TEACHER-TO-TEACHER - 2005
GAIL GW, "Got the H.O.T.S. for Inquiry?

Segment 1 – Higher Order Thinking Skills

GW: It's my pleasure to be here this afternoon and thanks for hanging in there toward the end of the day. I do appreciate that. One of the things that we will be doing this afternoon is trying to talk about ways to make sure we meet what the Bill and Melinda Gates Foundation call the main reformation pieces for high school and those are rigor, relationships and relevancy. So I will try to make sure that we have pieces of those woven into this presentation because with the focus on high school that we have this year in the nation, we are going to be asked to do that. I kind of need to know from this audience how many of you are secondary teachers? Okay. How many are elementary and at what level? Gwendolyn…

FS: Second grade.

GW: Second grade? Okay. There are still some relevance here for you. The general principles will be perfectly fine for that. And you are?

FS: (inaudible)

GW: Educational Advocate. Do I have anybody else that I've missed? Yes.

FS: (inaudible)

GW: Middle school. Great. You will find relevance as well to the pieces we are going to look at today. I do want to clarify that HOTS is Higher Order Thinking Skills. Okay? I was in a session at the beginning of working through the cities that we've been through and I had an evaluation comment that said that I didn't put together that HOTS and Higher Order Thinking Skills were the same thing until the last twenty minutes, so I though…oh gosh! Need to make sure that we clarify that upfront.
We have time as a limiting factor today, so I'm going to borrow from the Gates Foundation again as you probably have experienced when using Microsoft Word that you go to print and every so often it will say the margins…you are too wide for the margins, we are going to truncate. That

means "whacking it off" and ignoring the pieces that don't fit. We are going to have to truncate some of our activities today. You'll get the general gist of how they go and I'll talk about how they are used in the classroom, but we will not actually do them to their fullest possibilities. My examples today will be from anatomy and physiology. That is what I teach, that's where a lot of my examples are, but that often really works in several other venues…especially middle school where you cover several different subjects and there is a lot of other applications in a lot of other places. The inquiry piece that we'll talk about is going to be really K-12 and in…I've had lots of different teachers from lots of different disciplines. I was very pleased to hear that the business teacher found applications to a lot of the inquiry pieces so it's really your working through the possibilities here and applying them to your own situation that makes you a professional.

My goal today is to get you to engage students in inquiry as much as possible, to use that as an educational approach. So I will do that by…in this presentation by looking at four different things. First of all we'll kind of clarify definition for inquiry. There is a little bit of difference in how that is interpreted. We'll also revisit higher order thinking skills very briefly. Usually that's something educators are aware of so we do not need to spend probably a lot of time there. We will connect the presentation today to the National Science Education Standards which in most states align with the science standards in some way, shape or form. We will disaggregate the scientific method and although that's kind of a classic piece in the sciences, the problem solving aspect fits in a lot of different disciplines and not just the sciences. And also we will discuss the assessment pieces for both inquiry and high order thinking skills. So that's the journey and we'll get started.

First of all, let's take a look at inquiry itself. Research does show that inquiry produces positive results and I want to mention the particular piece that you see here and I want to mention that because the Center for Science Education has just begun a big research piece on the effects of inquiry. The research out there now is old…1983, 1993. There hasn't been much done since that time as far as research for inquiry goes. So I'm asking you to keep an eye on this Center for Science Education because they are going to put this up on their website and continually give updates on the different stages of the process. So if you are someone who wants to convince your school to do more inquiry, this would be a wonderful resource to have at hand. Also, inquiry is so ambiguously defined in the literature. I get a little irritated with that. There are really two ways to look at it. There is a way to look at it as scientists would look at it and it's the way a scientist works. They investigate natural phenomena, they gather evidence, they derive conclusions from the evidence, that's the way they work. In education we look at inquiry more like a teaching style. A hands-on, minds-on process where students are engaged in investigating science or some other discipline. So they really don't exactly match in the two arenas, however, the educational approach does reflect what scientists do in real life. We try as much as we can to give students the feeling that they are doing what scientists do. So that's how the two connect. So really we are talking about the spirit of inquiry when we talk about inquiry in the schools. But the bottom line is we want to engage students in that investigative part of science. We have to take a look historically at the science classroom at this point. When I started learning science it was very didactic. I see some of you that have been around for a little while shaking your heads…it was lecture. If we did any labs at all, they were verification labs, meaning that you were told how it was probably going to

turn out; you just went and did it so you could what? Prove to yourself that they were right? There wasn't a lot of surprises there. And that's basically how we approached things. It was very vocabulary laden and very fact laden. And as the reform movement came in and that's really why inquiry research was done in '83 to '93 was that minds-on, hands-on process…you know, let's do science, let's actively investigate, let's gather some data and then analyze that data and draw our conclusions from that rather than simply being told. So that's really where we are at now. If you do nothing else when you go back to your schools, convince your science teachers, math teachers, whomever, to do away with pre-made data tables. That will at least start the kids having to think about the data that's there and what is essential pieces of that data is and how they can then go about using that data. But that's…especially for the things that are observable…the concrete concepts, that works very well. So if nothing else, try to get that accomplished. There are really different types of inquiry in the classroom and I've got names for them, but you could find them named other things in other places, but I think you'll get the gist of it if I give you some examples. A structured inquiry is when you basically give the students the problem. Problem statement, maybe hypothesis, you give them the materials, you even maybe give them the instructions. They are going to work through it and they are going to come up with some conclusions. Now that sounds like the verification labs of old, except you don't tell them how it comes out first. They're really doing the investigating and the conclusion drawing on their own, not just proving what someone else said. I really like it when I start about here: guided inquiry. You don't give them as many pieces. This is an example of my students in a guided inquiry. They are trying to figure out the mechanics of breathing and I've given them the challenge and I gave them a dishpan

