Part A

Lesson Plan Context

The lesson plan included in this assignment is for a course I am just starting to teach. There is no established lab manual or set of exercises in this course (just what I've put together over the past couple of years), so I thought it would be a good place to try new things. Additionally, as a senior-level course taken by Environmental Science students as well as Biology Majors, it needs to cater to learners who come with very different backgrounds and interests. Thus, I can't assume much common background knowledge between these two student populations.

As I've already discussed in my research cafe, my students present me with several challenges (Rusyniak, 2018e), including low motivation and interest in course content, which are at least partially the result of their past learning experiences – Hatherley-Greene (2014) gives a good brief overview of the typical education experienced by students in the Gulf. I therefore need to be able to instill a sense of self-efficacy and interest in the course if I wish to engage my students. I hope to be able to do this by using Constructivist tools to give them "small tastes of success", stimulating conversations with their peers, leading them to confront some of their misconceptions or gaps in knowledge, and making the material as personally relevant as possible.

In planning my lesson, I wanted to ensure that it could stand up to some of the criticisms of constructivist case studies we've seen in this course. Namely, in response to Fenstermacher's (1994) criticism of much educational research, I discuss what 'knowledge' means to me. I then use Baviskar, Hartle and Whitney's (2009) criteria to help guide the design of the lesson.

Epistemic Background

I have found my introduction to epistemology in this course to be at times jarring and frustrating (Rusyniak, 2018c), but I feel like I have learned a few things and am a little more comfortable defending my beliefs about knowledge.

I believe that there is an objective truth which is independent of our beliefs, and that we should strive to learn it. I don't believe that we live in a "Matrix world" – philosophers are welcome to entertain such ideas, but I won't waste my time and mental energies on such useless speculation.

I also accept that our tools for studying reality are imperfect, and the best we can hope for is an approximation of reality/truth (like the blind men studying an elephant). As our tools get better, we will learn more, and we will adjust what we understand to be our knowledge of reality.

I'm not sure if that makes me an Objectivist, a Realist, or a Constructivist – the war of words between the opposing sides has resulted in much literature which misrepresents each view-point (Rusyniak, 2018d). For example, Carson claims that using 'constructivist methods' necessitates the acceptance of constructivist epistemology, which proposes that "reality is dependent on the perceiver, and thus constructed" (2005). Similarly, Nola notes that it is generally "assumed that a realist account of science goes with a didactic 'tell it how it is' approach to teaching" (1997). Neither of these are accurate representations, but they're both easy enough to latch onto in order to criticize the opposing side.

In the end, I don't think that Constructivism actually is an epistemology – it's not a way of thinking about what **is** knowledge, but rather a way of thinking about how best to **gain** knowledge. Thinking of Constructivism in those terms, I think, allows us to sidestep the confused mess that is Philosophy and Epistemology (I am clearly not a fan), and appreciate the compelling results that can be gained through the use of constructivist teaching methods.

Planning the Lesson

Having defined knowledge as our best, but imperfect, attempt at describing truth/reality – a description in need of constant adjustment in response to new data, and development of new tools – I feel like I have addressed the critique that vague and variable use of the term "knowledge" makes it difficult to evaluate educational research (Fenstermacher, 1994). I would also like to identify some of the knowledge I would like my students to have gained – the main learning goals for this lesson.

One of the themes I will be stressing throughout my course is that of the challenges involved in studying cells – much of it is indirect and requires us to make assumptions about what is going on. The first concept to be learned, in this particular lab, will be that cell death can be linked to a loss of control over cell membrane permeability. A secondary concept is that measuring cell death in a sample gives us clues about the sample's suitability for use in further experiments.

Since this is a laboratory course, students will also be learning practical skills. One of them is setting up a hemacytometer for use in order to perform an accurate cell count. Another skill involves calculating cell concentration and viability based on the cell count.

Since these skills are often poorly/carelessly performed at first, the practical exercise will lead into a discussion of a third, and probably most critical from a practical perspective, concept –the importance of consistency and reproducibility in experiments (ie. importance of paying attention to details in how an experiment is carried out).

These learning goals, along with the four constructivist criteria proposed by Baviskar *et al*. – eliciting prior knowledge, creating cognitive dissonance, application of knowledge and feedback, and reflection on learning (2009) – served to guide my planning for this lesson.

