MCS Capstone 2018

Preamble

This document is for supervisors, students and prospective employers. It sets out the aims and steps involved in the Capstone project that runs through the final year of study of an MCS major student at Yale-NUS College. It was written by Prof. Jon Berrick and modified by the MCS faculty. With Prof. Maria De Iorio commencing as Head of Studies on 6 August 2018, there may be some amendments to this document. Further, any provision that appears below may be overruled in the future by Capstone documents implemented at the level of the Yale-NUS College or its Division of Science.

Sources

This document is informed by, and on occasion quotes without specific attribution, the following sources:
The Senior Capstone: Transformative Experiences in the Liberal Arts Final Report to the Teagle Foundation 2012 (on Allegheny, Augustana, Washington & Wooster Colleges)
https://teaching.unsw.edu.au/capstone-project
Documents on final year projects from NUS Maths Dept & DSAP, and from Utrecht Maths
Yale-NUS documents for Heads of Studies.

Aims

The Capstone is intended to give students the opportunity to work independently; encourage students to develop and exhibit aspects of their ability that may not be revealed by course work or a written examination; foster skills and attributes that will be of continuing usefulness in their later career, such as determination of relevant sources; computational or statistical applications; critical analysis of source material; organization of relevant material; presentation in written and spoken form; enthusiasm for research; appreciation of how the corpus of academic knowledge in the discipline has arisen; a sense of academic self-confidence and achievement; and development of project management skills.

Faculty here and elsewhere describe a “successful” Capstone as one where the students are self-directed and take full responsibility for their learning; communicate their interest and passion; demonstrate advanced analysis, research, and writing; provide evidence of growth and change; and develop an innovative, novel, or original research question. These faculty describe their own role as including:
guiding the shaping of a feasible, well-defined topic and research question; meeting regularly and providing needed structure, direction, and deadlines; providing encouragement and emotional support (coach, advocate, cheerleader); reviewing, challenging, and critiquing a supervisee’s thinking and writing; and consulting as a “co-learner” and academic colleague.

Proposal

Matchmaking between Supervisors and students is facilitated by the Head of Studies in early summer before the students’ final year commences. Over the summer, the Supervisor and student should collaborate to produce a project proposal document, to be jointly submitted to the Head of Studies no later than the fourth week of Semester 1, as detailed below in the Research and Preparation section. (It is anticipated that, at Yale-NUS College, students wish to have a more active role in deciding the project

than occurs at most institutions. This is positive in that it encourages students to have a greater sense of ownership of the project; the Supervisor may need to guard against the project becoming too ambitious for the time available. A project that can later be scaled up as expectations are exceeded is more likely to succeed than a more ambitious project that needs to be scaled back later. The proposal will be reviewed by MCS faculty; it has an important role in setting expectations for the student and helping to avoid project drift that might lead to a project becoming unduly large or unwieldy. It also establishes benchmarks to aid the project's Examiner. The proposal should state the following.

Student:
Supervisor:
Title:
Subject Areas:

Challenges: The Supervisor's perception of aspects of this project may disagree with how students perceive it (e.g. numerous abstract proofs or advanced coding skills could affect the completion of the project). Such challenges should be carefully discussed towards finding a consensus between students and Supervisors.

Scope: The primary aim of the project is to contribute to the student's intellectual development. Likewise, for a project associated to an internship, the Supervisor needs to ensure that the student's education is paramount. Joint publications with the supervisor resulting from the project are encouraged, but they should not be obtained at the expense of the primary aim.

Expectations associated with grade achievement: Students should be informed about what kind of material the thesis should contain in order to lead to an A- grade. The prerequisites, the co-requisites, and the initial references must be made clear from the beginning.

Time allocation: Typically, supervision occupies about 1 contact hour weekly (with considerable week-to-week variation) and a further one or two hours for the Supervisor in reading material submitted by the student or related to the project. Contact time should not consist of lectures by the Supervisor. It is more profitable to have Q & A between Supervisor and student, with both asking/answering questions.

Drastic changes: Any drastic changes in the Capstone project, such as relative to the topic or the Supervisor cannot be made after the last day of November of Year 4. Before that date, they need the HoS's approval, which may be granted only under exceptional circumstances.

