Guidelines on how to Write a Thesis/Paper, and the Presentation Slides *Efficiently*

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Dear Student,

Here are some step-by-step guidelines on how to communicate your research ideas and outcomes in the form of a well-written thesis, proposal, or a paper. It is possible for the un-initiated student to spend an excessive amount of time and effort, and still end up with a poorly written document. Usually, a presentation accompanies the thesis/paper, so my guidelines include the production of the presentation slides as well. By following my guidelines, you should be able to reduce the time and effort, and produce a better document.

Step 1: Create the PowerPoint presentation first. This presentation will define the "story board" for your thesis/paper. Following this storyboard will ease the thesis writing, and eliminate the need for large-scale editing.

There are plenty of past examples of good presentations from my lab available for you on the FARSIGHT servers. You will notice that all of these presentations follow a well-established template (dark blue background, white and yellow text, etc.), and a pattern (specific sequence of sections). *Following this template is the fastest and best way to prepare your presentation*.

Below are the main sections that should be in your presentation, in order. In practice, it is easier to prepare the presentation in reverse order. Start with results, then methods, etc. Most presentations last 45 minutes, so you should encapsulate your presentation in about 40 slides, and maintain the rest of the slides as backup material for answering questions.

Images: Pull together your images to illustrate the data and its significance, the image processing challenges, your methods, and results. **Whenever you show an image, make sure to include a scale bar so the reader can understand how big objects are in physical units (micrometers, seconds, etc.). Pixel units and integer values representing frame numbers or time points are not acceptable.**

1. **Title Slide**: choose a title that invites attention to your work, and highlights the most important accomplishments/claims. Make sure to list your thesis committee members on this slide.
2. **Background and Significance**: using figures and text, explain the scientific background to the problem that you have solved (or you are proposing to

solve), and explain why solving this problem is important (significance). Usually, our biologist collaborator(s) can help you formulate this slide most effectively.

3. **Problem Statement**: Concisely list the overall goal of your study, and then list the specific aims in plain language.
4. **Challenges**: using figures and text, explain what is hard about the problem that you are solving. Usually, one can show images that are noisy, variable, complex, large, or otherwise challenging. Use arrows and text to highlight the specific challenges in each image.
5. **Prior Literature**: using a table or otherwise, identify the most important papers from the prior literature, and state how your work relates to them. Usually, your work would improve upon one of more aspects of the prior work, and it is helpful to say so. Sometimes, you may have adopted great ideas from some of the prior work, and it is helpful to acknowledge that. *Make sure to cite recent papers – your committee members will think that you are stuck in the past of your citations are more than 2 years old*. Keep in mind that there is a pragmatic aspect to selecting the papers to cite. You should make sure to cite papers of the leaders in the field, and make sure to cite papers from our own laboratory. You don't want to be in the unfortunate position of being told that you are unaware of relevant work! Use PubMed and Google Scholar frequently to screen for related work.
6. **Methods**: Use a series of slides to describe the central technical ideas that form the basis of your work. Make this sufficiently mathematical and deep. Add references to papers at the bottom of each slide. You are expected to demonstrate a deep understanding of the field as you go through these slides. *Whenever possible, highlight your advances over the prior literature*. The slides in this section will be somewhat heavy in terms of content. Remember that when presenting from these slides, you will not plow through every word, but rather state the main message while being prepared to answer any in-depth questions. The detailed content on these slides will provide ready access to materials that will help you answer questions more effectively.
7. **Experimental Results**: Start by describing the purpose of the experiments. Then describe the quantitative and qualitative evaluation criteria that you will use to evaluate your results. Then describe your experimental results. The goal is to show that your methods are superior to the prior methods. *Make sure to provide a clear interpretation of your results, and explicitly state their significance/value. Do not just leave the interpretation to the viewer*!
8. **Summary of Contributions**: This slide should match the Goals slide. In other words, your contributions should bring closure to your presentation by stating that you have overcome the stated, challenges and accomplished your goals. This is also a good place to list your publications.
9. **Future studies**: This is your chance to comment on the broader implications of your work. Describe ways to extend and/or apply your work on a grander scale.