1. Eliciting Prior Knowledge

Baviskar et al. (2009) identify bringing relevant background knowledge to the 'foreground' as a key event in any constructivist lesson. This is because it helps with linking new knowledge to what the students already know, a practice also supported by cognitive neuroscience research (Brod, Werkle-Bergner & Shing, 2013).

In the lesson, this is formally planned to be done three times. The first time, this happens in the pre-lab exercise. Here, background information is presented in an online learning module. The information is presented with a basis in what these students all learned in BIOL101 (all of them took that course before diverging into the two different programs). By going back to first principles, I ensure that the information covered by the students on their own is not too challenging, and also refresh relevant information in their minds.

Understanding of the material covered in the online module will be verified using direct questioning at the start of the lab. It also serves as the second time that I elicit prior knowledge. The pre-lab questioning will review some of the questions I initially posed in the online module and promote a brief discussion of the answers. This not only serves to elicit prior knowledge, but can also be used as a starting point to address some misconceptions and gaps in knowledge.

The third time is during the quiz planned for that day. Students will be asked questions relevant to this as well as the previous lab. Since my students tend to be motivated by grades, it is very likely that they will take the time to review the relevant information before coming to class.

In addition to these three preplanned events, I will be circulating in the lab throughout the practical portion of the lesson and asking more questions – a form of soft scaffolding described by Brush & Saye (2002). Some of these will be dealing with the students' current work, but others will serve to make linkages to previous knowledge. This creates the "question-rich learning environment" promoted by So (2002) and should serve to 'foreground' the relevant bits of prior knowledge.

2. Creating Cognitive Dissonance

One of the biggest challenges to gaining knowledge by students is the likelihood for a misunderstanding of a concept upon which other knowledge will be based.

Since my online module relies on independent learning, I am very cognizant of the perception problem; attempting to transfer conceptual knowledge to a student using words alone is problematic due to our inability to ensure that the meaning extracted from those words is what was intended (von Glasersfeld, 2015). This problem was elegantly demonstrated by Riemeier & Gropengießer (2008) in their investigation of how the meaning of the word "division" (ie. becoming smaller) can affect students' understanding of the concept of cell division (ie. making more cells). This is why my online module focuses on very basic declarative knowledge and presents information in a multimedia format – the text is accompanied by images as well as videos. It is also why I plan to do a quick check of student understanding at the start of the lab.

While being careful to not introduce any new misconceptions, I hope to be able to use some previously held student misconceptions to introduce some cognitive dissonance (Baviscar et al., 2009). Such misconceptions are very common – an attempt to compile literature dealing with this very topic up until 2009 boasted more than 8400 entries (Duit, 2009) – and can be very difficult to overcome, but seem to be the best target for making gains in knowledge (Tanner & Allen, 2005).

With this in mind, I plan to use a questioning style like the one described by Brody (2018), throughout the class to draw out any such misconceptions and either address them directly, or have students try to work through them in groups. Additionally, there is one specific problem that I am fairly certain will come up – this is in our discussion of the cell count and viability data.

Students will be performing counts individually and will be putting up their results on the board. Usually the numbers they present differ substantially from one another, but noone seems to ever think that it's a problem until I point out to them that all their samples came from the exact same original test tube (same culture), and thus the numbers should be very similar. This will lead to a discussion of what may have caused some of the discrepancies, identifying outliers, the problems with taking an average, and what could have been done differently (and should be done next time). This part of the lab has produced a lively discussion in the past.

3. Application of the Knowledge with Feedback

Another place where I hope to have students work through cases of cognitive dissonance is the quiz. This will take the form of a two-stage cooperative quiz like those suggested by Yuretich, Khan, Leckie and Clement (2001). Here, students will be given an opportunity (in 'stage 2') to discuss and compare their answers to the quiz with their peers and try to arrive at a correct answer together. This matches up well with Baviskar *et al.*'s (2009) suggestion of having students compare their individual constructs with their cohorts. When reading this part of the Yuretich *et al.* (2001) paper, this idea struck me as a brilliant and I am eager to try it out.

Baviskar *et al.* (2009) also point out that having students apply their knowledge to a new situation/problem allows the student to further see the interconnectedness of old and new concepts, this is something I hope to do through my concluding exercise (which will apply all the concepts I tried to target in this lesson), as well as through the reflection activity.

