Writing following discussion leads to greater achievement than writing-only or talking-only activities” (Chamberlain and Crane, 2003, p.67). While my students write and then discuss, I believe that the concept is the same. An added bonus of encouraging the students to talk to each other and write on their own is that they develop their own vocabulary for talking about
the subject. “Nonscientific language enables students to make connections between their scientific knowledge and their everyday lives” (Chamberlain and Crane, 2003, p. 73).

While this approach worked reasonably well in my Fall class, I decided to take it a step further in my Spring class, by focusing more on the metacognitive piece of the check for understanding pauses. What do I mean by metacognition?

Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g. the learning-relevant properties of information or data. For example, I am engaging in metacognition... if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as a fact; if it occurs to me that I should scrutinize each and every alternative in a multiple-choice task before deciding which is the best one.... Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of those processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete [problem solving] goal or objective. (Flavell, 1976, p. 232, as cited in Schoenfeld, 1992, pg. 38).

Wiggins & McTighe (2005) assert that self-monitoring, self-assessment, and self-adjustment essential to development of self-understanding. Self-understanding is arguably the most essential component of understanding for lifelong learning. Although my students are in college, many of them are not very proficient at this self monitoring - recognizing gaps in their understanding. Therefore, I hope to scaffold their ability to do this through a new grading system of their checks for understanding.

Question:

My broad research question is “Does using ‘Checks for understanding’ improve student understanding?”

More specifically, does the way I implement the checks affect their understanding.

I.e. for the Fall: If I make them talk to each other after they write, before the whole class discussion, do they do better on the exams?

I.e. for the Spring: If I make them write on the “reflections, questions, ah-ha’s!” side of the sheet, does it improve their understanding, as reflected by their performance on exams?

Methods:

During the Fall, I began distributing “Checks for understanding” every class, which I would collect and respond to in writing. If I found common themes or common gaps in their understanding, I would revisit those topics during the following lecture period. I increased my
insistence that they speak to each other towards the end of the semester and hoped to find an impact on their test scores.

During the Spring, I noticed that no one ever wrote anything on the metacognitive side of the sheet, so I changed my grading methods. I told them that they got one point for each side of the sheet. This has been an effective method to get them to write because class participation is 30% of their grade. I then copy all their questions into a powerpoint and provide answers during the review period. When time allows, or when they write something particularly personal, I respond in writing. I am monitoring their test scores and the depth and specificity of their questions and looking for improvements in both. Unfortunately for this presentation, I only have the results from one exam.

The implementation of a “check for understanding” in class goes like this:

• I get to a slide that says, “check for understanding,” and pause, read the slide and explain any necessary parts of the question.
• I set an alarm clock for 3 minutes, and remind them that the metacognitive side is required to be filled out.
• The students work independently to answer the questions and come up with reflections on the sheet that I make them.
• At the alarm, I tell them to talk to their neighbors for a minute, and I re-set the alarm.
• Then we review the questions as a class and I clarify any mis-understandings.

Data:

From the fall, I have the following table of test scores. The checks for understanding were implemented after the first test. I did not really force them to talk to each other until the fourth unit (before the fourth test). On the fourth test, I surveyed the students about their learning styles and their impact of the checks for understanding on their learning. They generally found the pauses useful, but not the discussion with their neighbor. I will discuss their answers in the analysis section.

Some quotes from their survey follow:

Q: Did you find the “check for understanding” pauses useful? Do you feel they helped you understand what was important in a lecture? Why/why not?

A: “I think your outline of check for understanding already contained the most important focuses of the lecture. Yes, it helped. The repetition of the material by listening, writing it down and discussing it gives three different ways to retain the information.

A: “I did find the pauses useful because they were like a review from what we just learned into a questions. And if we didn’t really get the concept you were able to see that by the check for understanding and were able to explain more on the topic so we did fully understand it and were comfortable with the material.”

A: “I think that the check for understanding was a great idea. It helped me recap what I learned and it also made me listen and pay attention more to the material with this technique it
was way more easier to process the information then to hear someone lecture for 2 hours. You get points for doing it and learned material that you may have not understood all in one.”

A: “I did, for note takeing. I didn’t think that ‘discuss with your neighbor was successful at all. It was awkward.”

A: “I believe they were not useful because as soon as you would hand them out I would start to really loose focus and worry about getting everything filled out on the paper because I knew there was a grade for it.”

A: “Yes. It is always good to periodically check that students are following what you are teaching.”

A: “I do like this section and it really made me realize how much I could remember (and forget) of what was presented. However, it also gave me a better idea of what I needed to concentrate my studies on.”