with a 2 liter Pepsi bottle…Pepsi because it's clear…any clear bottle would do, cut off the bottom of it so there is no containment at the bottom, balloons, rubber bands, straws, some paper toweling, those pieces are in there. They are supposed to construct a model that operates like the human lungs. Now it's not very hard for them to make one that looks like an appropriate model, getting it to work like a human model is much more thought provoking and although these students look like they kind of have smiles on their faces, they were arguing. This was not necessarily a happy discussion because they had different ideas and they were trying to get it together so they could make it work. I used the TI system in labs and find that it works extremely well. TI stands for Teacher's Initials. So I'll say to the students when you get to the point you think its working, then come get my initials. Come get the teacher's initials. And the reason I do that is because they have to find me at the appropriate time, not me try to keep track of several different groups and guess when they are ready. So they are to come get a TI from me when they've got it working. Oftentimes they'll bring it up and they'll start to blow in the top of the straw…oh wait…doesn't somebody blow into you every time you breath? Well high school students are "how gross is that!" So no they don't agree with that, so I say, okay back to the drawing board; this is not working like you work. How do we find that out? Well first I guess I'd sit down and breath for a while shut my eyes maybe and concentrate and figure out what's happening there. So eventually they work through that, but that would be an example of guided inquiry.

Now I brought with me a model that because I have a lot of pictures on people's faces…gee how does that work? So we'll throw in just a little science lesson here. I actually now teach online. I teach anatomy and physiology online and this is one of the models made by my online

students. And the way that it ends up working is like this. And I will pass this around so you have a chance to look at it. This is based on the inverse relationship between pressure and volume. As you increase the volume, you decrease the pressure inside; atmospheric pressure is now greater it rushes in. You decrease the volume, you increase the pressure inside, air rushes out. So that's what I'm looking for when I say the mechanics of breathing working appropriately. That's just an example of a model that students created in the guided inquiry approach.

We have some arguments going on about inquiry. Not quite as bad as the math wars, but there is some disagreement about how to approach inquiry. And one of the camps of this says that you really don't need a prescribed way of going about this. You don't have to start with a problem statement and then have the hypothesis. It's more of a generalized approach. So I would like to read a quote to you from the National Science Education Standards. This is their inquiry standard and it reads in one part like this. *"This standard should not be interpreted as advocating a scientific method. The conceptual and procedural abilities suggest a logical progression, but they do not imply a rigid approach to scientific inquiry."* A more generalized approach. Then you get the scientific method rules which is: *"You start with a problem statement with an experimental and dependent variable, you come up with the hypothesis, you establish a procedure that you are going to do, you gather the data, you draw the conclusion."* So where do I think we ought to be with this? I'll just give you my opinion since lots of opinions are out there. I think students need both sets of rules. What I have found is, it's true that not everything starts with legitimate problem statement and works through all those steps, however, as soon as we send kids off to college, guess what they are expected to know in their first science class and write up a formal lab

report? So it is my opinion that they really need to know both things. So if we teach them the more rigid or formal scientific method and then say you know you really can start this at various points. They at least know the formal concept and can vary from there. Again this depends on where you are in the whole scheme of things. Second grade, a lot of times kindergarten, first grade, second grade we talk about fairness in testing. For example if you took the tennis balls there and you said to second graders, which one of these bounces the highest? And they said, well drop them. So you do, but one lands on a table and one lands on the floor and they'll say, no you can't do that, that's not fair. So that concept of fairness really starts very early and so you can talk about some of these pieces, maybe not use the actual names, but still the concept can be discussed. I do want to make sure I throw in a big thank you to CSI because they constantly say where does the evidence lead us, and that really is the essential part of inquiry no matter how you approach it and no matter what rules you use. We are taking a look at evidence.

Okay, Higher Order Thinking Skills. I wanted to mention again research here…research does show that Higher Order Thinking Skills produces positive results. If you purposely work with students to improve their higher order thinking skills, they do better on achievement tests by a significant percentage and if you are wanting to know what that is, again the research source is there linked to the bottom of the slide. The part I'm talking about if you are familiar with Blooms Taxonomy starting with application, analysis, synthesis and evaluation. That's the Higher Order Thinking end. Not even so much application, really analysis, synthesis and evaluation is what I'm referring to for Higher Order Thinking Skills. I actually asked my students to write questions on these different levels. I asked them to write test questions or review questions. I actually asked

them to do it on different Blooms levels and they begin to really struggle with how you do that and they get so that they can recognize questions asked of them on the various levels much better.

Critical thinking is really pushed in the sciences as well as many other disciplines, but I wanted to mention here are a couple of definitions for critical thinking. Process of determining authenticity, accuracy or value. That is evaluation. Characterized by seeking reason and alternatives. That is analysis and synthesis. So really when we take a look at that problem solving piece, the critical thinking piece, it fits right into Blooms. Research also shows these skills, these Higher Order Thinking Skills, are teachable and learnable. So you don't have to just hope they happen.

