# Reflection on Inquiry-Based Lesson

SCE 5337 Secondary Science Methods

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The inquiry-based lesson plan implemented by my group this semester was quite successful, and I was pleased with the results. The process of developing the lesson was a lengthy one, involving much research and revision, but the result appeared to be the implementation of an engaging lesson that successfully addressed the misconceptions we had set out to address.

The content and language objectives were clearly defined. We created a template to ensure that each require section of the inquiry lesson plan was appropriately addressed, and provided the content and language objectives that aligned with the standards of the lesson. There were two content objectives for this lesson, which both included behavior, conditions and criteria. For example, our first objective was "Through experimental observation (touch and measurement) of several different materials (wood, acrylic, copper and aluminum), students will be able to distinguish between the specific heat of an object and its temperature, and understand the ways in which heat and temperature are commonly confused." In this objective, the behavior is that "students will be able to distinguish (between the specific heat of an object and its temperature), and understand (the ways in which heat and temperature are commonly confused)." The parenthesized sections of that quotation is also the criteria, specifying what precisely students are expected to distinguish between and understand. Finally, the conditions are given as "through experimental observation (touch and measurement) of several different materials (wood, acrylic, copper and aluminum)," where the listing of materials is also a part of the criteria.

The language objectives were similarly well-defined: "Students will be able to communicate an experimental procedure in their own words… and/or draw a scientific model"

(behavior) “using scientific terms from the lesson (including specific heat, thermal conductivity, and temperature)... to help explain the expected results of the experimental procedure.” This final portion includes both criteria (inclusion of specific terms) and conditions (the types of written or drawn work which will be acceptable, and the resources the students will use - specifically, using an experimental procedure like our own from which to work).

Reflecting upon the “five E’s,” some sections were more difficult to plan than others. I felt particularly challenged by the “Engage” and “Elaborate” phases. “Explore” came very easily, and was in fact the foundation of our lesson plan, and “Explain” was also planned in our first planning session, as well as “Evaluation.”

“Engagement” is an “E” I constantly struggle with as a new teacher, as I write lesson plans that both reach the necessary level of rigor, while trying to find time in a very tight schedule for engagement opportunities. In the future I would like to work more with demonstrations, when I am more comfortable with them, and have more demonstrations practiced. Instead, we used some guiding questions for engagement in our lesson. However, I am still developing my skill in forming well-worded guiding questions that create insightful moments for the students.

“Explore” was simple to create, and was in fact the first “E” we came up with during planning. We began with the misconception (confusion between heat and temperature) and discussed a freely-available video (the same we ended up including in our “Elaboration” phase). After watching that video as a group, we discussed ways to do a similar experiment in the classroom setting. After discussing the resources we had on hand or easy access to, we determined we could use density cubes of different materials for students to explore, and

inexpensive infrared thermometers for them to check the temperatures. This was the earliest confirmed portion of the lesson plan, and the remaining sections followed.

"Explain" was the second earliest confirmed portion, and was planned at the same time as "Explore," as the two are very closely linked. However, originally we had also included one other property unrelated to specific heat, density, in order to allow students to determine which properties were and were not related. We realized in a later edit that density actually *appeared* to be correlated to specific heat, which is not specifically true; in solids, specific heat is a measure of kinetic energy, and does not address mass. However, there does appear to be a relationship when you list the density of these objects, which generally causes a misconception among students that the two *are* related. Realizing this, we eliminated density from the table to avoid introducing misconception.

