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TE 861B: Interview Report

I. Initial Interviews Plans

Interview Topic and Informants

Please describe the topic and grade level or age of informants you will be focusing on.
The topic that I will be focusing on will be density. I will be conducting the interview on two different age groups. One group will be high school age students (juniors and seniors) and the other group will be adults. I am planning on doing two different age groups to be able to see different perspectives on the questions.

Ideas about Questions

Interview Questions about Inquiry:

1. If you were given two unknown solution how could you develop an experiment to compare the densities of the unknowns if you are not able to open the bottles?
    a. Inquiry goals that will be focused on: design a scientific investigation.
    b. Possible follow-up probing questions:
        i. What has to be the same about each unknown solution in order to be able to compare their densities? (vile and top, and solution itself)
        ii. What items would you need in order to compare the densities?
        iii. What is the relationship between mass, volume and density?
2. How are submersible submarines able to descend and ascend to different levels of water?
    a. Inquiry goals that will be focused on: Develop descriptions, explanations, predictions, and models.
    b. Possible follow-up probing questions:
        i. If given a group of different items and you dropped them in a container of water, why would some of the items float and others sink?
        ii. How does an objects density affect its ability to float?

Interview Questions about Nature of Science:

1. How do you think scientists decide when something is true?
2. Do "scientific facts" ever change?
3. After scientists have developed a theory (e.g. atomic theory), does the theory ever change?
4. Is there a difference between scientific knowledge and opinion? Give an example to illustrate your answer.

II. Interview Final Report

1. Interviewees will be shown a cup of water with an object that sinks and an object that floats.
    a. Why does one object sink and the other one float?
    b. Could you make up an experiment using equipment such as balances, measuring cups, etc. to show that your explanation is correct?
    c. Could you predict whether another object will sink or float? How can you do that?
2. Interviewees will be given two unknown substances. (The substances are of the same volume and in the same size vial.)
    a. How could you develop an experiment to compare the densities of the unknowns if you are not able to open the bottles?
    b. What has to be the same about each unknown in order to be able to compare their densities?
    c. What items would you need in order to compare the densities?
    d. What is the relationship between mass, volume and density?
3. How do you think scientists decide when something is true?
4. Do "scientific facts" ever change?
5. After scientists have developed a theory (e.g. atomic theory), does the theory ever change?
6. Is there a difference between scientific knowledge and opinion? Give an example to illustrate your answer.

Analysis

I interviewed two students and two adults. The students were both juniors in high school, one was an Advanced Chemistry student, and the other was a Chem-Com student. The adults were both in their mid-fifties. The first two questions were asked to gain an understanding of the interviewees' knowledge of density. The last four questions were about the nature of science. All of the interviewees were able to show at least a basic understanding of density and the nature of science. They had a very basic understanding of density and its relationship with mass, but not its relationship with volume. They also showed to have a good understanding of the nature of science.

For the first question, interviewees were shown a cup of water with a penny and a cork in it. They were asked three questions about the situation that they were shown. First, they were asked, "Why does one object sink and the other one float?" All of the interviewees were able to say that it was because of the density of the objects. One responded stating "because the penny is more dense than the cork" while another stated "the cork is less dense than the penny." This shows that they had an understanding that it is the density of an object that makes it sink or float. The interviewees were then asked "could you make up an experiment using equipment such as balances, measuring cups, etc. to show that your explanation is correct?" In response to this question, all interviewees said that they would need a balance or scale in order to weigh the objects. Not one person stated that they would also need to find the volume of the objects and how they could do this. It surprised me that