Segment 2 – Connecting Inquiry to NSES

GW: Taking a look at the National Science Education Standards, we are moving into inquiry here. *"As a result of activities in grades K through 12, all students should develop the abilities necessary to do scientific inquiry and understanding about scientific inquiry."* So we have a do and we have an understand part and we are going to look at how those look differently in the classroom today as well.

Okay, the "DO" part. My students really fall into the mantra gather data, gather data, and we are always gathering data. We start the very first thing; the very first day of school…I don't even take attendance first. I have them filling out multiple intelligence surveys. I'm gathering data on them immediately. So I need to model that same process and I'll share that with you in just a moment. I want to make sure that what we do is on the students agenda. If you want them to pay any attention and you want to buy into and own this information, then it has to be relevant to their lives. And I want to engage them. If my goal as a teacher is to have lesson plans every single day that compels the students to want to do what I want them to do, if I can get there, then I have succeeded in my goal of where I want to be. And using data a lot of time really piques their interest. For example, at the beginning of the immune system…I don't know if you have ever studied the immune system, but it can be highly detailed and pretty tedious. Lot of antibodies in there; lot of different kinds of cells; it's…there is just a lot to it. And so sometimes it's a struggle to learn. Well I want to pique their interest so that they want to learn this and it's not just because okay the immune chapter is next. Don't want to have to go there that way. So I ask them about three weeks in advance to take home a survey and the first question is "what are your immunizations and what childhood diseases did you have?" The second question is, "what

immunizations did your parents have and what childhood diseases?" And the third question is, "what immunizations did your grandparents have and what childhood diseases?" So as we open the immune unit they come with very rich data. Now somebody probably doesn't remember to do that or fails to comply with the assignment so I usually have some old surveys that I've asked permission to use, taking off the names, put them in plastic page protectors so everybody's got some data in front of them and it generates questions. I get questions like. "Well Mrs. Wortmann, why…what's the difference between German measles and regular measles? I didn't even know there were there were two kinds of measles." Or they will say, "My grandmother wrote that when she was a little girl they hung a white flag out on their doorway. Why would they do that?" And it just leads us to different kinds of disease types and what causes those disease types and how they are controlled, which is the immunity. But we are coming at it through data instead of just, "Okay, today we start the immune unit. Here's what we're going to do." Really piques a lot of engaging conversation and student interest. Okay. We are going to gather a little data and then we are going to share how that is used in the classroom. So we are going to divide down the middle. This group over here is going to do bone counting. This group over here is going to do body measuring. Both of your instruction pieces are on page 15 of your handout. You are going to need the tape measures and I'm going to ask you to use the centimeters. We are going to use the metric system over here and when you measure, everybody if you want to look at the top, this is the body measurement piece; I was trying to standardize this so that there was some usability to this information further down the road. So the descriptors that they are going to use to do the body measurements are for tux measuring. Tux for prom or weddings so that's where the

descriptions came from, and that's fairly standard for measuring bodies. Okay? You can either choose to measure one person or that's up to you however you want to go about getting these body measurements, but you need some data. All right? Go.

This group is going to count bones and you have to do that by palpating. So you got to be able to actually touch the bone and find it and you may have to be cooperative in this because it's a lot easier for somebody else to count my vertebrae than it is for me to count my vertebrae. Okay? So work together and come as close as you can to give me a bone count in six or seven minutes. Okay? Questions?

FS: What do you means by upper extremities and lower…

GW: Upper extremities…arms…fall from shoulder on.

FS: Fall from shoulder on and lower is…

GW: Hip down.

FS: Hip down. Okay. Great.

GW: All right. Okay. Go. Gotta count. Got to palpate.

FS: Are you just feeling for like an indentation?

FS: I don't know. We are just sort of feeling for any sort of distinction.

GW: In the interest of time, we are going to truncate and move on. I want to explain how these can be used the classroom to meet real standards, real benchmarks…it's just not an activity. Okay? The body measurement team over here and I'm hoping…we are not going to flip-flop sides so I'm hoping you had an idea of what they were doing and you had an idea of what they were doing. The build-a-body activity is a way for us to study anatomical descriptors. The students are asked to create a model of a human 30 centimeters tall based on the measurements taken in the group. Now that is a project that takes a lot of different skills. So I put the students in groups based on their multiple intelligences and I want a variety of

strengths in that group. So it's not random grouping, it's very purposefully done. So I might come around and I've put you in a group and I say to Linda. Linda, you scored really highly in mathematical logical and your…I'm making this up. It's hypothetical. And this group is going to have to scale the measurements down to a 30 centimeter model so they are going to look to you when they get to that part and you are going to be very helpful there. And Renee I notice that you scored very highly in interaction between students and so just…it's your job to kind of keep them focused and working together and that will be your challenge. They'll look to you to do that. So I keep going around and I actually take the time to introduce students to each other based on their strengths. Now I used to do that project with random grouping and when I switched to this process it improved the results about 300%. And I kept trying to figure out why. Why would it make such a huge difference to simply group them differently? I don't think it was so much the grouping as it was the introduction. Every student was there because of a strength and it was stated explicitly to the entire group. It had nothing to do with intelligence quotatient. It had to do with talents and strengths that they came to the table with. It made a huge difference.

MS: In relationships also they realize the relationship between the talents.