The earliest version of the "Elaboration" phase included watching the video and, hopefully, resolving the cognitive dissonance introduced in the "Explore" and "Explain" phases. In order to allow students to process this resolution, we decided to allow them to *revise* their previous statements prior to sharing them with the class. Originally, "Elaboration" ended with students sharing their revised statement, but by our third planning session, we began to feel that the section was too weak. We searched for a more interactive way for students to actually apply their new understanding and actually check if they had understood the concept. We performed some research of other demos on specific heat, and found the "ice melting cubes" used in our final lesson plan. At this point we had also decided to incorporate Nearpod, the web-based interactive presentation software, which allowed us to have students draw models to predict thermal energy movement. This was a late addition, and was probably the clumsiest moment in

class as a result; however, the results were so striking that the students did not seem to mind the clumsiness on our behalf in this section. Ultimately, I believe the drawing of models was a very important addition, as it ended up proving some students still had not fully understood the concept. This elaboration activity allowed them to again examine their understanding of the fairly tricky and persistent misconception that *heat* is what moves, not *cold*, and that the sensation of "cold" is actually the movement of heat away from an object (such as one's hand, or the ice cube on the melting blocks).

The "Evaluation" phase having multiple options was part of our original plan which persisted throughout. We all felt it is good practice, whenever possible, to allow students a certain amount of choice in regards to assessment options, and so we provided two for the general population and one for ELL students. When used in the classroom, this is probably the phase that would need to be adapted the most for each classroom, depending on the goals and time available for individual teachers for this lesson. My favorite option for evaluation is for students to develop a procedure of their own to examine specific heat vs. temperature, as I feel this is actually yet another "elaboration." In developing a procedure of their own and receiving feedback, I believe students are most likely to solidify their understanding of the concept - much like we did during the development and revision of our own procedure based on the initial video. Our original lesson plan, before we made several sets of revisions, did address the misconception clearly enough, because misconceptions still existed among our own group. Receiving feedback allowed us to clarify and correct those misconceptions, and I would hope the students experience the same.

The second reason I prefer the evaluation to be the development of a procedure by the students is that I feel it also ties in science and engineering practices, as students must address a problem by constructing an experiment or demonstration. Depending on the student, they could approach this task either through designing an experiment (tying in "Nature of Science" standards) or through an engineering approach (asking and addressing a real-world problem about specific heat - for example, what material should be used to make roadways in cold climates? How about in hot climates?). In retrospect, we could have even made the engineering approach a third evaluative option. I'd say the only challenge we had in this area was ensuring that the student exploration process reflected an actual scientific procedure. In an attempt to do this, we added quantification (through temperature measurement) and recording of the data in a table (the data table was a very late addition). During our reflection in class, we received feedback that we could have improved this section by directing students to all take temperature in the same units (preferably Celsius), in order to compare all the temperatures side-by-side. I would absolutely make this adjustment; I think that's a great suggestion.

We planned our ELL accommodations throughout the planning process. Every step of the way, we were discussing differentiation for IEP and ELL students, though we only highlighted ELL accommodations because of the assignment parameters. We considered this a fairly ELL-friendly lesson, since so much of the exploration is observation, and not heavily language-based. We had to incorporate language, therefore, in the sections were students were reflecting upon their predictions and upon their observations. Revising and improving one's answers turned out to be the literacy goal we most focused on, as this is the same process ELL students (and all students) use to improve their disciplinary literacy. For all science students,

scientific writing is indeed a process of transforming one's natural writing over time to better align with scientific rigor and expectations, so we felt this was a good objective. We also incorporated "claim, evidence, reasoning" statements to reinforce and remind students of our expectations, and build that reminder into the lesson itself. The process of planning for ELLs was not so much challenging as it was slightly time-consuming, but certainly worthwhile, as we received positive feedback about our ELL accommodations.

I've learned so much through designing this inquiry-based lesson. Originally, I had some worries about how successful and engaging this lesson would be. It's difficult to predict how a lesson will actually come out until trying it out in a real-world setting, so I'm thankful for the opportunity to have tried it out in this class before trying it in my own classroom. I've reflected throughout this paper on changes I would make to the lesson plan in my own classroom. A final change I would need to make would be to carefully consider differentiation and ensure students could read and interpret the table in the "explain" phase. This step was simple for the college-level students in this class, but I expect there would be more challenges in a high school level classroom.