Experimental Design & Onboarding New Trainees: Reflections from the TMM Pre-Conference Workshop ‘Surviving and Thriving in Grad School’

Reflections from the 2022 Till & McCulloch Meetings

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Graduate school is a very rewarding, but trying, experience. It is a crash course in how to be a scientist and critical thinker. A student learns many valuable skills by the time they graduate, but it can be difficult to recognize what skills they have acquired by the end of their program. At the Stem Cell Network’s 2022 Till & McCulloch Meetings (TMM), the Trainee Communications Committee (TCC) organized a pre-conference ‘survival guide’ to thrive in graduate school. The first half of this pre-conference workshop focussed on experimental design and included many live quizzes. This blog will unpack which concepts trainees struggled with the most, and which could be used to help onboard new trainees into a laboratory. We will also touch on some of the tips Dr. Cara Ellis (invited speaker) gave trainees, as well as the outcome of our ‘critical thinking’ group activity.

Statistics and the ‘*n* value’ are the two concepts new graduate students struggle with the most

There were two activities in Dr. Ellis’ presentation that are important to highlight. The first activity asked, “what words do you associate with statistics?” A word cloud of audience answers was generated in real time. ‘Complicated’, ‘pain’, ‘math’, ‘hate’, ‘useful’, ‘informative’ were some of the most common words associated with statistics, suggesting that the trainees understood the usefulness of statistics but struggled with the analysis.

It is possible the struggles arise from a lack of sufficient onboarding for new trainees. If laboratories facilitated activities that walked trainees through statistical analysis relevant to their project(s), it may go a long way to reducing their stress in graduate school. It could, for example, make trainees feel confident that their statistical analyses are sufficient. In future pre-conference workshops, the TCC will dive deeper into why trainees feel statistics are ‘complicated’ and ‘scary’.

The quiz results about sample size (the ‘*n* value’) were interesting. In this live quiz, Dr. Ellis gave the trainees a visual representation of an *in vivo* experiment —accompanied by descriptive text— and asked them (using a multiple-choice question format), “what is the ‘*n* value’ of this experiment?”

Surprisingly, across three different scenarios, less than 2% of trainees correctly identified the '*n* value'. Not understanding an '*n* value' certainly makes conducting statistical analysis harder and could be one of the underlying reasons that trainees felt statistics were 'complicated'.

Taken together, the activities could suggest that a trainee's feelings towards graduate school may be improved by activities that teach them these foundational experimental-design skills. Currently, trainees feel uncomfortable with essential research skills. These skills can often be overlooked by courses graduate students can take, so it may be up to an individual laboratory to teach these skills in meetings.

Try our 40-minute activity at your next lab meeting: have your trainees critically evaluate a single figure!

Graduate students are expected to create competent figures for their theses, but they may not have the experience to know what separates a satisfactory figure and an outstanding figure. Many laboratories have journal clubs to teach trainees cutting-edge information and critique papers. While this is an important activity, it can feel overwhelming to new graduate students, as there are so many skills trying to be taught simultaneously. Journal clubs are also time consuming, especially if your goal is to allow everyone in a group to speak. The TCC created an activity that kept the spirit of a journal club, allowing trainees to learn and critique, but allowed the activity to be completed in 40 minutes.

An essential skill to critique a manuscript is to be able to interpret data, without reading the author's interpretation. Thus, the TCC made figures using published data and gave them to the trainees. Accompanying the figures were a set of 3-5 guiding questions for the trainees to consider. Over the allotted 40 minutes, the trainees discussed answers to these questions in groups of ten.

The TCC observed several benefits to this activity. First, the trainees could quickly interpret a figure regardless of their background or year-in-program, as they could rely on the knowledge of other group members as needed. Second, in this environment, trainee's felt comfortable asking open-ended questions such as "why does the figure look like this?" These questions highlighted clarity issues in the figures and allowed trainees to identify areas the figure could be improved. For example, the trainees could not understand the statistical analysis used based on the notation. This insight is helpful, as it could allow a laboratory to develop their standards for data reporting. Third, even though trainees looked at a single figure, there was still a lot of opportunity for them to discuss the critical questions: Why was the experiment done this way? Was the experiment physiologically relevant? In our activity, we (the TCC) witnessed many of the same discussions that occur in journal clubs, and the activity was able to be condensed down into a much smaller time slot. In our future independent research laboratories, we will certainly bring this activity to our meetings.

Tips for trainees

Dr. Cara Ellis had many tips for trainees during the workshop. For those unable to attend, these were seven takeaway messages that stood out to the TCC.

1. **Design experiments to randomize data.** Not randomizing treatment or patient groups can bias data.
2. **Decide on a target '*n* value' before starting experiments.** Data will eventually be significant if you increase your '*n* value' by a 1 indefinitely. This may be a false positive.
3. **Do not exclude datapoints from analysis without a reason.** Absent data can bias results. Mixed models (statistics) can overcome missing datapoints, but the data has to be missing at random. Contact a statistician if you have missing datapoints and are unsure how to handle the situation.
4. **Show individual datapoints on graphs.** Graphs without datapoints make it difficult for other scientists to interpret results.
5. **Do not overinterpret your data.** This can lead to a level of certainty that can cause you to overlook alternative explanations and may lead you down the wrong path of inquiry.
6. **Experiments, manuscripts and theses are often not perfect, but try to make them the best that you can with your knowledge at the time.**

Tip 7: You may have to ignore these tips (for now)

While Dr. Cara Ellis offered these tips as best practices when designing experiments, she also acknowledged that sometimes you cannot follow these practices because of reasons outside of your (the trainees) control. As Cara showed a figure from one of her published articles, she explained, "I spent years trying to get this data presented in a different way, but co-authors who were senior to me wanted the data shown like this." The audience acknowledged it was a difficult figure to look at. Cara went on, "sometimes you have to do what your supervisors say, but that does not mean you have to do it like that for the rest of your scientific career."

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Building a strong, multiprong onboarding strategy for trainees starting their scientific careers will make the laboratory more productive and less stressful

Graduate programs put trainees in a fast-paced environment whereby they are required to juggle multiple experiments while learning many new skills. Any addition to the culture of a laboratory that can mitigate the stress that comes with graduate school would go a long way to improving the mental wellness of trainees. Importantly, it does not need to consume a lot of time to introduce changes. We suggest trying short 'journal clubs' that focus on a single figure, as this allows trainees to develop critical thinking skills that pertain to experimental design and figure construction — skills that are essential to write a good thesis. These skills are helpful to have as early as possible in a graduate program, as they are used throughout a graduate program. Background knowledge is more relevant later in a graduate program when the student is 'deciding the next experiment' or writing a manuscript. From experience, long journal clubs tend to focus on background information and evaluating the impact of a study, which are high level concepts that may lose new trainees.

While there is likely no perfect strategy to onboard new trainees, we must always remember that graduate school is hard, and any opportunity to reduce the overwhelming stress of new graduate students would pay dividends.

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