

EXPECTATIONS FOR A SENIOR CAPSTONE IN STATISTICS

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Introduction

The Senior Capstone in Statistics is designed to integrate and demonstrate the analytical tools, theoretical knowledge, and communication skills you have accumulated throughout your undergraduate career. This is both a demanding and rewarding experience. This document outlines expectations and guidelines¹ to ensure our collaboration is fruitful.

The Senior Capstone in Statistics is both a demanding and rewarding. As a student, you will make a significant investment into the completion of a product in which you can be proud. As your advisor, I will make a significant investment in you. Together, we will have a shared commitment to your project, your academic success, and your future. The expectations outlined in this document necessitate a strong work ethic and dedication to the project throughout the year. If you do not believe you can adhere to these expectations, we should either negotiate them, or you should consider finding a different advisor.

Learning Objectives

Successful completion of the Senior Capstone in Statistics demonstrates statistical literacy (interpretation and clear communication of statistical methods, results, and concepts) and statistical reasoning (defining the need for data to address questions, modeling variability in a process, choosing the appropriate methodology to address a question of interest, and critiquing an analysis). Through completion of the Senior Capstone in Statistics students should be able to perform the following tasks:

- *Independently* **develop** solutions to research questions. This can include (but is not limited to) the **identification** of appropriate methodology to address a scientific question given a provided data set; the **design** and **implementation** of a study to collect data to address a scientific question; or, **construction** of a mathematical proof or numerical simulation to characterize a statistical method.
- *Clearly* **summarize** through written and oral presentations the research conducted to a broad audience. This includes **motivating** the scientific question of interest and the need for the present research study; **describing** how the research adds to the body of knowledge; and **discussing** the primary results of the research to an audience which does not consist of discipline experts.

¹ These expectations and guidelines were adapted from several sources including Dr. Ingram's expectations for research students, [Princeton's guidelines for economics students](#), [USRESP](#), [USCLAP](#), [Harvard's thesis guidelines](#), and [Indiana University's guidelines for international studies](#).

- *Clearly describe* and **justify** through written and oral presentations statistical methodology used to address a scientific question of interest to an expert audience.
- **Identify** the value of statistical methodology in the advancement of science and **recognize** its limitations.
- *Critically critique* a scientific report or publication, noting both its strengths and limitations, and to *professionally respond* to criticism received.
- **Collaborate** with others in communicating the results of a research endeavor through a written report.

Content and Scope

A Senior Capstone Experience in Statistics generally has one of the following flavors:

- **Statistical Collaboration:** This consists of an analysis of data to advance another scientific discipline. The data may be a complex data set provided by a client, or it could be the result of a study designed and implemented by the student to answer a question of interest developed by the student and advisor. While this experience may rely primarily on existing statistical methods, it must be a non-trivial application of statistical methods, typically requiring methodology not covered in depth within the statistics curriculum. Note: this senior experience is considered a “Senior Project” within the department, requiring the student to complete *MA 491 Introduction to Mathematical Modeling* during the Fall term.
- **Numerical Investigation of Existing Methods:** This consists of researching an open problem in statistical applications. Generally, this involves a simulation study to characterize the performance of existing methods. This is typically complemented by an analysis of a data set illustrating the use of the methods. Note: this senior experience can be classified as a “Senior Thesis” or “Senior Project” within the department; if designated as a “Senior Project,” the student must complete *MA 491 Introduction to Mathematical Modeling* during the Fall term.
- **Development of New Statistical Theory:** This consists of researching an open problem in statistical theory. Generally, this involves proposing new methodology. This may include rigorous mathematical proof or the use of numerical simulations to support the use of the methods developed. This will also include a discussion of current methods and the benefits of the proposed methodology. While not required, this is typically motivated by an analysis for a particular data set. Note: this senior experience is considered a “Senior Thesis” within the department.
- **State of the Art:** This consists of an in-depth summary of methodological development for a particular application. The student should demonstrate a mastery of the origin of the problem, key developments, and statistical theory underlying the methods developed. The student should also describe best practices and current open-questions in the field.

Per the department guidelines, a “Senior Project” can be completed within a group if approved by the advisor. In such cases, all members of the group are responsible for all work completed. In addition, I reserve the right to assign unique variants of the project to each student in the group in order to expand the breadth of the final product.

In all cases, students are required to produce the following:

- A written report. This report details the scientific questions considered, the motivation for those questions, the methodology employed, the major results, and a discussion of those results as well as how those results fit into the body of knowledge on the chosen topic. This report will be archived on *Rose Scholar* and submitted to the department.
- A poster presentation to the department. The poster will summarize the written report for a broad audience. The presentation will be an interactive discussion with your peers and other faculty regarding your research. Note: if you are unable to attend the departmental poster presentation session, the department requires that you give a seminar presentation open to members of campus.
- A secondary presentation. This is a second presentation of the student’s choice. This can be a poster presentation at the Rose Show, a presentation (either poster or seminar) at a scientific conference (including the Undergraduate Mathematics Conference hosted at Rose-Hulman), or a seminar at another university.