Components

As well as the Supervisor, an Examiner appointed by the Head of Studies will assess the student's performance in the components mentioned below. The Supervisor and Examiner will make **independent** assessments.

Note that at other institutions with a Capstone, most students rate the experience as more stressful, more intellectually challenging, and more academically developing than a regular course. They also report the capstone as more effortful (14 hours per week on average vs 10-11 for other courses); however, at our College a 5MC load is expected to correspond to an average of 12.5 hours weekly.

The components of the Capstone are: the Research and Preparation, the Seminars and Symposium, the Initial Thesis Submission, the Interview, the Final Thesis Submission, and the Reflection, all of which are further described in detail.

Research and Preparation **(20% weight)**

This work is done during Semester 1 of the Capstone academic year. Before the end of this semester, students must read and summarize most of the literature in writing, describe most of the research they are going to do, and perform some of it. At the end of Semester 1, students should be advanced enough in their Capstone work, such that at the beginning of Semester 2 they can get to the core of their research work and start planning about how to write the Capstone thesis. The Research and Preparation part of the Capstone should be done according to the following schedule:

First and second week of classes (13-17, 20-24 August): MCS senior students meet with their Supervisors and finalize the proposal and the research plan. The Supervisors and the students agree about the literature that must be covered in Semester 1 and the overall goals of the Capstone project.

Third and fourth week of classes (27-31 August, 3-7 September): The student presents the Supervisor with a written Proposal of the project (as outlined above) and a Plan for Semester 1 (with deadlines, as requested below, and targets to be achieved). The supervisor may ask for changes to the Proposal and the Plan and then approve them. The Proposal is then submitted to the Head of Studies **before or on 7 September at 5:00 pm**. This gives the Head of Studies the opportunity to consult with other MCS faculty and suggest amendments before a version of the Proposal that accords with the College's template is submitted through the Head of Studies to Registry. The Plan is to be respected, with the student meeting the Supervisor weekly and discussing the progress made on reading the literature and doing the proposed research.

Written incremental reports prepared by the student must be shown to the Supervisor and submitted to the Head of Studies **at or before 5:00 pm** on the following dates:

Report 1: 19 October (Friday, Week 9) – 10% weight

Report 2: 16 November (Friday, Week 13) – 10% weight

The supervisor must assess the material and offer feedback to the student during the following week after the submission. Report 2 should include the material of the previous reports with the corrections and the changes requested by the Supervisor for the old material. The incremental reports contain not only a review of the literature and/or preliminary background material, but thoughts about how progress can be achieved towards reaching the goals of the project. Following the submission of Report 2, the Supervisor will submit a Semester 1 Progress report to the Head of Studies, for discussion and forwarding to Registry.

Seminars and Symposium **(15% weight)**

One seminar talk in Semester 1 **(2% weight):** (Weeks 11-12) Icebreaker talks: 5-6 minutes.

Two talks in Semester 2

Introductory seminar talk (**Weeks 2 – 6**): 15 minutes, then 5 minutes discussion and questioning **(5% weight)**

Symposium talk (**Saturday 6, Sunday 7 April 2019**): 20 minutes, then 5-10 minutes discussion and questioning **(8% weight)**

Note that Supervisors (or other faculty) do not sit in at rehearsals.

Attendance at all talks is compulsory for all MCS major students.

Initial Thesis Submission **(40% weight)**

Friday 22 March 2019 before 5pm

Note that this is two weeks before the deadline for other majors, who submit only a final thesis. In addition, MCS has other assessed components, such as the symposium and interview.

The project thesis should be submitted as a soft copy (A4 size) to the Capstone Canvas site. (Click on the Assignments tab, followed by the Initial thesis submission Assignment. *Turnitin* will conduct a plagiarism check upon submission.)

There is no strict limit on the length of the thesis, but it should normally be between 25 and 40 pages, and should generally not exceed 65 pages (excluding statement of original contributions, acknowledgements, summary, content pages, etc. and figures, tables or programs). Research papers are often short, but Capstone theses should contain more context and introduction than typical research papers. Font size should be 12pt and paragraphs should be double-spaced. The margins on each page should be at least 3cm (top, bottom, left and right).