one student did not indicate a need to find the volume, since she stated in the next question that density=mass/volume. This shows that they did not have a full understanding that density is not only related to an object's mass, but also its volume. When asked "Could you predict whether another object will sink or float? How can you do that?" Everyone stated that they could predict whether an object would sink or float, but differed on how they could do that. An adult stated "by the feel and weight of the object," while the other adult was not absolutely sure you could always predict, stating "yes, to an extent, some things you may not be able to predict." When he was asked what you would have to do to predict some objects, he stated "you could use a scale to find its weight." One student (the more advanced student) said "yes, you would need to find the mass and volume of an object, since density=mass/volume." The other student stated "yes, you would need a scale to measure the weight of the object." From these responses to the questions, I am able to see that all of the interviewees understood that you need to know an object's mass to find out its density, but did not understand that you also need to know an object's volume to find its density. Even the student that did know that density=mass/volume, did not, at first, show an indication that you need to also find the volume of the object in order to calculate the objects density.

The interviewees were next given two vials containing unknown substances. The vials used were exactly the same in size and weight, and contained the same volume of each liquid. The interviewees were not told this information; they were only shown the two vials containing the substances. The responses to the first question "How could you develop an experiment to compare the densities of the unknowns if you are not able to open the bottles?" were varied. The adults were less "scientific" in their responses. One stated "I could tip the bottle to see the thickness of the liquid. The one that is thicker would be denser." Although this would be true in many cases, this is not always a correct statement. If one substance was water and the other was salt water, for example, both would have similar "thickness" but the salt water would be denser than the water. The other stated "just by holding them, the one that weighed more would be denser." The student's responses included using equipment to find the density. One stated "you could find the density by mass over volume. You would have to find the mass of the substance and the vile. The volume looks to be the same, so you would not have to find that." The other student stated "you would need a scale to find the mass of the substance and vile. The one that weighs more would be denser." Overall, most were able to say that you would need to find the mass of the substance in order to find out which would be more dense. It is also seen in the responses to the next question, "What has to be the same about each unknown in order to be able to compare their densities?" that they understood that the amount or volume of the liquids would have to be the same in order to find the density. The responses were very similar, all stating that the vial and volume of the substances would have to be the same. Some responses were: "the mass of the vile and volume of the liquid" and "the same amount, same size vial." This showed that they understood that the amount or volume of the liquids inside the vial need to be the same, and the vials also had to be the same. When asked "What items would you need in order to compare the densities?" everyone, except for the interviewee that stated you could tell by the thickness, stated that they would need a balance or scale to find the mass or weight of the substances. The responses to the last question, "What is the relationship between mass, volume and density?" were more varied. One adult was very confused with the terms mass and volume, having a difficult time stating the difference between the two. She stated "mass

is the size, volume is the size also, but it is more the 'amount' and density is based on the type of material and its weight." The other adult was not very specific, only stating that "they are all a measurement." Both students were able to state a relationship between density, mass and volume; one stated that "density=mass/volume" while the other stated "density is determined by an objects volume and mass," but was not able to remember how density was calculated using the volume and mass.

The next question began the part of the interview on the nature of science. This question asked "How do you think scientists decide when something is true?" Both the adults and students responded with similar statements, stating that the scientists need to conduct a lot of experiments to prove it to be true. One adult simply stated "experimentation," when probed to give a more detailed response, she stated "they need to conduct many experiments and have the same results in order for something to be proven true." The other adult responded similarly, stating "they need to conduct multiple tests and the results have to come out the same to prove that theory." The students also stated that "they would need to perform lots of experiments to prove it true" and "they would need to repeat the experiment over and over, maybe considering different factors in order for it to be true." The interviewees showed an understanding of the scientific method that is typically taught in most science classrooms. You make a hypothesis, perform your experiment, and readjust your hypothesis, repeat. They did not make any indication that there would be a need for scientists to communicate with other scientists.

