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TE 861B: Inquiry Lesson Sequence

From now until the end of the semester you will be engaged in two long-term assignments: Lesson sequences and interview questions. These assignments are interrelated in that you will (a) interview a small group of adults or students about what they know about inquiry and the nature of science and (b) develop a sequence of lessons that teachers the students or adults about the nature of science. This file is to be used to report your initial plans, revised plans and final report on your lesson sequences.

You can do your lesson sequences and interviews **either individually or collaboratively with other members of your group.** If you do individual lesson sequences and/or lessons, we will ask you to exchange plans and comments with other group members. If you do collaborative projects, we will expect you to plan together, then to teach or conduct the interviews separately. You could turn in either individual or joint reports at the end; joint reports would compare data or teaching experiences from your two locations.

Inquiry and the National Science Education Standards introduces five phases that are common across inquiry instructional models (p. 35, Table 2-7). These include:

- Phase 1: Students engage with a scientific question, event, or phenomenon. This connects with what they already know, creates dissonance with their own ideas, and/or motivates them to learn more. (Also find out background knowledge of students on the topic)
- Phase 2. Students explore ideas though hands-on experiences, formulate and test hypotheses, solve problems, and create explanations for what they observe.
- Phase 3: Students analyze and interpret data, synthesize their ideas, build models, and clarify concepts and explanations with teachers and other sources of scientific knowledge.
- Phase 4: Students extend their new understanding and abilities and apply what they have learned to new situations.
- Phase 5: Students, with their teachers, review and assess what they have learned and how they have learned it.

We will use these five phases as general guidelines to help you plan and report on your lesson sequence.

The section on lesson sequences in *Teaching Science for Motivation and Understanding* (pages 61-76) describes two more specific types of inquiry lesson sequences:

- POE (for Predict and explain, Observe, Explain). This lesson sequence is based on experimental inquiry, where students formulate hypotheses, make predictions, and test their accuracy.
- TOPE (for Techniques, Observations, Patterns, Explanations). This lesson sequence is based on naturalistic or field inquiry, where students collect data, then find and explain patterns in those data.

Note that (a) these lesson sequences focus on the first three phases in the general model in *Inquiry and NSES* and (b) they differ primarily in how the teacher and students approach Phase 1.

Your assignment will be to design and carry out a POE or TOPE lesson sequence, using the interviews to help you understand your students and their learning. You will do this in three stages.

I. Initial Plans (Due October 18)

In this section, you will describe your goals and a general plan for your inquiry lesson sequence, selecting a problem or question to investigation, and your initial ideas about how to sequence activities. Please respond to the following questions:

Clarifying Your Goals

Explain your goals for this lesson sequence in terms of both EPE/OPM and practices that they should master.

A. Projected EPE/OPM Table:
Complete the EPE/OPM table below describing the 1) experiences, observations, or data you want your students to collect or have, 2) the patterns you will want them to discover, and 3) the explanation(s) or model(s) that is the goal of the investigation.

Observations or experiences (examples, phenomena, data)	**Patterns (laws, generalizations, graphs, tables, categories)**	**Explanations (models, theories)**
-layers made by four liquids (corn syrup, water, glycerin, vegetable oil)- test to see what layer orders are possible to make -mass of various objects (corks, grapes, rock, coin, rice) -volume of the various objects- find by dropping in a graduated cylinder -drop various objects (corks, grapes, rock, coin, rice) into layers, observe what layer the object stays at	-the layers formed will be corn syrup on the bottom, then glycerin, water and vegetable oil on the top -objects with the same density as a layer will go to that layer, objects with more density then a layer will sink to the next layer -low density liquids will come to the top of the layers and the most dense liquids will go to the bottom -density of objects will determine the layer it ends up at	Density is an intensive property of matter that is defined as the ratio of an object's mass to its volume. Mass is the amount of matter contained in an object. Volume is the amount of space taken up by a quantity of matter. This property allows us to predict if an object will float or sink, based on the density of the liquid it is put in.
⇐ **Application: Model-based Reasoning**		
Inquiry: Finding and Explaining Patterns in Experience ⇒		

B. Objectives: Practices that your students should master
What do you want your students to learn to DO as a result of this lesson sequence?
I want students to be able to compare the density of liquids and objects. They will learn how to test the density of liquids and objects and how to compare to other liquids and objects.

