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Playing with Science Concepts

My Vexation:

My vexation arises with the inability of science students, specifically science students who will themselves become educators, to create ways of explaining and demonstrating concepts in science. This seems to be independent of the classroom performance (which itself leads to interesting questions about classroom evaluation, but I'll leave that for another day). Even the best students have difficulty with inventing new analogies, examples, illustrations, and demonstrations to fit the circumstances of the personal interaction they are having at that moment, whether with a class or an individual.

This problem could simply be another way of stating the well-worn maxim, "Teachers teach as they were taught." However, I think this problem of pedagogical tunnel-vision goes beyond that. It is something akin to writer's-block, and involves an inability (or unwillingness) to relax inwardly and become comfortable with concepts. For the best students, who presumably have mastered the material, it seems to be a psychological problem, a rigidity of thought that reflects an inability to relax enough to become playful and inquisitive.

It is especially mysterious to me because this is an aspect of teaching that I really enjoy: deciding how I can most effectively reach my audience, whether it numbers one or one-hundred. But I can connect with that rigidity of thought in another arena. It arises for me in cooking. Although I am very willing to follow any recipe in print, I feel compelled to measure exactly those two teaspoons of curry or three cups of flour. I get out a knife and level off the contents of the teaspoon or measuring cup. Any deviation from the recipe causes immediate distress. I am simply unwilling to play around with the recipe. It knows more that I do, and is not to be trifled with.

Einstein once remarked, "All of our thinking is of the nature of a free play with concepts." Although the very nature of science imposes boundaries on the extent of the playing field (no "Then a miracle occurs," as in the famous Sidney Harris cartoon), it seems that experience of playing freely with concepts is something our students are missing. Without this willingness to relax and become familiar and playful with the material, students will be handicapped when they attempt to pass on their understanding to others.

My Venture:

Let's muse for a moment on the phrase "free play." What is it? Here's a definition (from www.wakefield.gov.uk):

> Free Play is an activity undertaken by a child in their own time, in their own space and using their own endless imagination. It is freely chosen and is under the full control of the child. Free Play does not have to have an outcome. Free Play is whatever the child decides it to be.

When I slavishly followed my recipe, I was most definitely not playing freely. Traditional science classrooms are inimical to free play, even classrooms that incorporate guided inquiry. Yet, I would argue, it would be beneficial for all students, and especially future teachers, to have some experience playing freely with the concepts they have learned.

I would suggest that after certain concepts are learned, an environment be created in which students could exercise their imaginations toward a general goal and apply those concepts in a creative way of their choosing. To further my cooking analogy, I might be provided with a kitchen and an array of ingredients on a table. My goal would be to make something … anything!

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Learning a new concept using inquiry involves the narrowing of a student's focus, using discrepant events to pare down alternative explanations and eliminate misconceptions. The conceptual context is necessarily specific and is often idealized. For example, a student may arrive at an understanding that an image can be formed on a screen when a source of light is placed outside the focal point of a biconvex lens. The instructor views this as a specific instance of the general concept of image formation, but the student may consider it as an indivisible whole: image formation is narrowly defined as what happens when a light source is placed outside the focal point of a biconvex lens. This will especially be true if the student has no previous experience with image formation -- and who among us has?

This is an example of context binding. A student is context-bound when he or she cannot separate the essential elements of a concept from the specific context in which it was encountered.

How would free play help break context binding? By promoting the student's invention of new analogies, examples, and demonstrations. The goal of free play, introduced after the concept has been learned, would be to broaden the student's experience by providing many examples that allow the student to recognize the concept in a variety of different contexts. Then, by recognizing the commonalities among the examples, the student is prepared to realize the essence of the concept, apart from any specific context.

Free play is inherently unscientific. There may be no formal hypothesis and no methodology. There are no expectations imposed and no egos imperiled, just pure exploration for its own sake. Students are encouraged to relax and ask, "Let's see what happens if … ."

To pursue our optics example, students would broaden their range of experience with image formation by playing freely with a light source and various transparent substances. What would half a lens do? A lens with one flat side? A curved piece of glass? A glass of water? A baggie filled with water? A drop of water? Jello? By exploring image formation in a wide range of contexts, students would experience its many manifestations. In the process, they would realize the essence of image formation by recognizing what the various examples have in common. Ah ha! All we really need is a transparent substance with a curved surface! The essential elements of image formation are no longer bound to the specific context of a light source placed outside the focal point of a biconvex lens.

After students have been freed from the constricting specific context of their original learning and have recognized the essential elements of a concept, they are better equipped to create ways of explaining and demonstrating concepts in science. I like to imagine sending my teaching majors to a grocery store or a craft store, and asking them to purchase materials they could use to demonstrate a certain principle in science. The chances are they would not find a biconvex lens on the shelves. But if they roam the aisles while keeping the essence of image formation in mind, they would find baggies and glass beads and jello and all sorts of items they could use to form images.

Scientists already have this enlarged view of the world; they see everything through the eyes of their own discipline, and applications abound. We should share this vision with our future teachers.