When asked "Do 'scientific facts' ever change?" most did not seem confident in their responses. One adult stated "I think they do" while the other stated "sure." The students responses were "yes, but laws cannot change" and "yes, scientific facts can change." Since their responses were so short, I also asked the interviewees to explain their thinking more. One stated "scientific facts are based on the information that they know, if they gain more information, then their 'facts' may change based on their new found knowledge." Another stated "an example of when a scientific fact changed would be when scientists once believed that the world was flat. When new information emerged to contradict that 'fact' they changed it to say that the world was round." The other two responses were similar; both stated that if new knowledge was gained, then the 'fact' could either be added too, or could be not believed to be correct anymore. All interviewees were able to say that scientific facts can change, and their changes would be based on new knowledge that is gained.

Next interviewees were asked "After scientists have developed a theory (e.g. atomic theory), does the theory ever change?" Most stated that they believed a theory could change. Responses included "yes, nature changes, so the theory can change, or they discover something new to change the theory," "yes, they could be disproven" and "yes, like the last question, if new knowledge is gained, then the theory can change." One interviewee did not think theories could change at first, but then wasn't so sure about her original response. She stated "no, I don't think a theory can change. Well, I guess it can be proven true or false, but then it would not be the same theory." They were all able to conclude that theories could change, but did not seem to have a good understanding of why a theory could change. They did not understand that the world itself does not change, but it is instead our abilities to observe and take in information about the world around us, such as the equipment that we

can use to test theories, has developed over time, so thus theories will change based on the new information that is found.

The last question the interviewees were asked was "Is there a difference between scientific knowledge and opinion? Give an example to illustrate your answer." The interviewees gave very similar responses. One adult stated "knowledge is something proven, while an opinion doesn't have to be proven, it is someone's idea about something." The other adult stated "an opinion is not proven, it is the scientists' thoughts on something and knowledge is something proven or tested." A student responded by saying "knowledge is something proven, while an opinion is something someone thinks to be true." The other student stated "knowledge is believed to be true, it is proven and an opinion is someone's ideas or thoughts about something." For scientific knowledge, an example given was "an element is known to have a certain atomic weight." Another example given was "the world is round." For scientific opinion, an example given was "color or scent, things that you cannot really measure that is based on a person's perspective of it." Another example given was "something that is objective, like how something feels- if it is soft or scratchy." These responses show that the interviewees were able to distinguish a difference between scientific knowledge and opinion.

Based on the responses for the questions regarding density, I do not believe the interviewees had more than a very basic understanding of the density of objects. They did not understand that density is not just measured based on an objects mass, but it is also determined based on an objects volume. Even the student that stated density=mass/volume, did not realize that the volume of the penny and cork would also need to be found in order to fully show that their explanation that density causes an object to sink or float would be true. In the second set of questions about the two vials, most of the interviewees did have an understanding that the amount of the liquid and the vials would have to be the same in order to compare the density of the two substances. They also understood that you would have to find the mass of the substances and vials to compare the densities. In this question as well, I think the interviewees showed a good understanding that an objects mass is needed to determine its density. Even though they were able to say that the amount of the substance needed to be the same, they were unable to, except for one student, clearly state the relationship of density, mass, and volume. Mostly, they were unable to show a good understanding of volume, one even showing that she had a hard time explaining the difference between mass and volume, stating "mass is the size, volume is the size also, but it is more the 'amount'."

I think that the interviewees also only had a basic understanding of inquiry and the nature of science. They understood that experimentation was necessary for scientists to prove something to be true, some stating "lots of experiments" or "multiple tests" were needed, and that "the results have to come out the same to prove that theory." This shows that they have an understanding of the scientific method, which is taught in school. But they did not have an understanding that the scientists would also have to communicate with other scientists, for example. They also were able to say that scientific facts or theories may change based on "new knowledge gained" or "they discover something new to change the theory." They also stated that "the theory could be disproven." These statements show that they have an

understanding that scientific facts or theories are derived from the world around us, and that we are able to "discover" new things about the world, which would change what we once believed to be true. Not everyone seemed to understand that the world around us does not change, (one stated "nature changes, so the theory can change ") it is the ways in which we are able to interpret and study the world around us that has changed and developed over time, thus changing scientific facts and theories.