If the work is judged to be of sufficient quality, the student may be encouraged to seek publication in a scientific journal or to submit the work to the Undergraduate Statistics Research Project (USRESP) Competition or the Undergraduate Statistics Class Project (USCLAP) Competition. If a manuscript is prepared and submitted to one of these outlets, the requirement for the secondary presentation will be waived, though still encouraged.

Depending upon the specific project, the student may also need to seek approval from the Institutional Review Board (IRB), seek approval from the Institutional Animal Care and Use Committee (IACUC), or submit a grant (for travel purposes).

Committee and Peer Review

The application of statistics necessitates collaboration. All capstone experiences will be subject to periodic review. This review process aids in communicating results to a broad audience.

The student will identify two additional members which, in addition to the advisor, will serve as their capstone committee:

- **Discipline Expert:** This individual must be a professional in the field relating to the external discipline addressed in the capstone experience. This person could be the client who provided the project, a faculty or staff member at Rose-Hulman, or a member from the community. Unless approved by the advisor, this individual should not have a personal relationship with the student. If the work is a “Statistical

Collaboration” (see *Content and Scope* above), the discipline expert cannot be a faculty member within the Department of Mathematics.

- **Peer Reviewer:** This should be a current student at Rose-Hulman with expertise in statistics (mathematics major conducting a Senior Capstone in Statistics or a student completing a statistics minor).

Individuals agreeing to participate on the committee will have the following responsibilities:

- Read and provide feedback on a short (max 2 pages) progress report during week 9 of the Fall and Winter terms.
- Read and provide feedback on a draft of the final report detailing the research during week 9 of the Spring term.
- Attend and provide feedback on an oral presentation summarizing the research during the Spring term.

It is the responsibility of the student to identify these individuals, though the advisor can provide appropriate recommendations. The selection of these individuals must be approved by the advisor. It is the student’s responsibility to contact these individuals and request their participation. A document to help in explaining the process to your committee members is available from me.

In addition to receiving feedback from your committee, you will be expected (when possible) to provide feedback to another student completing a senior capstone experience. This can be accomplished by serving on the committee of another student or through a more informal process. You should arrange a time to meet with me to reflect on this experience.

Timeline

This section states required deadlines as well as recommended pacing. This provides a good checklist for ensuring you are making adequate progress towards the completion of your project.

In general, the Fall term is used for reviewing relevant literature, clarifying the research question, and proposing an analysis plan for addressing the question. The Winter term is used for implementing the developed analysis plan, including any revisions as a result of preliminary results. The Spring term is used for finishing up any work not completed, writing up the results, and presenting the research.

Term	Deadline	Deliverable
Fall	Friday, Week 1	Topic finalized; schedule weekly meetings with advisor.

	Weekly	Weekly progress report submitted 24 hours prior to scheduled meeting.
	Tuesday, Week 9	Submit quarterly progress report to committee.
	Friday, Week 10	Submit literature review.
Winter	Weekly	Weekly progress report submitted 24 hours prior to scheduled meeting.
	Tuesday, Week 9	Submit quarterly progress report to committee.
	Friday, Week 10	Submit methodology section and analysis/numerical simulation description.
Spring	Weekly	Weekly progress report submitted 24 hours prior to scheduled meeting.
	Wednesday, Week 5	First draft of poster submitted to advisor.
	Monday, Week 6	First draft of written report submitted to advisor.
	Wednesday, Week 6	Second draft of poster submitted to advisor.
	Monday, Week 7	Submit poster to print shop for production.
	Wednesday, Week 7	Departmental poster presentation.
	Monday, Week 8	Submit draft of written report to committee.
	Friday, Week 10	Submit final written report to Rose Scholar, departmental archive, and advisor.

Other deadlines may be integrated into the weekly report depending on the research. For example, the second presentation deadline will generally occur during the Spring term.

Format

While there is no requirement to use a specific software to complete your written reports or presentations, this section contains formatting guidelines for various required deliverables.

Weekly Progress Reports:

The weekly progress report is to be typed, single spaced, using 10- or 12-point font with 1-inch margins. The weekly progress report should be at least one half of a page in length.

The document should contain:

1. A summary of the work you have undertaken since the previous meeting.
2. At least one concrete step you intend to take during the next week.
3. Any questions you would like to discuss at our meeting.
4. A list of any references you have consulted during the week.

Weekly progress reports will be submitted electronically via a Moodle page.