The thesis must be submitted by the stipulated deadline above. In accord with general College practice, any late submission without a valid medical certificate or a Vice Rector's note will be subject to the following penalties to be deducted from the final grade of the Capstone Report:

a. Deduct one third of a letter grade (for example, A to A-, B+ to B) if submitted by midnight of the same day, 22 March 2019.

b. Deduct another one third of a letter grade (e.g. A to B+, B+ to B-) if submitted over the following two days (from 12:00am of 23 March 2019 to 11:59pm of 24 March 2019).

c. Deduct one full letter grade (e.g. A to B, B+ to C+) if submitted between 12:00am of Monday 25 March 2019 and 5:00pm of Friday 29 March 2019.

d. If the submission time is late by more than a week, the Report will receive a failing grade of F.

The thesis will be assessed by the Supervisor and Examiner. This is the most important component of the project work as it accounts for nearly half of the overall project grade.

If the student claims to have made an original contribution, the two assessors should comment on the validity of the claim and the significance of the contribution.

Interview **(15% weight)**

Monday 8 – Thursday 11 April 2019

After the oral presentation, each student will have to appear in an interview by two assessors, comprising the Supervisor and the Examiner, and chaired by the Examiner. The interview will be on the subject matter of the project. The interview, which is the second most important component of the project, gives the student an opportunity to clear up misunderstandings or uncertainties about the materials presented in the report.

At the interview, the assessors may give the student a list of matters requiring attention (ranging from typographical to mathematical errors requiring correction). The student would be required to amend the thesis accordingly for final submission. This reflects the importance of MCS research being error-free when released into the public domain.

The Examiner and the Supervisor will jointly finalize a list of questions to be asked before the commencement of the interview. They should also agree on the weight to be given to each of the questions. Questions not in the list are allowed during the interview. Should such questions be added, the predetermined weight should be adjusted after the interview.

Each answer in the interview will be assigned a mark **independently** by each of the two assessors. Each assessor will then award a final mark for the interview, which will be a weighted average of the marks for the questions. The interview will last between 30 and 45 minutes.

Final Thesis Submission **(5% weight)**

Tuesday 23 April 2019 before 5pm

A student who is required to make amendments to the report should do so as soon as possible after the interview. The amended thesis should be submitted as a soft copy (together with the Student's Declaration of Personal Work form) at the Canvas Capstone site. Note that the online submission is logged.

A soft copy, in pdf format, should also be emailed to Raymond at Goh Bros raymond@gohbros.com.sg (who request a left margin of 4cm). This is a reference copy for the College archive. The College will bear the cost of printing and arrange to collect this copy directly from Goh Bros. Please list the pages that are to be printed in colour in your email.

Suggested sequence of contents

I Capstone Title page
II Acknowledgements
III Summary
IV Statement of author's contributions
V Table of Contents
VI List of Tables (optional)
VII List of Figures/Photos (optional)
VIII Other Lists (optional, e.g. acronyms, glossary etc.)
IX Chapters and Sections
X References
XI Appendices (optional)

For the copy to Goh Bros, the intention is that the front cover of the bound copy will look like (centred):

Title
Student's name

Capstone Final Report for BSc (Honours) in
Mathematical, Computational and Statistical Sciences
2019

The spine of the bound copy will show:
Student's name MCS 2019

By default, theses are made available on-line to the general public. In exceptional cases, theses can be (1) published under embargo, i.e. become public only after a certain date, or (2) non-open access, i.e. not accessible to the general public anytime. Please email the Head of Studies if you consider your case is exceptional.

Reflection (**5% weight)**

Tuesday 23 April 2019 before 5pm

This is to be a short essay (up to 750 words) relating to the intellectual journey that the student has travelled while at Yale-NUS College, and which may include considerations such as the following:

- the nature of knowledge and inquiry

- self-awareness and connection with others
- the relationship of individuals to a community
- awareness of higher cognitive skills and attitudes relevant to the research discipline
- holistic understanding of the way different courses over four College years have contributed to the academic attainment of the Capstone
- awareness of the student's own development during the years at College

This essay must be submitted as a soft copy at the Canvas Capstone site at the time of final submission of the thesis.