Initial Plan

Describe a plan for the first three phases of your lesson sequence:

Phase 1: Engaging with a problem.

a. Will you do a POE or a TOPE lesson sequence? This will be a POE lesson sequence. I will have students predict what they think will happen during the investigation and explain to others their predictions. Students will then conduct the investigation and observe what happens to the liquids and objects. They will be able to explain what they observed and why the layers were formed and the objects stayed at the layer that it did.

b. What question or problem will you use to engage your students (or adults)? In other words, what will be the driving question that will be the focus of your inquiry lesson sequence?

What layer combinations are possible to make with the four liquids when put into straws? What is the density of the objects? What will happen when we drop in the objects to the liquids?

Phase 2: Data or observations. How will your students collect data or make observations?

Students will be given four different liquids that are four different colors. They will take a straw and stick in upright on a piece of clay (to hold in the liquids). They will be asked to try to find out how many different layer combinations that they can form using 2-4 liquids and using an eye dropper to put it into the straws. The students will then measure the mass of five different objects (cork, grape, rock, rice, coin), the volume (they know that they are able to measure the volume of an irregular object by putting it in a graduated cylinder of water) and calculate the density of the five objects. As class, we will decide on the possible layer combination of the four liquids. I will put the four liquids, in the order we agreed upon, into a larger clear container. I will have the students predict where they think the objects will sink or float to in the layers and drop them in one at a time.

Phase 3: Finding and explaining patterns. How will your student find and explain patterns in the data?

Students will find patterns by watching what happens when the liquids are combined and when objects are dropped into the liquids. The students will decide upon layer combinations that are possible to make using two to four of the liquids. They will also find the density of the objects, so that they will be able to compare the density of the liquids to the density of the objects. They will explain the patterns by talking about the density of the liquids or objects.

II. Revised Plans (Due November 8)

1. What have you learned from interviews with your students or discussions with your colleagues that leads you to change your plans?
   I have learned that I was focusing more on sinking or floating aspects of objects and liquids, and not on the density as I had wanted. I think that the changes made in the lesson will lead students to a better understanding of density of both liquids and solid objects.

2. Use Track Changes on Section 1 above to show how your plans have changed.

Sorry, I forgot to use track changes, so I just highlighted the things that I changed.

III. Final Report (Due December 5)

I decided to change my lesson one more time after I found out that it took more time than I expected. I originally was going to have the students find the two and three layer stacks that were possible (with only three of the substances, see below lesson plan), discuss as a class their findings, and then give the students the fourth liquid to see how many stacks were possible when we had all four substances. After the students found the stacks possible with the fourth liquid, we were going to again discuss, and then I was going to have them find the mass and volume of different objects and as a demonstration, drop them into the four layer stack to see where they would stay at. The first part, using the three substances, discussing, then using the four and discussing took about two and a half days, I was expecting it only to take a day and a half. Since it did take longer than expected, I decided to not do the last part with the objects. Although I still think that it would be a great extension (helping them to make a connection with mass, volume and density), maybe next time I would just do the three substances so then I would have time to have them work with the objects.

<u>Density Lesson Plans</u>

Materials needed:

- Four different liquids, 50 ml each (for each group) of corn syrup, vegetable oil, glycerin, and water
- Plastic 8 oz cups (one for each liquid)
- Four eye droppers (one for each liquid)
- Food coloring (red, blue, yellow)
- Plastic 1 or 2 oz soufflé cups for students to make layers in (each group will need quite a few for trial and error)

Teacher Instructions:

1. Color the corn syrup (red), vegetable oil (yellow) and glycerin (blue) with the food coloring. Leave the water clear.
2. Make sure each group has 50 ml of the corn syrup, vegetable oil and water. The glycerin will be used later, so have 50 ml ready for each group to use, but do not give it to them until later in the lesson.
3. Before students begin, show the students that the clear solution will stack on the red solution.
4. Give each group a set of note cards with guiding questions on them. They are:
    a. What will happen when you put the red solution into the other solutions? The yellow solution into the other solutions? And the clear solution into the other solutions?
    b. What two color layered stacks can you make? Which stacks are impossible to make?

    c. What three color layered stacks can you make? Which stacks are impossible to make?
    d. Why did your solutions float, sink and stack as they did?
5. After students have made their possible stacks, conduct a class discussion about their findings. Use the questions on the note cards to guide the discussion.
    a. Were the students able to correctly identify and agree upon the possible two, and three stacks? If they were not, guide them to how they could come to agree upon conclusions. How can they prove to each other their stack is correct?
6. When the class has agreed upon the stacks that are possible with three substances, introduce the fourth substance to the class. Students can use the fourth solution and see how many stacks they can make out of the four total solutions.
    a. How many two-color stacks are possible? What are they?
    b. How many three-color stacks are possible? What are they?
    c. How many four-color stacks are possible? What are they?
7. After students have made their possible stacks with four substances, conduct a class discussion about their findings. Use the questions on the note cards to guide the discussion.
    a. Were the students able to correctly identify and agree upon the possible two, three and four stacks? If they were not, guide them to how they could come to agree upon conclusions. How can they prove to each other their stack is correct?

Your Students' Learning

How well did your students understand the observations, patterns, and explanations in your table and achieve your objectives? Describe at least one way in which they were successful and one way in which they were not completely successful. Provide evidence from student work to back up your claims.

The students were able to understand the observations and patterns, but still need to gain a better understanding of the explanations in my OPE table. I think that the students gained a fairly quick understanding of what liquids were the least/most dense. As I was observing their investigations of the possible stacks, I heard many students predict what they thought was going to happen in the three or four color stacks based on what they found with the two color stacks. It was also interesting to see that some students were more confident in their predictions than others; and that some students were more thorough in their investigation than others. Curiosity ran wild in this investigation; the students asked many questions and were very interested in finding their correct stacks (and defending them to others!); even one group asking if they could combine all of their small cups of stacks into a bigger cup to see if they would eventually separate into the correct layers.

When the students were looking for the two and color stacks, there were very thorough investigations going on, and some predictions being made. The students followed the directions on the first note-card (see above lesson plan), and were quickly able to see that the possible two color solutions were (reading top to bottom): yellow then red, yellow then clear, and clear then red. Most students tried each possibility to make sure they were correct in their color stacks; they followed the note-card, first seeing what would happened when you put the red solution in with each of the other, then the yellow and finally the clear. They were able to see that no matter the order you put the substances in, they floated or sank to the correct stack (though the

vegetable oil and water had a hard time separating). A couple groups made predictions of what would happen when you put the clear into the other two based on what they already saw; but were encouraged by me to test their predictions, to make sure they were correct. Next, when the students were trying to make the possible three color stacks, I had students take different approaches. Some students wrote down each stack that they would try to make (for example: red yellow clear or clear red yellow) and put the liquids in according to that order. Other students took their existing two color stacks and added in the missing color to see what would happen. Both techniques found that there was only one three stack that was possible (top to bottom: yellow, clear, red), and that the liquids would "float" or "sink" to make that stack-no matter what order you put it in. When we discussed their findings as a class, they were able to agree that red was the densest, followed by clear and yellow was the least dense of the three.

The students were also able to make observations and patterns when using all four substances. The groups were able to realize that they did not have to redo the possible stacks that they already made with the three colors; they just had to test the new color. For example, they knew that clear then red was still a possible two stack, they did not have to redo that stack. They did, however, have to find the possible two, three and four color stacks that included the new blue substance. Some of the groups had a hard time (at first) with the blue and the red substances. If they mixed blue then added red, they found that the two mixed together. They had to be encouraged to try the other order to see what would happen when you put red then blue; which showed that the stack blue on top of red was possible. Many groups argued that the two must be close in density, since they do not quickly separate like the others when put in the wrong order. They did find that if you let it sit long enough, it would begin to show a little separation.