Committee Progress Reports:

The committee progress report is to be typed, single spaced, using 10- or 12-point font with 1-inch margins. The progress report should be at least 1 full page, with a maximum length of 2 pages. The document should summarize the work you have completed over the term while motivating the research completed.

For the fall term, this will include a motivation of the question of interest, a summary of the literature, and a sketch of the methods you will investigate during the winter term. For the winter term, this will summarize the question of interest, summarize the methodology employed, and present any preliminary results.

Committee progress reports will be submitted electronically via a Moodle page and emailed to the members of your committee.

Written Report:

The final written report is to be typed, single spaced, using 10- or 12-point font with 1-inch margins.

The title page should include the title of the project, the name(s) of the author(s), the advisor, and the name of the institution.

The executive summary should be around 350 words summarizing the research and the key findings. You can place this on the title page or on a page of its own.

The primary report itself should be around 20 – 40 pages. The literature review (approximately 3-5 pages) is a subset of this report.

The written report is to be submitted electronically via a Moodle page.

Poster:

The poster should be 36 inches high by 48 inches wide. It should have 3 or 4 columns. An electronic version of the poster is to be submitted electronically via a Moodle page. The final version will be printed using the campus poster printing shop.

Logistics

The majority of this document describes the philosophy underlying the research process. This section describes the practical mechanisms which will govern the research process.

Early during the first week of the fall term, you should meet with me to finalize your topic and schedule our meetings.

We will meet at least once each week throughout the term. At least 24 hours in advance of each meeting, you are to submit a weekly progress report. These will help guide our conversation during the meeting. You should plan to spend 10-15 minutes at each meeting presenting your work over the past week and what you have learned. You are essentially the teacher during this time. We will then brainstorm the work to be completed over the next week.

During the fall term, you will be exploring the literature. This involves a lot of reading and summarizing each reading. Some reading will be sections of a textbook, but most will take the form of a journal article. While I may only assign you 1 or 2 readings each week, you are expected to supplement your reading as appropriate. You should expect to commit 8-10 hours each week toward your research. You may have some pre-requisite coding assignments to familiarize you with basic techniques.

During the winter term, you will be analyzing your data, developing necessary mathematical theory, and/or conducting any needed numerical simulations. There will be a substantial amount of coding and debugging during this term.

During the spring term, you will spend the majority of your time writing and presenting your results. You may need to finish up any work not completed during the winter term.

Grading

Unlike other courses, research does not have a pre-specified set of topics and assessments. This section clarifies how a grade is earned during the course of the year.

The following expectations (when applicable) govern all work presented during the term (progress reports to committee members, written reports, and oral presentations).

- **Innovation:** Work demonstrates a student's ability to independently research topics, develop solutions, and implement methodology.
- **Clarity:** The question of interest and results are presented such that a broad audience can understand the goal of the research. The methodology is presented so that a discipline expert could replicate the results.
- **Methodology:** A well-developed empirical approach or theoretical solution is provided which is appropriate for addressing the research question. For an applied project, the work (1) gives a detailed description of the data set used and why it was chosen, (2) states appropriate statistical methodology implemented and justifies its

use, (3) thoroughly and accurately implements the chosen methodology, and (4) the results are correctly reviewed and discussed. For a theoretical project, the solution provides a justification, either analytical or numerical, for the suggested methodology.

- **Results:** An explicit statement and discussion of the results which resulted from the work conducted is given. The relevance to the broader research community is stated. Any limitations are discussed. Directions for future research are listed.
- **Structure:** A visible, easy-to-follow structure consistent with conventions in statistical literature is adopted. A reader should be able to easily identify sections that typically occur in a peer-reviewed statistical publication. A common layout includes Executive Summary, Introduction, Literature Review, Methodology, Numerical Simulations or Analysis, Results, Discussion, References.
- **Literature Review:** The work clearly places the research being conducted in the broader context of statistical work. This is not an attempt to exhaustively cite the literature but to link the question and results to other work being done.
- **Style:** Lucid, informative, and readable sentences are used in all written work. Well-defined key terms and concepts are clear and consistent with broader statistical literature. Clear and concise explanations are used.
- **Source Citations:** Other's work is appropriately cited using a system consistent with published statistical literature.