GW: Exactly. That you need more than one kind of thing and you can count on each other is a great group builder…you are exactly right. It's a very big time team effort approach…whatever. So I wanted to at least convey to you that process that if that were to help some of the things that you do, that would be wonderful.

That's not where it stops. We are going to use this body that they build to also study anatomical descriptors. In anatomy and I'm sure this is true in other disciplines as well, I get very irritated trying to study three

dimensional objects on a two dimensional piece of paper. Two of the descriptors that we have to learn is superficial and deep. Superficial, laying on the outside; deep, being more toward the core of the body. You can't do that on a piece of paper. There is no deep to a piece of paper. So it helps immensely to have a three dimensional model to study three dimensional terms. So they use this to learn their planes of the body which are sagiittal, coronal and transverse. So they've got a three dimensional body to consider those as well as the various descriptor terms and they have to put little tags on to come as a group, put that together. Now I just want to tell you for teacher purposes here, we really like Model Magic made by Crayola Crayon. I don't know if you've used that before, but it's wonderful modeling material for the classroom. It doesn't dry out overnight. You can use clays and Play Dohs and things they will dry out overnight and you are stuck the next day not being able to adjust anything. Model Magic is great. The students in this project have to make that body as realistic as possible. It must be proportional, correctly proportioned which takes a lot of the fun out of it for some of my high school students. It has to match the measurements of the person measured and it must be an anatomical position, which is standing, facing forward, palms forward. That is the reference piece. So it also must have a real human integument color…a skin color that is actually human, so no purples and greens unless they are like in third stage of hepatitis or something. So we want to make sure that it's got a correct integument. The girls in my class actually figured out how to do that the easiest. They went home and got make up and it went on there and worked beautifully and they were done. If they have real hair it's better. So they'll stop by a barbershop or something and get real hair or I have seen them lifting up people's hair and cutting pieces off in order to turn it in the last day. I give

about three days to do this, and usually those three class days may be a couple class days and then we'll give it a while and work on some other things and come back to it, so they've got some time to accomplish things and bring things and whatever it is that needs to happen. But that actually meets some of the standards and benchmarks for anatomy and does it three dimensionally and gives them good group building skills, problem solving skills, lots of things in that particular project.

The bone counter is a group processing piece. These guys did not have enough time to get their whole bone count done.

FS: But you know, this brought me full circle because it's always a group that does not complete something simple. They say, well we've got stuck doing something simple. And so that was a very good experience.

GW: And what I do to help get us by that point is I'll have an overhead or something or a chart or something when they are done, they just go up and put their number and so we do it as a whole class process. Well…what do you think? Here's the data we got, so if you didn't get all the way done, we are still using data from the class. Usually the kids will come up with about 175 that can be palpated from the outside. How many are there really? Anybody know? 206. Okay? We could have looked that up in a book to start with. That's not anywhere near close to the process we went through in palpating bones. So what we do is somebody…in fact we don't even look up 206 in our own book. We go to the internet, go to an original source document, Gray's Anatomy is online. His original Gray's Anatomy is online and you can look up the number of bones. In fact my chart matches his chart pretty closely. So there is a connection there with a historical piece. And so they come up with about 175, the actual count is 206, so what's their next natural question? Where are the rest of them? Did I compel them to want to find out what I wanted them to do? Yes.

They are now ready to hit the resources and go looking for the names of the bones. And if you listen to the conversations, at the age I have them, there is some prior knowledge. So somebody will say oh that's the collarbone; somebody will say nah I think it's the clavicle. I expect she is gonna want us to say clavicle…which is true. And you hear that so that they get the prior knowledge piece as they work through this and I didn't do a thing to have that happen except set up the data gathering experience. So it works really well.

Couple other examples that might be helpful to you in your classrooms, I'm not going to spend much time on these. The first one is the caffeine lab. This is actually something you can assign them at home. They are to drink a non-caffeinated beverage and I like to have the two beverages that they're gonna consume match, so if they are doing Diet Coke it should be caffeinated Diet Coke and non-caffeinated Diet Coke so you are reducing your variables it should stay with the same kind if you can. So they drink a non-caffeinated and every two minutes they take their pulse for twenty minutes. That's it for the assignment. Okay? Then at another time they are to drink the caffeinated beverage and do the same thing. What do you guess were the results of that?

FS: Caffeine (unintel).

GW: It peaks and drops in twenty minutes you can't believe it. However the interesting aspect of that was that we had some students who peaked and dropped like this and some who peaked and dropped like that. There was a huge discrepancy between the two

MS: That's weird. Because if I drink caffeine I get tired.

FS: It makes me go to sleep too.

GW: In twenty minutes or later when you crash?

FS: I have the opposite affect because when I was in college I drank coffee because that was what they said you needed to stay up and I would drink coffee and go to sleep and when I went to the doctor, they said I'm one in a million…one of those people…

GW: …that reverses the effect. Well that's pretty intriguing to bring into the data… to bring into the discussion. Any guesses to why we have these two different kinds of peaks?

FS: Because some people it takes caffeine react higher than other people…like it takes more drugs…

GW: Why? You are right.

FS: Maybe because it's how much they weigh?

FS: …consistent. They are used to.