A: “I found the “check for understanding” questions difficult and challenging, but extrememly helpful. I paid closer attention to the lecture so that I could answer the questions. I also had to process the information I just learned and actually use it to answer questions. I have always found that it is much easier to remember things in class if the important information is consistently being reinforced.”

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<th>Fall Semester N = 6 to 7</th>
<th>Raw Score</th>
<th>Grade</th>
<th>Test 1</th>
<th>Test 2</th>
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<td>88-89</td>
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| Proportion of Fs         | 0.43      | 0.17  | 0.14  | 0.17  |
| Proportion of above a C  | 0.43      | 0.33  | 0.43  | 0.71  |
From my Spring class, I have the scores from their first test, as well as copies of their checks for understanding. They did not ask any questions, or write anything on the metacognitive side of the sheet until I made it graded. The extrinsic motivator was effective and now they almost all write questions or notes about their level of understanding on particular topics. The class mean on the first test was 54% with an Standard Deviation of 15 points. By Friday I should have some data about the second test.

Some examples of their questions follow:

• How do the tissues in skeletal muscle interact anatomically and physiologically? (explain the questions…)

• Describe atrophy and hypertrophy

• Describe a model system - why using rats and fruit flies instead of humans for physiological studies works…

• Describe how a muscle contraction happens.

• How long does it take to use all the O2 in a muscle cell? How long does it take to return to normal activity?

• What happens if a person can’t sweat?

• Is there a time after action potential is released that it can’t go again - like a lag between impulses?

• If you have low muscle tone are you weak? What does isotonic mean? Is it that your muscles aren’t working right?

• What happens if someone is on pure O2? Do they have more ATP?

**Analysis:**

The Fall data shows a clear improvement in the class average. On the first exam there were 3 Fs, and there were never more than one after that. There was a general shift toward higher grades.

As you can see from the answers about the “checks for understanding” in the data section, the students almost universally enjoyed and found them useful. They did not, however enjoy the discussion with their partners. “They were awkward,” was a theme on that question. However, you can see that their grades improved with the increased discussion. This might be a bit of grade inflation, though, because the survey counted as points toward their test grade.

The size of this class may have made the partner discussion less useful, because no one was afraid to speak up in class. We had a really wonderful, collaborative, and fun rapport. During my observation, this was acknowledged and mention several times.

The students always sat in the same spot, and so they always had the same partner for discussion. I would like to alter this habit, but do not feel that comfortable telling adults where to sit.
Although they rarely, if ever, wrote any questions on the metacognitive side of the paper, several of the quotes refer to the “checks for understanding” as helping them to find gaps in their understanding and get help with it in class, as well as study it more at home.

This Spring, I have been pushing the students to ask questions on the metacognitive side of the sheet and, while I can not determine its impact on student understanding yet, it certainly is an excellent formative assessment for me to use when preparing the review session. In addition, the students have been using it to share personal information and ask questions they might not want to ask out loud in front of the class. They seem to enjoy seeing their questions up on the board for review, in their exact words. After the first review session, two students came up to me afterward to comment on how much it helped their understanding and how much better they felt going into the test.

Again, the students always sit in the same place and so they always have the same discussion partner.

**Conclusions and Questions for the future:**

The Fall students and I agree that this is a useful method for them. It improved their grades on their tests, as well as their comfort level at participating in class. I feel confident that it was an important part of creating the collaborative class culture that we achieved. Despite the fact that they never wrote on the metacognitive side, a few of the students noted that it helped them to figure out what they understood and didn’t understand and enabled them to focus their studying.

The Spring students have a more vocabulary heavy course, which makes it harder for me to come up with conceptual questions. However, in this section (I teach two sections) I feel that the “think. pair. share.” aspect of the “checks for understanding” have dramatically increased the level of participation in class. The first couple of weeks only one or two students spoke up to answer questions during lecture, or during the checks. Now, at least half the class speaks each class period. This is a dramatic improvement.

In addition, it has opened a line of communication between several of the students and myself that would not have existed otherwise. I answer all personal questions in writing and all the others in class, and I believe that it validates the students feeling that I care whether they succeed. This is harder to achieve lecturing part time at a community college where I only see the students two times a week. At the very least it helped me learn their names.

**Questions for the participants:**

- Should I force the students to change seats and discussion partners? How?
- Do you have any suggestions for how to help the students ask deeper, more specific questions than they are currently?
- Do you see this as transferable to a middle school high school environment?
- Should I give them harder questions with longer time to finish them?
Works Cited


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