MODULE THREE
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Active Teaching and Learning

John Bransford: Part of the trick in engagement is, can I get you to become interested in a problem for which you have some knowledge and some intuition and are willing to grapple with first, maybe as an individual, and then maybe in a small group, suddenly you go, "Oh, isn't this interesting? These different people grappled with the same problem but they used different strategies."

Joshua: Temperature probably is a phenomena that we are all used to.

Narrator: Joshua Bieri's (sp?) introductory physics class balances short lecture segments with hands-on activities that explore heat and heat transfer.

Joshua: We used to have a lecture sequence which would be followed by a lab. Somehow the students were not making a connection between what you discuss in lecture and what you're doing in the lab.
We begin by looking at how our senses interact with the environment, and one of the senses we look at today is the sense of touch.
They would do activities that is related directly to the theory that you are teaching.
And so we're going to do a very simple demo now. On your table you will find I have a metal rod. So I want you to go to that metal rod and I want you to feel it. On your table you also find a piece of towel. I want you to come up with a deduction. How do the temperatures of these two objects compare. So discuss amongst yourselves what you feel. How do the temperatures of these two objects compare?

Student: The rod feels kind of cold compared to…

Joshua: The activities sometimes are short. Sometimes they are long. But the whole aim is so that whatever they do, they first try to discover by themselves.
So what's our deduction?

Student: The rod’s colder.

Joshua: What does that mean?

Student: It has a lower temperature.

Joshua: The rod has a lower temperature? Compared to the rag? Well, that’s… we’ll try to find out whether that is a fact or not. And so what we are going to do to begin with is an experiment where we try to deduce the temperature of several things.
As we set up an experiment, we say “What do you think will happen here?”
You have five sets of materials. Look at those materials without touching them and try to deduce what you think the temperature of each of those materials are in relation to the other.
So we want the student to come up with some idea.
And you are going to use these instruments to try to deduce the temperature, and after you have done this experiment, we will try to discuss what your results are and what your findings are. So let’s go ahead and do it.

Man: 27. I’ll say 27.7

Man: It’s moved up to 28 now.

Man: It’s going to keep going up.

Man: 28.

Man: 24.

Joshua: Then at the end, after they have done an experiment, we come up with a dialogue where we try to see where you need to tie it up together so that it makes sense to the student.
Okay, what did we find out?

Man: They’re all the same.

Joshua: They are all the same. Why does one of those feel colder compared to the other if they… the temperature is all the same?

Man: Because of the texture?

Joshua: Because of the texture? Because of what?

Man: The ability to hold in the heat.

Joshua: The ability to hold heat. What of this team? What do you think?

Man: The room's the same temperature.

Joshua: The room is at the same temperature.

Man: It's absorbing the heat out the room.

Joshua: Yeah, so what we deduce from this is that the human body is really a poor thermometer. And hence, we have to establish some quantitative way of measuring temperature. This is called a pyrometer. So all I'm going to do is I'm going to heat this metal and tell me what happens to that dial. Do you see anything happening? It's going up. Why is it going up?

(all talking at once)

Man: The thing's heating up.

Man: Metal rod.

John Bransford: Connecting the practical with the theoretical is really an important thing. And so the quicker we can get people to experience the complexity of real-world environments, the more they're able to appreciate the value of new information that they're learning.

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Engaging Students in Lecture and Lab

Man: The task is to get it in the front.

Man: It’s going to run (inaudible – sam to go first?) first and then it’s going to (inaudible – call sam pivot?) pivot.

Narrator: Robert Chaney and Jean Carlson teach their technical math students to program robots using algebraic functions in both a lab activity and through lecture.

Robert: Students are given a pretty traditional lecture. Um, in the lecture, um, they are slowly introduced to an activity that they’re going to be working on.

Jean: If we’re going to graph those, then this is the graph of a function.

Narrator: Jean Carlson uses questioning strategies to engage a broad spectrum of learners.

Jean: We have found that, as math teachers, we assume that the students know what a variable is and what a function is, but in fact, some of them don’t.
In the lab last time, you had a robot and you had a stepper motor that turned the wheels, but then you wanted to know the distance that it went, and you had to come up with a way to get it. Tell me about that.

Student: You put in the distance you want to get the steps that, uh…

Jean: How did the calculator know what to do?

Student: You already had a, um, a function set up, a formula set up.

Jean: Okay, the formula is what I’m getting at. Did you come up with a formula all by yourself?

Student: Me and my teammate.

Jean: Okay, how did you come up with…?

Student: What we did, we, uh, we had the robot and we played around with it a little bit, we put numbers in to the program to figure out how many steps... like, we put 600 into it and plugged it in for the steps and set a meter stick up and we measured how many centimeters 600 steps would equal.

Jean: In the lecture, I talked about the basic “what is a function” and then we take them into the lab and elaborate on this topic.

Robert: As you remember the last time, we were working with the robots and getting them calibrated so that they would move forward and reverse.
We really have two goals. One is that we want to prepare the students traditionally, uh, helping them understand what a function is, algebraically, uh, understand the notation, uh, prepare them for higher levels of mathematics. Uh, another goal we have is to have them apply the function to make something operate like the robot.
Today you’re going to want to calibrate it so that it turns.
We want the students to be thinking about what they’ve learned in the class when they go over and get in their groups to do the activity.
And remember the last time I was talking about the robot pivots from the center.
When they’re doing the activity, they’re pretty much just given a problem to solve, and it’s not apparent to them immediately how the mathematics that they learned a few minutes ago, many times, is going to apply.

Student: 200 steps. We’re going to see how many degrees that is, so we calibrate the robot.

Robert: But as they get involved in the problem as they start asking each other questions and figuring out what they need to do, they will discover what the lecture was about.