GW: Tolerance. It was tolerance. Body size might play a part too and when you mentioned that boy/girl a lot of times it's a body size difference, but it was really the tolerance piece. Those kids that drank caffeine all the time did not peak as high as the others. What I do with that particular piece is the caffeine lab leads into the nervous system. They want to know what the connection is and so it takes us right into that. Although you could use it for a variety other reasons, that's the way I use it in anatomy. Another one…blood pressures is a great thing. We have the little wrist cuffs you can see Jackie right there using the blood pressure wrist cuffs. Those are great for the classroom. They are not highly accurate, but they'll do for gathering data in the classroom. And you can do a lot of different things with this. She is working on a lab that just…she is finding the difference in blood pressure if she stands up or lays down or sits or stood on her head…she actually stood on her head. But she was investigating that. But what I do at the beginning of the circulatory unit is once again I give an assignment way in advance saying that on the day we

start this, come with your blood pressures taken. You need to come with a blood pressure reading. First of all they then…some of them discover it's one number over another, which some of them didn't even know that, but if they go to any of the machines or anything, the kids will say how do we do that, we don't have the tools to do that and somebody will say oh I work at Wal-Mart, there is one of those blood pressure machines at Wal-Mart. I work at HiVee, which is our local grocery store…come in there…you can take it there. List ditch effort is the school nurse has agreed to take their blood pressure as long as they don't all show up five minutes before the class on the last day. So there is a way to get their blood pressures taken and they post them again on the overhead or chart or whatever and the question is…so what's normal blood pressure for a teen? So look at your data. What can you tell me about normal blood pressure for a teen? Right now the number for us is not as important as the idea. Is it a specific number? Or is it a range of numbers?

MS/FS: Range.

GW: It is a range of numbers. If I had started out by saying open your book and find normal blood pressure, what would the answer have been? I know Renee knows. 120/80. The textbook will tell you 120/80. Is it really 120/80? Or is that kind of the general consensus and it's really a range? So it brings you to the discussion…be a little wary of those "normal" numbers in the textbooks because that's not always the way it is; and you can get to that conclusion by gathering some simple data here.

FS: I was told the body temperature….

GW: Body temperature makes a difference. In fact we do another lab with body temperature where we take…I have the students take their body temperature different times during the day, different kinds of activities and then graph what's going on during the daytime. Leads you to the same

basic discussion and that's another good data gathering one that works really well.

Segment 3 - Disaggregation

GW: Okay, I want to move on to the idea of disaggregating the scientific method. And what I mean by that is a lot of time we expect students to do the whole works…the problem statement, the hypothesis, gather the data, draw the conclusions, all at once. And I find that students struggle with that and oftentimes I'm disappointed in the results. As a result I have been kind of driven myself…I've been compelled to take that and look at it in a different way. So now we do problem statements first…for a while. Practice…everything I can think of that might lead to a problem statement. We practice writing good problem statements and we might do that for a three or four weeks. Then we'll take on hypotheses and we'll work on learning on to write good hypotheses and do a bunch of practicing and that has resulted in much more sophisticated work on the part of my students. I had a chance to sit down with a year-old ACT test, SAT test, the Iowa Test of Educational Development, which is the one we give at the secondary level in Iowa. What I found was the science sections of those are almost entirely inquiry based. They use different disciplines for the content of the question, but it's really about controlling variables, doing a controlled test, analyzing data, making inferences, those are all inquiry process skills and it's just…I mean, all of the tests are really based in that. So if you can get them to do that piece appropriately…I had one gentleman in one of my sessions…Minneapolis. He had done his Master's on the inquiry approach. He was teaching enough of the same subject that he had two groups. One that he taught by inquiry and one that he taught by traditional approach. And what they did was they gave them the regular standardized test and the inquiry group way outscored the non-inquiry group and they had just hammered them full of all the facts that they were going to need to know for this test, but it didn't help them process the

information and that was what the test was mainly about. So keep in mind that this, if you can get this, coming to things by using data and analyzing what you've got, you'll be better off.

Okay. So the activity I use is called the problem is a statement and we practice writing good problem statements. I usually have them practice by giving them real abstracts of scientific work. In Iowa we have an astronaut that lives in Iowa…Peggy Witson from Mount Ayr and she spent time on the space station, and her research was to try to figure out the relationship between long space living and kidney stones. People who live in space end up with more kidney stones than the rest of us down here. So I gave them an abstract of her work and just said, okay what possible problem statements might she have been investigating? Write as many different problem statements out of this abstract as you can. So that's the kind of practice that I'm talking about and I want to make it relevant…real…something from state…you know, real research…those kinds of pieces so that's worked out really well.

Okay, I gave you body temperature idea of taking body temperature all the time during the day. We are going to do a little practice in writing problem statements. The English teacher just went…ughghghg I heard you. If you will turn to page 16 this is Robert Boyle's actual experiment the way he wrote it up in his scientific journal. So what I would like for you to do is to read through Robert Boyle's experiment and try to figure out his problem statement. So read first, quiet time and then discuss with each other and see if you can come up with that. If you need friendly reminders on what a problem statement looks like, that's at the top of the next page. Okay? Go.

GW: What were they doing in this experiment with the quicksilver?

FS: To see how it would rise up in the small…the shorter tube.