Presentation Checklist:

1. **Projector Compatibility Check:** Actually test your slides on a low-quality projector. Remember that your desktop monitor is far superior to the projector that you will use to deliver your presentation. Make sure to use large fonts with contrasting colors (red text against a dark blue background will not show well, but white/yellow text will show nicely).
2. **Consistency Check**: Make sure that all the arrows and boxes are thick enough to be seen on a screen. Make sure that all equations are formatted using the same tool. Symbols for the same variable should look EXACTLY the same in all equations throughout the presentation. The color scheme should be exactly consistent throughout the talk. Use white text (bold without serif, like Arial/ Trebuchet) for normal text, and yellow for highlight text. *It is extremely important to be consistent in your use of fonts and colors, otherwise you will appear unprofessional.*
3. **Animation Simplicity Check:** Animations are a great way to bring your ideas alive on the screen, but please use them sparingly. Overly complex and frequent animations will make your audience dizzy rather than enthralled. The best way to include movies in your talk is to paste GIF animations. This will result in a larger file size, but don't worry. The resulting portability is well worth the investment in megabytes.
4. **Take-home message Check**: Check that each slide has a clear take-home message (conclusion) that leads naturally to the next slide.
5. **Validation Check:** Make sure that all of your claims are supported by experimental results, and that the results are validated. When possible, use statistical significance measures to describe your confidence in your results.
6. **Spelling and Grammar Check:** PowerPoint indicates spelling and grammar errors. Make sure that there are no errors in your slides. If in doubt, ask a colleague if they can understand your message easily.
7. **Knowledge check**: Make sure that you have sufficient background knowledge to answer questions for each slide. Study as needed.

Step 2: Show your presentation to your lab mates first, and then to your advisor.

You should seek comments from as many people as possible, and use peer feedback to make your presentation better. Once the presentation passes the initial checklists noted above, your advisor is in a good position to provide in-depth feedback in an efficient manner. Expect to go through multiple revisions of you presentation. Once the advisor is satisfied, you may start your thesis writing.

Step 3: Write your thesis/paper, in reverse order

Do not start with the abstract/introduction – you can easily get stuck with these sections. Instead, start with the Experimental Results and Conclusion sections, then the Methods section, and so on. The abstract should be written last.

Again, there are numerous examples of past theses that you can learn from. Here are some of the most critical practical issues. Most of these issues arise from the way people read theses. Readers rarely start from the beginning and work their way to the last word. They usually look at the figures first, look at the conclusions next, and then read the introduction. If still interested, the reader will dig into the methods section, and then re-visit other sections as needed to grasp the message of your thesis. As he/she flips around your document, impressions are being formed. For example, inconsistent formatting or poor grammar will irritate the reader, and make them less favorably inclined to endorse your work. With this in mind, here is a checklist for you:

1. **Document Structure Check**: the entire document should have a hierarchical structure. At the lowest level, make sure that each paragraph has a lead sentence, and a closing sentence. Make sure that each section has an introductory paragraph and a closing paragraph. This structure will enable readers to go over your thesis quickly.

2. **Three-part Figure Captions Check:** Every figure should be big and clear, and on a separate page. Remember that the readers may be older, and have poorer eyesight than you. Make sure to use bright colors and such other tools to make your figures easy to see. Readers should not be assumed to understand the message by just looking at the figure. Readers should not be assumed to even read the main text where the figure is described. On the other hand, the figure caption should be a stand-alone item that should describe everything needed to understand the central message conveyed by the figure. For this, make sure that each figure caption consists of three parts. The first sentence should describe what the figure is about, and what purpose it serves. Next, you should walk your reader through each panel of your figure, and point out the important items (these should be highlighted with arrows, boxes, highlight colors etc.). The caption should then provide a closing sentence stating the conclusion (take-home message). *Sometimes, you may adopt/borrow figures from other colleagues – make sure to acknowledge them clearly.*

3. **Graph Check:** Whenever you have graphs, make sure that each of the graph axes is labeled with at least 2 items: (i) indicate what is being plotted, using appropriate mathematical symbols; and (ii) state the units, again using the correct symbols. Use physical units whenever possible, rather than pixel units. Finally, make sure that the fonts and lines are thick and easy to view. The font on graphs should be consistent with the thesis text. Avoid colors

when possible, so your graph can be understood even from a black/white photocopy.