<p>A</p>	<p>The work presented (progress reports / written reports / oral presentations) meets or exceeds the expectations for research described above.</p> <p>A weekly progress report was provided to the advisor during the term.</p> <p>All work (advisor progress reports each week, committee progress reports in the Fall and Winter, final written report and presentation in the Spring, and all requested drafts) was submitted by the stated deadline.</p> <p>Adequate progress is made on the research.</p>
<p>B</p>	<p>The work presented represents good, solid work despite some deficiencies with regard to the expectations described above.</p> <p>At most 1 weekly progress report was omitted during the term.</p> <p>At most 1 deadline was missed.</p> <p>Adequate progress is made on the research.</p>

C	<p>The work presented has some major flaws and represents work that is below the expectations described above.</p> <p>At most 3 weekly progress reports were omitted during the term.</p> <p>At most 2 deadlines were missed.</p> <p>The progress made on the research does not meet expectations but represents more than minimal progress.</p>
D	<p>The work presented reveals virtually no command of statistical methodology being studied and dramatically falls below the expectations described above.</p> <p>At most 3 weekly progress reports were omitted during the term.</p> <p>At most 2 deadlines were missed.</p> <p>Minimal progress made on the research.</p>
F	<p>Failure to meet the above requirements. This demonstrates work that is unacceptable, a complete disregard for deadlines throughout the term, or little to no progress made on the research.</p>

Professional Expectations

All collaborations necessitate a need for professionalism. This section outlines expectations regarding professional behavior.

Conscientious Work: All work performed should have your full attention. Sloppy work is unacceptable. The expectation is not perfection; everyone makes mistakes. The expectation is your best effort toward all products produced.

Documentation: All work should be well-documented. The form of documentation will depend on the project. The following components must be included:

- **Documented Code.** Any standalone scripts should contain a header with a brief description of the script. Code chunks should contain comments to aid readability and future use. Any special directions for running code on a different machine should be made clear.
- **Key Decisions.** Any decisions which impacted the direction of the project should be recorded. Many of these will appear in your final written report, but key decisions are not limited to those discussed in the report. A future researcher should be able to understand the decisions made which led to the final product.

- **Reproducibility.** Your work should be able to be reproduced by another researcher. Code should compile and all original documents should be available.

Mutual Respect: Regardless of another's behavior, you are to act with consideration and respect for others. This includes written and verbal communication as well as the use of shared resources. Emails should be responded to promptly; the expectation is not immediate response but timely response. Tasks should be completed by the stated deadlines. If a task cannot be accomplished in the stated timeline, this will be communicated as soon as possible so that alternate arrangements can be made; this should be a rare occurrence. You will respect input and decisions from your peers and collaborators during the research process; in turn, you can expect respect regarding your input and decisions during the research process.

Patience and Humility: The research process requires patience and an understanding of your limitations. When you are unclear about a concept or task, ask questions. Unlike other courses, the role of the advisor is not to primarily convey information; it is to guide the research process. I will provide assistance by probing your thinking, suggesting an alternate strategy, brainstorming alongside you, referring you to appropriate literature, or occasionally providing a direct answer. Answers will not be immediate, and there may be occasions in which no answer is obtained. Be honest about your capabilities.

Meaningful Critique: While it can be difficult to receive, critique is an important part of the research process. I will provide commentary in order to advance your understanding and the project itself. Similarly, you will provide commentary on your work and that of others in order to improve it.

Personal Note

As stated above, the research process is both demanding and rewarding. No other experience during your undergraduate career will allow you to explore a topic to such depth. No other experience will give you as much control over your education. You will become the local expert on the topic you choose. Be confident in your work and choose to view others' questions as scientific curiosity (not looking to critique you personally).

There will be moments when you love your project and cannot wait to work on the next part. You will be consumed by the excitement of what you are learning and accomplishing, and you might get lost in your project for hours at a time. There will also be moments when you hate your project. If you are not careful, you can be consumed by doubts about your decisions and skills. In those moments, take a short break, treat yourself, and then fight through to meet your deadline. If you are feeling paralyzed by stress, reach out to me immediately (I am very familiar with this feeling). Deciding to take a week off your project because it is no longer exciting is not acceptable.

You will fail. Part of any research experience is running down "blind alleys" only to find that they are dead ends. Some failures will be small (code produces a small error because of a missing comma); others will be large (implementing a procedure inappropriate for the context, requiring you to redo an entire analysis). You will fail, but you will also overcome

that failure. While you should not expect anyone to do the work for you, you should never be afraid to ask for help.

You will need to be organized. You will often have multiple tasks that you need to be working on for your research, in addition to other commitments in your personal and academic life. Plan ahead; set realistic expectations of the time required to complete each task.

Remember to breathe. Research has a lot of moving parts, in addition to preparations that you are making for the future. Each graduate before you, with help, survived this experience. I would not have agreed to work with you if I did not believe you were capable of succeeding.

Contract

While this document does not cover all aspects of a senior capstone experience, it does capture the primary tenants of my philosophy regarding applied work and research and effective collaboration. These expectations are not one-sided. By signing below, we each acknowledge that we have carefully read this document, and each agree to the terms described herein. Our signature also acknowledges our respective commitment to your project.

Student Name

Date

Eric M. Reyes, Advisor

Date