Teaching Notes for Gene Expression in Stem Cells (Student Version C)

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Implemented in BIOL 1106 (Biology for Science Majors Laboratory I)

What did you do to make the module work for you and your students?

I used Student Version C of Gene Expression in Stem Cells handouts as written, but added the verbal instructions for students to calculate standard error in addition to the mean for each treatment (calculation of the means is part of this version). I also had the students do these calculations in Excel.

I scaffolded the calculation of basic summary statistics (mean, standard deviation, and standard error), data graphing, and data interpretation from the very first class meeting and throughout the course. In the first lab student groups were required to work through the case study "Antibiotic Resistance: Can We Ever Win?" In the process, they "collected" data, calculated the basics statistics and graphed the data by hand. As part of later lab exercises, students learned to do the calculations and graphing using Excel, including using their calculated standard errors to add error bars to their graphs.

In addition, the first time we used Excel, I lead the students through how to use the built-in formulas and write their own formulas by projecting the steps from my computer while they did the same steps on school computers individually. The next time we used Excel, I had them work in groups and do the steps themselves while I roamed around helping groups that got stuck. Students groups that finished quickly were encouraged to help other groups. I used this latter approach for all subsequent sessions in which we used Excel. I decided to use this method rather than providing a detailed handout on using Excel after discussions with others in my group in the Data Nuggets Faculty Network. My goal was to focus on getting the students using Excel and being comfortable enough to be able to use any version of Excel or similar spreadsheet. In addition, Excel versions change quickly enough that students may have a different version on personal computers than they have available at school.

Instructors that would like to follow my scaffolding approach, may wish to use the same case study that I used in the first lab meeting:
http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=666&id=666

For interpretation of error bars, instructors may wish to prepare by reading the "Some Basic Statistical Procedures" from Radford University: http://www.radford.edu/~biol-web/stats.html
or the article:
Kugler, C., J. Hagen, and F. Singer. 2003. Teaching Statistical Thinking: Providing a Fundamental Way of Understanding the World. Journal of College Science Teaching 32 (7): 434-439.
(link requires JSTOR access): https://www.jstor.org/stable/pdf/42992329.pdf
This paper provides the basis of how I discuss error bars and their interpretation with students that I learned from colleagues at Radford University.

What kind of background knowledge is required?

Students should have a basic understanding of gene expression and molecular techniques (I covered these in the lecture course before the last lab class).
In addition, as mentioned above, students should already have learned and practiced how to calculate basic statistics and graphing skills by hand and then using Excel, including error bars as discussed above.

What worked well? How did these materials help you emphasize a particular concept or set of skills?
Having students first calculate basic statistics and draw graphs, including error bars, by hand before introducing these skills in Excel allowed the students to first focus on understanding and getting comfortable with the math, graphing, and data interpretation. Over the semester, I then had them calculate basic summary statistics and graph data collected in various experiments by hand or in Excel as part of the scaffolding for the quantitative student learning outcomes for implementing this module. Because many of our students are not familiar with Excel or similar applications AND are not confident in their quantitative skills, getting comfortable with calculations, graphing, and data interpretation first is important.

What do you plan to do differently the next time you teach with this module?
Next time I teach with this module, I would like to take the data analysis a step further and have the students perform an appropriate statistical test, such as a t-test, as part of this exercise. I've used chi-square (to interpret data from genetic crosses) but no other statistics in this course. Based on my experience with this module and the scaffolding I provided in basic summary statistics, graphing, and data interpretation, I think they could handle such an addition. I would scaffold this part by explicitly pointing out that the interpretation of P-values that students learn as part of the chi-square also applies to the t-test and other statistical tests.

What do you wish you knew before you taught with it, or what advice would you give to a colleague interested in adopting it?
I liked using this module as a final application many of the quantitative skills they practiced throughout the semester. I highly recommend that any other adopters at the college level scaffold these quantitative skills in a way similar to that described here.

Assessment
I used two forms of assessment:

1. **<u>In class assessment strategy:</u> My class is small (10 students), so I will review graphs from each of the student groups (of 2-3 students) during the class to verify that they can apply the skills. They will also answer the questions in the activity within their groups. We will then review the graphs as a class, discuss the graphs and their interpretations, and then discuss the answers to the questions. Students will be given verbal feedback on their graphs, their interpretations, and their answers to the questions.**
2. **<u>Final exam assessment strategy:</u> I will assess students' knowledge and understanding of the material presented in the activity and their interpretation of the data on the final exam using a variety of questions types. (Questions provided below.)**

<u>Final Exam Questions</u>

<u>Fill-in-the-blank</u>
The "P" in iPS stands for _____, which means the cell has the capability to turn differentiate into many different types of cells.
Answer" Pluripotent

<u>Multiple choice (correct answer indicated by *)</u>
Which of the following were measured in the comparison of fibroplast and iPS cells?

a. amount of DNA
b. sequence of DNA
*c. amount of mRNA
d. sequence of mRNA
e. amount of protein

The genes that do not change expression much when a fibroblast is induced to become an iPS cell are sometimes called “housekeeping” genes. Such genes have said to have _____ expression.
*a. constitutive
b. regulated
c. altered
d. mutated

Short Answer (Answers in **bold** type.)
What question was Adam Heck trying to address?
How does gene expression differ between human fibroblasts and iPS cells?

For 3 points extra credit, describe the results of his experiment and what they mean.
Answers should mention the that housekeeping genes did not differ much in their expression between the two types of cells, but that genes encoding pluripotency factors had higher expression in iPS cells and those encoding developmental factors had higher expression in fibroblast cells. For full credit, the answer should also mention that these results do indicate differences in gene expression and that these differences appear to coincide with differences in cell functions.

For an additional 2 points extra credit, tell me what question you would ask next and why.
These can vary quite a bit. The teacher notes that are provided with this Data Nugget includes some ideas.