At the end of this lesson, I do not think the students were able to gain a good understanding of the explanations in the OPE table. Based on the student discussions, I think that they had a good understanding that the density of the liquids were the basis for what stacks were possible. They did not understand, however, that density is found by mass/volume. I had quite a few students think that it was the thickness, or viscosity, of the liquids that made them more or less dense. This belief caused some confusion when the water was found to be denser than the vegetable oil, which was thicker than water. I think that this lesson is a good starting point in talking about density, but would need further lessons in order for students to gain a better understanding of density. I will discuss more on what I think I would do next time, or continue to do in order to help students gain that understanding in the next sections.

Final Revisions and Reflections

Explain how you would teach this lesson sequence differently or change your goals the next time. Why would you make these changes?

One thing that I would do differently about this lesson would be to not include the fourth liquid, but instead include the measuring of the objects and dropping them into the layers as I had originally planned. I think that if the students were able to find the volume and mass of each of the objects, then drop them into the stacks (or watch as I drop them into the stacks), they would be able to connect that volume and mass of the objects and liquids determines density.

Another thing that I could do, if I decided that I didn't want to change what I had done in the lesson, just add to it, would be to have the students find the mass and volume of each of the

liquids. They could use the same volume of liquid, but then measure the mass. This would help them see that density=mass/volume.

A simple change that I would make would be to not use the eye droppers. The viscosity of the corn syrup and glycerin made the eye droppers difficult and time consuming to use. Having the students carefully pour the liquids to make the stacks worked better- many of the students were frustrated with the eye droppers and turned to this method during their investigation.

I would want to make these changes so that the students could gain a better understanding of density's relationship with mass and volume. I think that this lesson was a great starting point for students to gain an understanding of density, but they still need more to be able to understand the relationship of density, mass and volume.

Continuing to Work with Students: Phases 4 and 5

How will you follow up on this lesson sequence, helping students to assess and extend their understanding, and to apply what they have learned in future units?

To follow up on this lesson sequence, I will have the students find the mass and volume, and then find the density of each liquid that they used in the lesson sequence. I think that this will help the students gain an understanding of density=mass/volume. They will be able to apply what they found in the investigation to the actual density of each liquid. This would help them to later be able to be given unknown solutions and determine what stacks would be possible without being able to actually test what stacks can be made, which I would use as an assessment. The students would be given three substances in containers that could not be opened. They would have to describe what stacks would be possible when using these substances. The students would have to find the density of each substance, finding the mass and volume. I think this would be a good way to assess their understanding of density.

There are many applications of this lesson to future units in science. When teaching about the layers of the earth, students can relate their "stacks" to the layers of the earth and why the density affects the organization of materials that make up Earth's crust and interior. The students would be able to understand that the more dense the substance is, the closer it would be to the center of the Earth. This lesson could also be applied when teaching about miscibility and viscosity. Students could relate back to their stacks and how when combining some substances they were able to quickly separate, while others did not. Many students confuse the viscosity of a liquid and its density, as seen in my interview. When teaching viscosity, students could relate back to the vegetable oil and water. The vegetable oil was thicker than the water, but it was less dense. This may help the students understand the two properties are different.

I found another lesson that relates to this one that I would like to do if I have time at the end of the unit. I think would be fun and interesting for the students. The lesson is on beverage density & sugar content analysis (it is a document that I found on google, you can find it by typing in 'beverage density sugar content analysis'- it is the one that says "So how well do you know the beverages you drink?"). The students compare the density of five known sugar solutions: 0%, 5%, 10%, 15% and 20%; and popular beverages such as Coke Classic, Welch's 100% Grape Juice, and Powerade. They need to be able to rank the beverages from the lowest sugar content to the highest by comparing the density of the known sugar solutions to the beverages. Although this lesson was originally written for a Chemistry class, I think that it could be simplified to be used in a less advance course. I think that having the students' conduct an investigation such as this one would apply what they have learned to a new situation, relating

density to sugar content. It would also help students see the application of density into their everyday lives.