GW: Right. They were putting the mercury in the long tube to see the effect of the volume of air in the short tube. Okay. I would process that a little more at length with my students, but usually we do a jigsaw when group works on number one; one group works on number two and if they are just concentrating on a part of this, it's a little easier to figure out. But we are using an original source document, we are using some skills from English to try to decipher and decode this message. Also we are getting practice with writing problem statements and we are not going to take the time to work through that whole process, but you get the idea and basically you've got two variables…one is pressure and one is volume and they are inversely related. As you increase the pressure, you decrease the volume; which goes right back to this. And actually, it's in the respiratory unit I use this information. If you were teaching chemistry, it would be in the unit on gas laws. There are all kinds of application to that, but if you can find the original source document. Again they are using that processing of inquiry. They are investigating mentally, as a mental model, instead of just going and looking it up. Moving on, let's practice doing hypothesis. And we are going to be working with the muscle fatigue lab on page 17. You need a tennis ball. Rules of the game. Use your non-dominant hand please. In order to count as a squeeze, you've got to dent the tennis ball. Now in my school, I go and get the ones from the PE Department that are just so…looking a little ratty, but we borrow them. These are new so the squeeze is a little tougher, but they will work for our purposes today. We are going to squeeze it 100 seconds in a row. You need a writing utensil in your writing hand because you are going to jot down some data. Every 10 seconds I'm going to say mark and I want to know how many times you were able to squeeze it in that 10 second block.

So I'll do the timing, you are going to keep track of the number of squeeze every 10 seconds. Is that clear?

MS: (unintel).

GW: A squeeze…got to dent the ball. Okay?

FS: (unintel.)

GW: Do the best you can at making the squeeze. However before we squeeze, what is the hypothesis? What do you think will happen? Fewer squeezes as time goes on. Is that an agreement with everybody? Okay. Our hypothesis is…that there will be fewer squeezes as time goes on. All right. So let's get that up there. And we'll talk about the way that's stated, but generally speaking that's the idea. Are you ready? Okay. On your mark, get set, go.

GW: Mark.

Mark.

Mark.

Stop. Oh groan, oh groan. Normally I would have students graph the information. Can you mentally graph? Can you get a picture in your head of your numbers? Hope, is your hypothesis supported or refuted?

FS: Mine is not consistent.

GW: Yours is not consistent. Can you mentally in the air draw me what your graph would look like?

FS: Okay. I started here…

GW: Okay. Is that…were you watching Hope? Did that match your data? We could have a discussion about this, but generally speaking what you are seeing is an aerobic and anaerobic pathways for muscle fatigue. So it doesn't go like this.

FS: What if it did?

GW: What if it did? Well then you would say…you got to base your conclusions on your data. If you really wanted to go about this correctly, you would gather a lot of data, not just one single session.

FS: Because mine when from 10 to 5 because I was tired.

GW: And there could be other variables in there. Some people have wrist problems. There are some things that might plan to be an excellent discussion to have based on the data, but large groups of data will show array…it's like camel humps…the graph is really a camel hump…aerobic means you are feeding your muscles with the oxygen that you are breathing in…eventually you can't keep up with that and so you kick into a biochemical pathway to supply oxygen to the muscles and that graph will show you those pieces. Okay. So that again, you come back to the idea of writing hypotheses. I just want to mention one thing about this. Often when you look at hypotheses it will state that hypothesis is an "if, then" statement. Many times in classes we start with the then part and leave off the if, because if you say "I predict" you are really saying "then I predict this will happen". So if you want a good hypothesis, it should start with the experimental and dependent variable. If the number of squeezes in 10 seconds is related to the amount of time you've been squeezing the ball, then I predict that this will happen.

All right. I want to spend a little bit of time on assessment. Oh here is a graph of my students in that lab. Just to give you a picture. The drawing in the air though makes them think mentally, so I use that a lot too. Heart rate lab. If you want to use heart rates again that's another thing that works really work for this kind of activity. Okay.

Segment 4 – Assessing H.O.T.S.

GW: I want to give special recognition to the Ottumwa High School Science Department. They are the ones that wrote the rubric I'm about to share with you on how to assess inquiry. And I'm not going to go through it in detail, but I want to tell you that the rubric that we devised. In Iowa we have to have multiple measures to show where the kids are proficient. So we use our Iowa Test of Educational Development as one measure, but we must have another measure as well. I get very jealous of reading and math because they've got all of these assessment pieces out there available to use. Tested assessment pieces, validated assessment pieces… The sciences…don't have those. It's a real problem to find something that assesses inquiry just as a piece in itself. So we wrote our own and that's the product that you see there. You are welcome to use that. We cussed and discussed this thing. It is what we all could live with, so it's a consensus piece. There were nine of us working on this. All of us had a little bit different ideas of what should be there. You will note as you read through that however, that it has a lot to do with Higher Order Thinking Skills. For example, I just got the hypothesis one here up here. Hypothesis is specific and clearly predicts. Higher Order Thinking Skill. A relationship between the experimental variable and the dependent variable: the reasoning logically supports the prediction. Higher Order Thinking Skill. So as you read through those you'll see a lot of the Higher Order Thinking pieces in that rubric. We would give this to the student upfront. This is how you are going to be assessed; and this what we would use to assess them. Now we use…you'll notice, it is 10, 8, not yet. Not yet means if you are not at least a "C" level proficiency, you go back to the drawing board and do it again. So that's what that means. We are not accepting "D" and "F" work for this. It is something they need to attain;

we'll keep working at it till we get there. I don't have them do a whole inquiry piece until about November where they do the problem statement…the hypothesis…the whole piece. And mine is in the senses unit, and I just say do an investigation about the sense of smell. Up to you what you want to do. So they have to go through and define. We had a discussion one of the other session I did with this about why this is applicable and a good one to do in the classroom, especially for middle school. That group had decided middle school. It has to do with olfactory fatigue. You walk into a room and it smells and pretty soon you don't notice. It's not that the smell is gone. It's that your neurons are no longer firing for that particular odor. Special needs adaptation…what we finally decided to do to really reach proficiency in our school, was to have a class called pre-biology. Pre-biology works on this same rubric, they just do it at a slower pace with more practice. They enter regular biology ready to roll.

