Guidelines and Recommendations for Defending a Senior Thesis or Undergraduate Honors Thesis in Biomedical Engineering

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** Adapted from a guide generated by Prof. Tanmay Lele in UF Chemical Engineering

Adoption Date: January 2017
Last Review Date: February 2017

Overview

The Department of Biomedical Engineering defines active research as participating in the design of experiments, prototype development, data collection, and/or data analysis. Depending on the project available in your advisor's lab, you may perform research that meets one or all of these definitions. Our anticipation is that students completing a senior thesis or undergraduate honors thesis will have participated in multiple areas of active research during their time at UF, and that their thesis will be reflective of these activities.

The senior thesis and undergraduate honors thesis defense involves an examination by three professors of the student's skills and training in active research. It is important to note that the success or completion of the project itself does not necessarily lead to the completion of the senior thesis and undergraduate honors thesis. Many projects in biomedical engineering take years to complete, or have ongoing hypotheses and objectives that evolve over time. Instead, the senior thesis and undergraduate honors thesis is an examination of the student's skills and training in active research; and, the presentation and defense of the thesis will test and examine these skills in our graduating students.

Of course, this can be an intimidating prospect especially if the professors are experts in your field of research! Our professors will calibrate their expectations based on the time you have spent working in the field. However, there are some basic expectations that apply whenever a student stands up and defends his/her research. This document has been prepared (with the help of Prof. Tanmay Lele in Chemical Engineering) to help you defend the thesis exam successfully without (undue) stress.

Requirements, Expectations, and Critical Deadlines

1) BME requires that all senior thesis or undergraduate honors thesis students register and complete a minimum of two semesters of EGN4912 in good standing prior to graduation. It is expected that most students completing a senior thesis or undergraduate honors thesis will register for EGN4912 three or more times.

- Note, it is not required that EGN4912 be taken for credit.
- The 2nd semester of EGN4912 may occur during the final semester for the graduating student, meaning the student must have enrolled in EGN4912 at least once prior to the declaration of the senior thesis and undergraduate honors thesis.
- The 2 semesters of EGN4912 must occur under the same academic advisor. In rare instances, a change of academic advisor may be approved by the Associate Chair of Undergraduate Programs. These requests are only allowed when the project is clearly a continuation of a single research project (examples: student moved between collaborating labs, student begins data collection in medical center then completes analysis in engineering college).

2) Committee must be identified by second Friday of the spring semester. The faculty committee should include:

- At least one primary BME faculty member (non-affiliate)
- An additional primary BME faculty member or affiliate faculty
- An affiliate faculty or external faculty member

3) Comply with all University of Florida Guidelines and Deadlines and complete the appropriate paperwork.

Available at

https://www.eng.ufl.edu/students/resources/graduating-with-honors/ and

https://www.eng.ufl.edu/students/wp-content/uploads/sites/5/2015/06/Honors-Thesis-Instructions.pdf

Critical BME Deadlines:

Declaration Deadline: The student must identify their supervisory committee and submit the Supervisory Committee Form to the BME Academic Office by the end of the second week of classes during your graduating term.

Defense Deadline: The student must defend the thesis to the supervisory committee and submit the Final Oral Examination and Honors Thesis Submission Forms to the BME Academic Office no later than one week prior to the last day of classes in the graduating semester. Forms submitted after this deadline will not be accepted. The student must also complete the necessary paperwork with the library and college (see link above).

Submission Deadline: An electronic copy (PDF) of the completed thesis must be submitted to undergrad@bme.ufl.edu by the last day of classes in the graduating semester.

Defense Documents

A senior thesis and undergraduate honors thesis in biomedical engineering must include

1. *A written thesis, submitted to the supervisory committee no later than* ***7 days prior to the oral defense****.* The thesis should include
    - A title page identifying the thesis title, presenting student, supervisory committee, and oral defense date.
    - A 250 word abstract
    - A main text with a minimum of 10 written pages
        - The abstract and title page are not included in this page count.
        - References at the end of the thesis are not included in this page count.
        - Appendices are not included in this page count
        - The main text should have margins no smaller than 1 in.
        - The main text should have fonts no smaller than 12 pt.
        - The main text should have line spacing of 1.5 lines exactly (do not single or double space)
    - A bibliography for the thesis. There is no page limit for this section.
    - Appendices are not required, but may be used, if necessary. Applicants should be aware that the supervisory committee is not required to review appendices, and thus, appendices should only be used as supplementary material.
        - Absolutely, *do not include critical figures in the appendices*. Critical figures should be in the main text, as your committee is not required to review the appendices.

2. *An oral examination and defense to a committee of 3 faculty.*
    - The student should prepare a 10 minute presentation that covers their thesis work.
    - Students should also be prepared for a minimum of 20 minutes of questions and answers.