Student: 60. That means… should… 200 steps would be 30 then, if that went to 60. 30 degrees for 200 steps, 60 degrees…

Man: And it should turn an entire 90 degrees for 600 steps. Bingo.

Robert: We get them involved in the lab on the first day and it's pretty much self-selection.

Woman: We just pretty much go with what each other knows, and we all put in our input and then if we feel that's right, then we'll go with that. If not, we'll try and show each other what we did wrong and try to help each other out.

Man: Yesterday when I was figuring it out, I figured that it would have to turn 60 degrees, and that's where it's showing right now on the protractor.

Woman: So let's go do our measurements.

Robert: 460 steps is going to give you 90 degrees.

Man: Yeah, something was wrong because it should have been 450 but…

Robert: If I see that they're getting too frustrated I will ask a question and get them thinking down a different road.
If that's true, 460 steps equal 90 degrees…

Man: Till we found out what that angle is right there, to see what our turn is going to be.

Robert: Right.

Man: So if we get, uh, say if that's a 30-degree angle…

Robert: Mm-hmm.

Man: We put in, um, well, we divide that…

Man: 135. 135 for 30 degrees.

Man: Okay. Because that would be a…

Robert: All right, if you know that 460 steps is equivalent to 90 degrees and you want to go 30 degrees, what would you do?

Man: Okay, I got you. I got you. I know what you're talking about now.

Robert: Now, what you want to do ultimately is automate this. What formula would take the angle you want the robot to turn and figure out the number of steps for you based on this data that you've collected?
If I see something that's good, um, I'll point that out and get them to continue to consider that.
You might want to measure some angles and distances there ahead of time. Because when we write your path program, you can then put those values in before you run the…

Man: You know, we made an assumption that the angles were 45 degrees…

Robert: Ah.

Man: And perhaps that's not the correct way to do that.

Robert: Yeah, I wouldn't assume that.

Man: Okay, we won't assume that then.
To come in here as a team and take that from paper and actually put it into motion, it really hammers the math home. That way, you see what your results are.

Robert: What I try not to do, and this was the hardest thing for me early on, is to tell them how to do the problem. I don't want them to get too frustrated, but a little frustration's okay. As long as they're trying and working hard, I just try to keep that going.

Man: What we wanted to do is to have the center of the axles come out exactly in the center of the angle to make the pivot correctly, and that's just about perfect.

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Skills and Theory

Leslie: Just to remind you sort of where we've been and where we're going, so let's put our plasmate up one more time before we finish up this procedure.

Narrator: Leslie Barbour emphasizes skills before theory in her biotechnology class.

Leslie: What I have in mind is for the theory to follow the skills. The powerful learning modality for this course is that they do with their hands what we're talking about theoretically.

We were separating, in essence, the hydrophilic proteins from the hydrophobic proteins. And of course, there are thousands of proteins inside of those cells.

We have sort of a bite-size piece of theoretical material, and then we pause and they actually do that, and they work with an actual experiment or two based on that theory.

Woman: So we want to transfer 15 microliters of the bio(inaudible) broad-range protein size standard fixture to each of the tubes marked (inaudible – bladder?).

Leslie: Then they have to write up a pretty detailed analytical lab report. Through the lab reports and my responses, I can participate in an individualized conversation with them about the material that they're engaging. It forces them to sit down and integrate the theory with what it is they were running around doing in the lab. They can't write the lab reports unless they understood the theory and they understood what they were doing in the lab.

Two microliters. Uh, what'll happen is if you put 13 microliters on, it would be so overloaded. You guys have seen what an overloaded DNA gel looks like, right? It's just all, like, spiky and ugly looking. So yeah, 2 microliters, and then it's 13 microliters of the, uh, triss (?).

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Real World Problems

Frank: While retrieving her nets, the commercial fishing vessel “Lucky Dog” found an unidentified container with four small cylinders inside.

Narrator: Frank Barros introduces a simulated news report as his students engage with remotely operated underwater vehicles.

Frank: It’s up to us to actually give them the foundation in science that’ll help support the learning curve, the very quick learning curve that they need to come up with in order to build these ROVs successfully.
So the main team at Monterey Peninsula College has been requested—that would be you folks—to build a special-purpose ROV to handle this emergency.
The beginning of the class that we’ll start with today is actually a simulate news broadcast of some toxic canisters that have been collected and then spilled into Monterey Harbor. So we need a robot to go down into the harbor and recover these things.
Kyle, what are some of the things we might think about that are important in building an ROV?

Kyle: Design, buoyancy, where the motors are—a lot of different things, characteristics.

Frank: James, what do you think?

James: You probably want a pretty light frame, some nice buoyancy, want to keep it neutrally buoyant and you want some strong motors.

Frank: Any other design considerations or thoughts you might like to… Matt?

Matt: With only three motors, you have to design the motors so you can still move in every possible direction you need to go—up, down, sideways, turning.

Frank: Then hydrodynamics are going to be pretty important. So as you’re building your ROVs, you’re going to be thinking about, well, how smoothly can I get this ROV to

actually travel through the water. All righty, team. On your mark, get set, go. Let’s go build some ROVs.
They have about 50 hours to build the ROV. The other 50 hours of the class is me lecturing. The hands-on today is to find out about making a vehicle move in three dimensions; getting a vehicle with three motors to move vertically, horizontally and forward and aft. The nickname for it is ROV in a box, and the students come out and very quickly they assemble a vehicle which is hard-wired to the controls on the surface, very similar to their more sophisticated vehicle except we’re going to do this whole package in about a half an hour.

Woman: Give it a shot and see.

Frank: Do a lot with electricity and electronics and buoyancy and ballast and stability and all the physics that, uh, goes along for the ride with the ROV.

Woman: Little less on the (inaudible) and maybe a little… couple of little ones on the back. Here.

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