4. Reflection on Learning

Baviskar *et al.* (2009) argue that the student needs to be made aware that learning has taken place; they suggest a variety of tools like: presentations, written papers, and teaching a concept to a fellow student. Reflection is generally acknowledged to be a very powerful learning tool (Moon, 2001), I therefore felt it was important to incorporate it into my lesson plan, as well as the overall course.

One of the places where I hope to be able to promote reflection is in the post-lab questions, but a bigger place where I hope this happens is in a long-term exercise with scientific literature.

At the start of the Animal Cell Culture course, I provided groups of students with a research article and assigned them the task of presenting it to the class at the end of term. I selected the articles based on their use of all the methods we will be discussing in class – at the start, it's unlikely any part of the article will make much sense to the students, but as we progress through the course, students should start to be able to make sense of the data being presented. I plan to make them aware of this as we progress deeper into the course.

Part B:

Course:	**BIOL 451 – Animal Cell Culture Lab**
Lab / Week:	**Lab 3 – Determination of Cell Concentration and Viability**
Materials needed:	Online Learning Module Lab Protocol Handout PPT slides Whiteboard and coloured markers Microscopes Hemacytometers and coverslips Cultured cells and Trypan Blue stain 70% Ethanol squirt bottles Eppendorf tubes, micropipettors and tips
Overview:	
Students will be introduced to one of the most basic skills needed for working with cultured cells – determination of cell concentration and viability. Students will learn to properly set up a hemacytomoter, and to make the calculations needed to determine the concentration of their cell samples and assess the health of the culture. Students will use their results to determine the volume of the culture to use in setting up plates for the next week's experiment.	
Learning Objectives:	**Students will:** • Demonstrate their knowledge of Lab Safety Rules by coming in dressed appropriately. • Describe the composition of media used in animal cell culture. • Explain how cells attach to the culture vessels. • Explain why Trypsin is needed and why it's only used for short periods of time • Demonstrate good technique in the setting up of the hemacytomoter. • Explain how Trypan Blue helps determine cell viability. • Perform an accurate cell count and calculate cell concentration
Pre-Lab Preparation	
Students will be asked to read complete an online learning module and read the lab protocol before attending lab. Online module provides some theoretical background information about the procedure, and introduces the concept of control of transport across the cell membrane as an indicator of cell viability.	

Lesson Development:	**Time:**
The lesson is divided into 3 parts: ***Discussion of Pre-Lab Problem:*** Students were given a problem describing some confusing results, and asked about the assumptions being made, which may not be justified. The idea is to recognize	 **~ 15-20min**

that cells in the presented experiment may not have been seeded equally and thus the final results can't be fairly compared to one another.
(this establishes the importance of this week's topic)

Instructor Demo:
~ 20-30min

Instructor begins with a brief demonstration of setting up a hemocytometer. This will focus on the proper setting of the coverslip (and how this will ensure the proper volume in the counting chamber) as well as the process of loading the sample into the counting chambers.

Student Practical Exercise:
~45-60min

All students will perform a count of a sample of the same initial culture. *~ 30-40min*

All their calculations should theoretically provide similar results, but usually they don't. We will use this opportunity to discuss random variation between samplings, sampling error, and ways in which this can be minimized. *~ 15-20min*

We will also try to identify any "outliers" in the class data.

Conclusion:

Students will decide if the provided cell culture can be used for the next experiment (ie. is healthy enough) and determine the amount of the culture to use for setting up a 96-well plate (20000 cells and 100ul of total media) (time: 10-15min)

Reflection Activity

Students are normally asked to answer some post-lab questions from the lab manual in their notebooks. This week's questions deal with ensuring consistency in sample loading, and the differences between a live count and a total cell count.

- Based on what you learned today, what specific things could you do in setting up your plate for next week's lab to ensure that all the loaded wells start with the intended number of cells?
- If you used the 'total cell count' to determine the concentration of cells in your culture, and then used that number when calculating how many ml of cells to plate, how many actual living cells would you be plating?

Assessments:

- Two-stage, cooperative quiz
  - This week's lab will need to include the first quiz, which will cover material from the first three labs.
  - The quiz will contain:
    - a few simple memory-based questions (most of my students are used to this type of question and only know how to study for this type of test)
    - at least one calculation question
    - at least one data analysis/interpretation question
  - Students will be given 15min to complete their first attempt
  - Students will be given 15min to complete the second attempt in their groups.

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