<u>Tips and recommendations for preparing the written thesis</u>

The senior thesis and undergraduate honors thesis in BME should be written in a similar format to the scientific literature in biomedical sciences: Abstract, Introduction, Materials and Methods, Results, and Conclusions. It is recommended that figures, if any, be included in the body of the text.

The Abstract (250 words or less).

As with the scientific literature, the abstract should stand alone and not reference the main text. Many students find it easier to sub-divide the abstract into the same sections as the paper (also known as a structured abstract), writing a few of the main points from each section. This is completely acceptably, but not required. However, the abstract should highlight the main objective, hypothesis, and conclusion from the conducted research.

The Introduction

Tip #1: In biomedical sciences, problem identification and problem definition is paramount. Successful students should be able to identify the basic aim and/or scientific hypothesis of their research – what is it we don't know that we seek to understand better? This ideally should be identified early in the project and potentially prior to the plan of study.

Effective research aims should be identified in the introduction, with introduction reviewing the relevant literature and defining the problem. Ultimately, the main aim or objective should be able to be stated in one sentence near the end of the introduction:

The aim/objective of my research is to…
1) Evaluate gene expression changes due to various inflammatory mediators in activated macrophages.
2) Design a drug delivery system to release a bioactive agent over 5 days.
3) Measure action potentials in the sciatic nerve following reconstructive surgery in the rat.

Also, research aims in biomedical engineering are typically paired with testable scientific hypotheses or with engineering objectives. Like aims, objectives and hypotheses are typically stated in one or two sentences, such as

Aim: Design a mechanical testing chamber to evaluate tissue engineering blood vessels

Hypothesis: In engineered blood vessels, cyclic pressure will result in greater matrix deposition relative to static loads.

<u>Being able to condense your research into definable aims, objectives, and hypotheses is a critical part of the thesis introduction.</u>

Tip #2: Identifying the significance of a research activity is highly important, as is identifying what questions are left unanswered by your research activities. Why is your research activity significant and what can it add to the field that is not already know? What are the consequences if you are able to meet the goal of your research? And what assumptions are your making and how may your conclusions change if your assumptions prove to be false? By nature, biological systems are highly complex and often inter-related. To analyze and assess these systems the following must be done:

A) Understand the field, what is known, what is not known. To do this, students should demonstrate a reasonable understanding and ability to reference the scientific literature.

B) Define the problem space, such that the solution is possible. If your objective is to cure cancer, you are unlikely to achieve this during your undergraduate studies. The problem is too broad and the problem space has too many variables. But if your objective is to understand how cell membrane mechanics differ between normal and cancerous cells, reasonable progress toward this objective could be made during your studies.

C) Finally, in defining BME problems, assumptions are almost always made. Understanding these assumptions and developing hypotheses for what may occur should the assumption prove invalid is an important skill in biomedical engineering.

This advice is critical to both the introduction and discussion of your thesis. If you can set-up your problem effectively (Introduction – see A/B), you will be able to set up your discussion section (see C and below) to generate new hypotheses and ideas to move your field of study forward.

The Materials and Methods

The methods should state what you did, when you did it, and how you did. It generally reads as a chronological sequence of events with subheadings. While students often find this section the easiest to write, it is often an area of focus during the oral exam.

Tip #3: Understand what methods are typically used to accomplish similar research, as well as recognize the advantages and potential limitations of these methods. While you are not expected to be an expert at an analytical method or a sophisticated technique, you are expected to have a general idea of the basic principles of the key technique used in your research and how it was used to generate data.

Tip #4: Be cognizant of the biological aspects of systems/modeling used in their research. For example, familiarity with limitations of in vitro and in vivo models, specific features of cell lines, relationship between gene expression and protein expression.

The Results

The results section should show your data and your data analysis. Like materials and methods, it is fairly straight-forward, noting significant scientific findings. As expected, this section is typically a major point of emphasis during the oral examine.

Tip #5: Understand your results and how your data was analyzed. It is understood that a typical undergraduate thesis will not contain voluminous data. If there are no results because a technique did not work, an instrument was broken, the simulation code had bugs in it, or cell lines were contaminated, the professors will understand. But only if you can explain how you attempted to circumvent these problems and diligently addressed these issues). Remember, you are ultimately being assessed on your skills in the design of experiments, prototype development, data collection, and/or data analysis, not whether your original hypothesis (i.e. scientific guess) was actually true.

Tip #6: It's ok to present negative results. If you have a negative result (i.e., the result was counter to expectations), that is valuable too! Research to demonstrate an outcome that is already known isn't necessarily research. Again, your hypothesis (i.e. scientific guess) does not need to be true in order for you to conduct quality research.

The Discussion

The discussion is your opportunity to present your data relative to what is known in your field (see introduction).

Tip #7: Don't punt the discussion: Students can fill the tendency to try and rush or skimp on this section, but this is your opportunity to really discuss what you learned, what you would have done different, and what you would do next if you were to continue this work. This is a prime section to demonstrate your research skills - design of experiments, prototype development, data collection, and/or data analysis – by critically evaluating your own work and what you would do next to continue to solve problems in your field.