Assessment

An incomplete list of possible assessment criteria:

- Level – Theoretical level, practical/experimental level, understanding of the underlying matter, amount of work in relation to number of MCs
- Problem handling – Methods, techniques, design instrumentation, implementation, experiments
- Skills – Analytical skills, model building, distinguishing matters of major and minor importance, evaluation, independence, collaboration, self-reflectiveness, planning
- Effort and attitude
- Originality
- Relevance, valorization (sense of significance of the project in the broader subject)
- Report/Thesis – literature survey, problem statement, style of writing, quality of English, report structure, textual structure, coherence/consistency,
- Conclusions/recommendations for further research
- Neatness, attributions and citations.

The thesis will be examined by the Supervisor and an Examiner nominated by the Head of Studies. The assessors will evaluate the thesis independently.

In order to help the Examiner make a more accurate assessment of the student, the Supervisor is required to reveal to the Examiner certain information about the student's contribution to the thesis by completing a Supervisor's report form.

In the evaluation of the thesis the aspects to be taken into account should include

- theoretical content,
- organization,
- style,
- originality,
- physical presentation.

The relative importance of these items varies from one project to another. Each assessor will assign a mark (see item (vi) below), and submit an assessor's report to the Department before the oral presentation. In the report the assessor should highlight any particular strengths and weaknesses of the student's work.

Report Writing

Notes and Referencing

Principal original sources of the material for the project should be consulted as far as possible, in addition to accounts that may be found in textbooks or surveys. All sources that have been used should be *explicitly* acknowledged in the thesis. The status of the results in the thesis, whether they are new and obtained by the student or whether they are obtained by others, should be stated.

Summary

The student, in consultation with the Supervisor, should prepare a summary of about one page on the nature and scope of the thesis.

Statement of author's contributions

The thesis should also contain a statement highlighting the contributions made by the student. The statement should include, if any,

(a) *the student's own ideas, own results, own proof, own interpretations, own applications; own examples or counterexamples, own computer programs, which he/she does not obtain from other sources. The relevant parts of the written thesis that contain such contributions should be explicitly stated.*

(b) *improvements made by the student on existing theorems, proofs, etc., found in books or papers. The sources from which the results are improved upon should be mentioned explicitly.*

Examples of the *Statement of the author's contributions.*

Example 1.

- Theorem 3.2 is new and is a generalization of Theorem 2.1 ([1], page 188) for nonlinear regression. The proof is modified for the nonlinear case.
- The simulations in Chapter 4 are new and I developed the computer programs.

Example 2.

- I have extended some bootstrap methods to longitudinal data in Chapter 2.
- Some asymptotic properties of these bootstrap methods have been considered in Chapter 3.
- Theorem 3.2 is my own contribution and it is similar to Theorem 6 ([3], page 26).
- I also have run some simulations in Chapter 4.

Example 3.

- I have applied statistical models to forecast the trend of stock markets. The models I used are: (i) the simple nonparametric regression; (ii) local linear nonparametric model and (iii) logistic regression. The data I used are: (i) Hong Kong Heng Seng Index; (ii) Japan Nikkei Index and (iii) IBM Computer Corporation stock.

Acknowledgements

The thesis is expected to reflect work done by the student under the guidance of the Supervisor. If any other person has contributed to the thesis, that should be explicitly stated in an *Acknowledgements* section. This is the convention for all academic publications, and failure to give due acknowledgement may be considered as a breach of academic integrity. Examples of best practice follow.

Example 1.

I am grateful to classmate X for pointing out an error in a previous version of the proof of Lemma 3.2.

Example 2.

I would like to acknowledge a conversation with classmate Y that led to my improving the program in Chapter 4.

Example 3.

My thanks too to Professor Z who drew my attention to references [3] and [5].

Reading material

- *"Handbook of Writing for Mathematical Science"* by N.J. Higham, SIAM
- *"How to Write Mathematics"* by P.R. Halmos

Pointers for Oral Presentation

(I) Things to do

(A) Before the presentation

a) Identify the main results and main ideas in your thesis. Focus on them.
b) Try to put across a few main ideas to give the "flavour" of your project.
c) Prepare and organize presentation aids in advance.
d) Make sure your notation is consistent throughout the presentation.
e) Draw diagrams, give tables and plots to help bring across the ideas to the audience.
f) Have a practice presentation with a friend (not your Supervisor).
g) Time yourself, allowing the audience plenty of time to read each slide.
h) Slides on non-white backgrounds give less glare
i) Text on slides should be large enough to be easily read.