4. **Equation Presentation Check**: Mathematical symbols and equations are extremely important to a paper/thesis, and presenting them in a professional manner is extremely important. Before you start typing your equations, make sure to come up with a consistent notation. Make sure that symbols are not reused.

   Now, there are two kinds of equations – inline equations, for example, $I_T^2(x, y, t)$, and offset equations, for example:

$$I_F = \prod_{n=1}^{N} I_F(n), \qquad (1)$$

   where $n = 1, 2 \ldots N$ is the index. There are at least FOUR parts to each offset equation: (i) the equation (this should be centered on the line); (ii) the punctuation following the equation (for punctuation purposes, treat the entire equation as if it were a single word); (iii) the equation number (so you may reference this equation in the text); and (iv) a follow-on explanation of symbols used in the offset equation. Quite often, you will need to add a sentence preceding the offset equation that explains the purpose of the equation, and relates the names of variables to mathematical symbols. For example, the sentence "The total image flux, denoted I_F, is the product of the image fluxes for the N elements, and is mathematically written as follows…"

   In a paper/thesis, you are very likely to have a sequence of equations. These should be interspersed with explanatory text. Without this "glue text," the reader may have a hard time understanding your work. *The consequences of unclear writing can be awful, especially of the reader is judging your work!*

5. **Equation Formatting Check**: Make sure to use the same equation editor for both inline and offset equations. You should make sure that each symbol looks exactly the same in each equation, *regardless of where it is* (inline equation in text, offset equation, equation in a figure, etc.). DO NOT BE LAZY ABOUT THIS. A common temptation is to type inline mathematical symbols without the equation editor. Here is a bad example:

   "The total number of elements is denoted as N."

   Here is the correct version:

   "The total number of elements is denoted N."

   Make sure that there is no re-use of symbols that may cause confusion. When you imply a multiply or a cross product, use the proper symbol "×" rather than the letter x. The best way to ensure consistent and clear use of

symbols is to create a glossary of symbols that you follow consistently. *Again, do not be lazy about this issue*. Typing equations correctly at the outset will save you a lot of effort later.

6. **Acronym Check**: Avoid/minimize the use of acronyms to the extent possible. Too many acronyms make it harder for a reader to understand your work. Use acronyms for only the most commonly used phrases.

   Make sure that all acronyms are defined in a sentence *before* they are used again. For example, "the Point Spread Function (PSF) of a microscope is a three-dimensional (3-D) profile describing the blurring pattern of a microscope." It does not hurt to define acronyms again a few more times in your thesis so the reader does not have to search for their meaning.

7. **Programming Variables Check**: You should never have an equation with programming variable names in it. For example, you may have a variable in your computer program called "counts". This does not mean that you should use "counts" in an equation directly in your thesis. Instead, create a symbol, say *N*, and use it instead.

8. **Citation Check**: All citations should be handled in a consistent manner. One frequently problematic phrase is "et al." referring to multiple authors. You should place a period after the "al" but not after the "et". Here is the reason for this rule. In Latin, "et" is a full word that means "and". On the other hand, "al." is the short form of "allii" a word that means "allies," or "others." *Look it up*.

9. **Capitalization Check**: All titles should be in Title Case. The second part of a hyphenated phrase should be in lower case, for example "Long-term".

10. **Spelling and Grammar Check**: It is better to compose your text in MS Word rather than LaTex, because the former checks your spelling and grammar, whereas the latter does not check for grammar errors. Regardless of what tool you use, make sure that there are no spelling and grammar errors – these are distracting and embarrassing. One common type of error that is often not flagged by automated tools is a missing article ("the"). Here are some websites that you must study:

    http://learnenglish.britishcouncil.org/en/grammar-reference/articles-1
    http://learnenglish.britishcouncil.org/en/grammar-reference/articles-2
    http://en.wikipedia.org/wiki/Article_(grammar)

11. **Abstract Completeness Check**: The abstract should be written last. It should have all of the essential elements in it to form a complete summary of the paper. Take a look at this website for guidance:

    http://www.ece.cmu.edu/~koopman/essays/abstract.html