So the next page is how we take that scoring rubric and convert it into a numbers piece that can actually be reported to the state for proficiency levels. So that's just a guide. The teachers would be doing that. We wouldn't report it back to the students. It's used to determine the level of proficiency. We do the double scoring. We poll 100…we have 400 of them about every year. We poll an extra 100 after we've scored all 400 to get interrelated reliability so that we know that we are scoring evenly among all of us that are doing the scoring.

Okay. The understand part. That was the do part. Get in there do inquiry. Hands-on pieces, all of those things. What about the understand part? How do you assess that some student understands inquiry? One of the ways that I use is to analyze real research. So on page 21, you have a piece of research…real research that I pulled off the internet. This was

actually the first virtual Congress of Cardiology. I was looking for something to go in the heart unit. You can find research pieces out there for a lot of different things including educational research if you want to take a look at that or reading research or whatever it might be. This was just a piece of it. It also had the data, conclusions, etc. I asked the students to evaluate (Higher Order Thinking Skill) this piece of research based on the rubric that they use in class. They gave this piece of research a 31 out 60. We had a really rich discussion about why it scored so low. Well in real research, especially when you are talking about people, and this was about blood pressures in Cuba, they have a really bad time with high blood pressures in the Cuban population, and they were trying to discover how young that started to inform their practice. And the problem is when you are working with people you don't get permission from every single person to participate so you might not have 100% of the population. You might have lots of different people taking the blood pressures, source of air, and there are just a variety of things that in real life are going to influence an actual study that if you have a very controlled environment, you don't have those pieces getting in the way of a perfect study. But did they understand the process of inquiry if they can evaluate a real piece? Yeah. So that's one of the ways that you can assess. Another one is the idea that you can have students write experiments that they are never going to do. We always think in the classroom in terms of Oh gosh, I can't really do that because we don't have the equipment, so we just won't go there. I would argue that we should to go there and we just won't actually complete the research piece. Elsue Featherstone is one of the patients that I created for my online class. Every unit I have a patient and the students get emails throughout the unit about this patient. So their knowledge of their patient keeps building as they go through the

unit and then as they study the information that is eventually going to come together that they've got to use the information they've learned to do something about their patient. So Elsue Featherstone is a Navajo Indian that lives on a reservation and she has osteoporosis. So the two pieces are coming together. More information about Elsue and you know…what are you gonna…how are you going to diagnose this? And I give them enough resources that they can just problem solve and figure it out. But the idea in the end is they need to write an experiment that they are never going to be able to do because it takes a DEXA machine, which is a bone densitometry machine. I don't know if any of you have had your bone density done. I have, but…big x-ray machine, you are lying down on this thing…actually I fell asleep. Takes a while to get it done, but they actually have these in vans. The kids read an article about taking a van…a DEXA machine on a van to remote places in Texas and Alaska gathering bone density readings on people. It's never been done in the Navajo population, so truly this would be a piece that they could be writing for real. And they have to write the problem statement, the instructions and procedures, the hypothesis, how they are going to gather the data and organize it and that's where we stop. Because it really hasn't been done. There is no data out there, but that doesn't mean they can't go through the process and show the understanding of the inquiry process, and again that could be an assessed with the same rubric.

Okay, the last piece that I want to talk about is using the H.O.T.S., Higher Order Thinking Skills, and how you assess those. That can get to be a little bit tricky and we don't have time in our classrooms to just assess that. It's got to be in conjunction with the rest of the stuff that we are teaching. So as I mentioned, we do multiple assessments. And I also mentioned the embedded scenarios in the Iowa learning online anatomy

course which is the patient piece, and I just wanted to tell you just a little bit about that to give you the idea and that may be something that works for you in your classroom.

I base the online course on telemedicine, doing medicine at a distance, because it fit the concept of online learning really well. And we have these different patients. One of them is Roseanne and I always try and come up with some kind of a problem so students are going to have to use this Higher Order Thinking that's on their agenda and still matches the benchmarks and standards that I've got to meet. So Roseanne…this is early in the year, she…this is in the unit for studying the skin. And she is a teen who has got a job, she's also got a tattoo and she's now in the place where the tattoo is showing and her boss is not real appreciative of it. The clientele in wherever she works are offended by this and she's got to do something to cover it up. She wants to keep the job. It's good money, she's happy there; the only problem is this tattoo. And she's also found out that she's got to take medicine and it really doesn't matter what kind. She's decided to take the medicine through the patch…transdermal patch. So she's come up with this brilliant idea, I'll just put the patch over the tattoo. The question to the students is: is that a good idea? So they've really got to go through and look at allergies, the skin patch and how allergies tie together with that. They've got to look at skin structure. Is the tattoo going to get in the way of the delivery of the medication? You won't know that until you look at tattoos microscopically and skin structure. So there is a lot actually to that problem, more than just opinion. I accept opinions, but you are going to have to do something more than that. That takes you to Higher Order Thinking.