(B) During the presentation

a) Give an outline for the presentation.
b) Highlight the main results. Give motivation as to why you think they are interesting.
c) Give some applications and/or connections with other topics you know of.
d) Speak clearly, and try to make eye contact with the audience.
e) Be enthusiastic about your presentation.
f) Work out some examples during the presentation to illustrate definitions and theorems.
g) Make sure the audience can follow the presentation to some extent; be prepared to pause and clarify if the audience looks puzzled. Allow time for this.
h) Ensure that you keep within the allotted time for presentation, making sure to allow time to …
i) … give a brief summary before concluding the talk.

(II) Things not to do

a) Write up a set of notes and read them out loud word for word
b) Introduce lots of definitions and notation
c) Carry out proofs in full detail
d) State a long list of Theorems and Lemmas
e) Give excessive details of proofs without the main idea
f) Cram everything in the thesis into the presentation
g) Go over time
h) Rush
i) Try to say in *n* minutes everything you have learnt in the previous 9 months
j) Pretend to know everything

(III) Reading material on giving effective lecture/talks

- Chapter 3 of *"Handbook on Teaching"* by Daphne Pan et al, printed by NUS
- *"Effective Presentation"* by Pat Levy, Longman
- *"The Art of Lecturing: Some Practical Suggestions"* by Clark and Clark, Cambridge, Heffer

Grade

The Capstone occupies two semesters, weighted at 5MCs for each. For Semester 1, students will be given an IP (In Progress) grade. For Semester 2, a weighted average of the component marks, equally from each of the Supervisor and Examiner, will determine the final mark and grade – applicable to both semesters – according to the following correspondence.

Correspondence of marks and grades

A+	A	A-	B+	B	B-	C+	C	D+	D	F
≥ 90	85 to 89	80 to 84	73 to 79	66 to 72	60 to 65	55 to 59	50 to 54	45 to 49	40 to 44	≤ 39

Note that the correspondence is designed in order to reflect the fact that most students should be getting B+ and B. An assessor is required to give reasons for awarding a mark greater than 79 or less than 60 in any part of the assessment. If the discrepancy between the marks awarded by the Supervisor and the Examiner in any part of the project is 15 points or more, the Supervisor and the Examiner will be informed of the situation and asked to reconsider their assessment; a third assessor may also be called upon.

Examples of indicators for students to be awarded A- or above include the following:

- Are there any significant original results?
- Does the project contain material or references besides those suggested by the Supervisor?
- Is there any original proof of known results (not just slight changes)?
- Did the student find any mistakes in the referenced material?
- Are the results obtained useful?
- Does the student demonstrate near complete understanding of the materials?

An A+ should only be awarded to a truly exceptional project, for instance, one that contains original results publishable in a well-regarded venue.

Grades should be based on the student's level of achievement, moderated by the extent of the Supervisor's contributions (which will be indicated to the Examiner prior to assessment). The Expectations section of the original Project Proposal is also intended to inform the Examiner about appropriate benchmarks. The amount of effort expended by the student to reach this level might be a factor in letters of recommendation, but not in the grade. Thus, the following assume that the student's effort in the Capstone approximates the guidelines. References to "next steps" below can relate to further study, research, product development or employment.

A+,A,A-: A student attaining this level of achievement with a standard amount of effort is actively encouraged to pursue next steps in the topic of the Capstone.

B+,B,B-: A student attaining this level of achievement with a standard amount of effort can be recommended (possibly with reservations) to pursue next steps in the topic of the Capstone.

C+,C: A student attaining this level of achievement with a standard amount of effort can be approved for further study or employment in the topic of the Capstone.

D+,D: This indicates a level of competence adequate for the award of a degree; however, a student attaining this level with a standard amount of effort would normally be advised to choose a different topic for further study or employment.

F: The unfortunate complement of the above.