Tip #8: Understand your data analysis techniques and the interpretation of results: Biomedical experiments are often nuanced and quite dissimilar in design, as such, there are not necessarily boiler plate methods to analyze each experiment. But, if you have results, try to have a reasonable explanation/analysis of your findings. You should absolutely approach your advisor and graduate mentors, if any, for guidance on how to analyze your datasets. Remember, it is important to be critical of your data, analyze it carefully. Do you have enough runs to be sure that your data is reproducible and consistent? How much variability is in the data? Are your simulations realistic and representative of the physical situation? What are the assumptions in your analysis? Comment on these limitations and comment on the statistical significance of your results.

Tip #9: Be your own critique: If you worked diligently but found road blocks which there was no time to overcome, or obvious problems with the research strategy or alternative approaches opened up toward the end of your dissertation, be sure to explain this. Your careful troubleshooting will save your professor and any others who attempt to continue your work valuable time and you have accomplished a lot in a short time. Remember, science progresses by building on the work of others. And again, you are ultimately being evaluated on your skills in active research -- the design of experiments, prototype development, data collection, and/or data analysis. Often these skills are built by understanding how to address the problem better in the future -- <u>Leave the problem in a better state than you found it!</u>

Tips and recommendations for the oral examination and defense

The student should prepare a 10 minute presentation, and be prepared for 20 minutes of questions and answers.

Tip #1: Practice, practice, practice. Be off-notes by the time you present to your committee, because if you are using electronic notes or notecards.... (see Tip #2).

Tip #2: Don't be surprised if questions begin in the middle of your presentation. A student who has practiced a presentation that runs approximately 10 minutes without interruption is at the expected length. However, in many thesis presentations, questions will start in the middle of the presentation, and if you aren't well practice, it's easy to lose your place in your notes. Whether questions begin during or after the presentation partly depends on the 'personality' of the committee. But remember - this is actually an "oral examination and defense", not a "presentation". Questions can start whenever they are deemed warranted by a committee member.

Tip #3: Think of the oral examination as your time to teach your audience. This is actually your chance to teach your professors! Don't assume that the audience knows all the intricacies of your research. Take the time to explain things clearly.

And like all good teachers:

Tip #4: Be clear, concise and keep things simple. Do not drown your audience in detail.

Tip #5: Do not have a large number of words on the slide – use pictures/images as much as possible.

Tip #6: Expect a lot of questions and try your best to not take questions personally. There are two primary reasons for a large number of questions – 1) your research is really interesting to the professors and they are eager to learn more, or 2) they are trying their best to understand what is going on so they can evaluate what you did during the research. Prepare yourself mentally for lots of the questions and answers. It's easy to get flustered, but "lots of questions" is simply the norm for oral examinations, But, *probing questions about the results and how strongly they support the conclusions are an important part of the research process, and in most instances, these questions are more reflective of the professor's interest in your work than a personal critique*. Questions should never be taken personally.

Tip #7: Find the sweet spot between "I don't know" and "wild speculation": See the tips to avoid at the end, but unsuccessful defense most frequently feature 1) students that are incapable of answering most questions and/or unable to formulate a scientific hypothesis as what the answer would be (i.e. says I don't know too often), and 2) students that try to answer every question as fact, even though they are speculating at best (i.e. wild speculation presented as truths).

My best advice is listen to the question carefully, and try to answer it to the best of the ability. If you don't understand the question or know the answer, feel free to admit it. Even the most seasoned researcher doesn't have all the answers. If you aren't sure, but have a good guess, a good place to start is "I'm not 100% sure, but I do know that ……, so I would speculate that ..... would occur." For the "I don't know" student, this tells your audience what you do know and often helps your committee rephrase the question in a manner that may help you reach the right answer. For the "wild speculation" student, this tells your audience that you are actually speculating, and often helps your committee point out where your assumption may be wrong, providing the opportunity for you to re-think your answer from a new perspective.

<u>Things to Avoid</u>

In an unsuccessful defense, a student typically

1. Does not know what the research objective is
2. Drowns the audience with a lot of related/unrelated information without understanding the basic problem at hand
3. Cannot communicate the basic idea behind the research in layman's terms
4. Has no idea why the research is being done. Says things like, 'this is what student X or professor Y told me to do'
5. Has no understanding of the main techniques used in the research
6. When questioned, answers with a lot of unrelated information.
7. When questioned, does not take time to listen to the question carefully
8. When questioned, feels the need to answer even though they have no idea what the answer is ("Afraid to say I don't know"). Or alternatively, when asked to speculate, fails to demonstrate the ability to form a scientific hypothesis based on the knowledge they do have ("Say I don't know to everything")
9. Presents a lot of work but is unaware of why a crucial step in an experiment is being performed