MS: But if it's…the patch obviously…anything medicinal comes with directions and any recommendations, so they probably need to look at the wrapping or…

GW: Good point. And you would hope that they would do that, but I'll tell ya. If she got it in her head that it was going over this tattoo to cover that tattoo, you would have to sit her down and say read these instructions. It does say as this patient develops that she is not the best decisionmaker ever. So it gives you a little bit of information about the patient which also leads you to that. But that's a real problem with no solution. I have no idea without just putting the pieces together and drawing the conclusion ourselves. There is nothing out there that says…they usually say to move it for exactly the reason that you are stating is it can be irritating and so it should be moved in different parts of the body, but that's about…you know…it's delivered in lots of different ways. There is actually some additional patches hooked up to batteries because the molecule…the medicine is too big to go through the skin. Insulin is one of those.

FS: Another angle, you know, the gue to the patch. She might be allergic to that.

GW: Glue to the patch might be a problem.

FS: Because I'm allergic to like, you know, the glue on bandaids.

GW: Ah ha! Okay. That would also be an interesting aspect. Thanks for sharing…that's good. The last one I'll share with you is the corrupted data one. I actually got this idea from a first grade teacher. They were studying the states surrounding Virginia I think. And what the first grade teacher did is she had these letters that mentioned the state bird, the state capital, all those pieces, but not the name of the state. And they had an envelope address that had the name and the state in it and the students were to match the envelopes with the letters, which was a really good

approach to learn all kinds of things about surrounding states. I thought well that matching is kind of cool, so in my class I did it in the respiratory unit…ground zero for antibiotic resistant tuberculosis is in Kazakhstan prisons. That's where it first started and it has spread out from there and so I made up about six different patients from a Kazakhstan prison and Doctors Without Borders was woven into this story. They were sending data to Doctors Without Borders headquarters and for some reason the data transfer messed up so the patient name and the diagnosis came through separately from the data on the patient and they had to match. They had to use spirograms and all kinds of data and that, it was really difficult. But again, Higher Order Thinking, yeah… They were really using Higher Order Thinking. So that Blooms connection comes back in there. I wanted to share with you one of my favorite finds. So on pages 24, 25 and 26, I didn't put the knowledge one in there because that one's pretty easy and most of us do that one well without more practice. The rest of them you see that you have the useful verbs and then you have sample question stems. So it's like okay if I'm supposed to ask a question on the synthesis level, what does that look like? And I found this source and I'm going…aha! That's what it's supposed to look like. So I went to a session somewhere and I wish I could remember the names of these folks it was kind of like a session you are at and I just…I don't remember who they were. I'm sorry. I give them credit wherever they are. They gave me the idea of writing a scenario and then writing six questions about that scenario based one each on Bloom's levels, purposefully setting it up so that you are covering all six levels of Blooms with that scenario. I got really excited about that because I wanted to purposefully do that and with the list of question stems it made it possible. I just set up a grid and say, okay here are the concepts I wanted covered in this scenario…okay the

evaluation question would work best for this concept; the synthesis question would work best for this concept and I just kind gridded it out before I started writing. The interesting thing is that they gave the students the scenarios a week ahead of time, which changed it from a reading comprehension test to a Higher Order Thinking Skills test. If the students didn't know a vocabulary word, they could look it up. They could prepare to take the test. If they wanted a study guide this scenario was their study guide. Here is basically what we are going to cover. If they wanted to ask me questions that was fine, I wasn't going to give away the answers to the six questions, but anything else I was willing to answer. I really like that. So I started using that and I gave you a real example. If you are not into the nephron and the kidney, this might not excite you. But I did want to give you a real example so that is what you have here. This is an actual test set from one of my tests that I give. It freaked out the kids who normally memorize and feedback easily. They really struggled. They got better at it because they began to look at the scenarios differently. Okay, what might I have to think about instead of what might I have to know. So it really changed how they approached it. So you have to really take into consideration these kids that have trouble with that. So what I did…these high achievers that get really shaky when they don't get great scores. I wanted to give them an out to regain some scores without just changing the test or making it…going back to where it was easy for them. So what I do is I allow them to argue for points and that usually has three different outcomes. Number one, they explain to me how they perceive the question and why they answered it the way it did and I'm going…Geez…that's logical. I can live with that. I didn't write a perfect question…okay. So I give them the point back. Secondly, they can still be wrong in their answer, but give me such good reasoning on a

high level that I'm going okay I still disagree with your answer for this reason, but your reasoning was such that I will give you credit for your Higher Order Thinking, so I'll give them the point back. The third one is, the answer is still wrong and their reasoning is way out there. And I'll explain why I'm thinking that, but it gives them a chance with Higher Order Thinking, to gain back that which is causing them worry and that's turned out really well.

Okay. We are getting to the end of our time. The rest of the slides basically just kind of conclude…here's what's happened in my classroom, the improvement in student's work because we work with an inquiry approach and we consistently work with Higher Order Thinking Skills. So that's basically where the rest of this goes and if you take a look at the Making a Difference, I have a before and after. This is a student…piece of student work at the beginning of the school year and at the ending of the school year, and you can easily when you read that on your own, see the significant difference in how the approach has helped my students. So I'll trust you to read that through on your own, but basically the message is, go forth and gather data.