Effective Capstone/Master's Projects – Do's and Don'ts

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Abstract

Final program projects (typically 'master's projects' at the graduate level and 'capstone' at the undergraduate) are intensive experiences in critical analysis and are designed to broaden students' perspectives and provide them with an opportunity to integrate the knowledge acquired from various courses (integration of coursework) into their area of specialization. This paper analyzes a successful final project to present a list of Do's and Don'ts necessary for developing and implementing effective capstone and master's projects.

Introduction

A capstone course can provide an invigorating experience to students in their program of study since it integrates the concepts and skills they learned during their academic tenure. Final program projects (typically 'master's projects' at the graduate level and 'capstone' at the undergraduate) are intensive experiences in critical analysis, and are designed to broaden students' perspectives and provide them with an opportunity to integrate the information obtained from their various courses into their area of specilization. Typically, projects focus on the application of materials learned throughout the program to solve multi-faceted problems such as those students would encounter in their future post-academic employment. In these projects, students select project topics under the guidance of a faculty advisor, analyze the problem and formulate a detailed plan to reach a solution, perform necessary evaluations and/or experimentations, identify and/or propose meaningful results and solutions, test the proposal to the extent possible, and prepare a detailed report and associated presentation. Projects can be done in teams or as individuals. The 'front end' project plan and the 'back end' documentation and presentation are both important elements. Since the entrance into the capstone and master's projects follows completion of other courses, faculty project advisors can assign problems that are not only relevant to the students' interests but also are helpful in reinforcing the concepts taught.

Typical learning outcomes for such a culminating project experience include students demonstrating the ability to:

- evaluate critically a given project's feasibility and define a specific problem or study
- present a comprehensive review of relevant literature

- identify sources of relevant data, generate and/or gather data as appropriate, and provide in-depth analyses
- identify, describe, and apply appropriate models for drawing conclusions
- create a comprehensive project report based on the findings that relate to all essential elements of the project
- defend the project's findings during oral presentation to faculty, class and, where necessary, to external project sponsors/clients

National University's courses are offered in an intensive one-course-at-a-time, one course per month format. This includes 45 instructor-student contact hours per month, and projects require two or three courses. Since these constraints require projects to be completed within a time intensive setting, preparation and execution have to be flawless to meet the learning outcomes previously established. There is little room for error or slack. This paper analyzes a successful final project to present a list of Do's and Don'ts for developing and implementing effective capstone and master's projects.

Capstone Project

The Integrated Project Course is the capstone course of National University's curriculum. It is the last two classes taken by students before graduating from the university. Each class runs for two instructional months. Although the capstone course is done at the end, students are encouraged to identify and select a project about six months before graduation. Typically, projects are proposed by corporate sponsors, frequently employers of the students or corporations looking for answers to a problem through a lead faculty. As a result, students deal with problems that are both real and significant to the sponsor. Typically, the issues are engineering, technology, science, or business related. Interdisciplinary teams of two to three students are assigned to each project. These teams work with faculty members and representatives of the sponsors to develop solutions that can be implemented. At the end of the course, the student teams formally present their project to the sponsoring company. Before venturing into any project, student teams typically travel to the sponsor's location to learn about the problem and meet the company representatives with whom they will be working on the project.

Here are some examples of previous projects:

- Effect of San Diego Wild Fire on the Ambient Air Quality
- Perchlorate: Drinking Water Contamination Toxicity Threshold Proposal
- Environmental Effect of Natural Gas Storage in Tijuana
- Perchloroethylene (Perc) Remediation
- Hexavalent Chromium Pollution Control
- Storm Drain Design in a Section of the City of Imperial Beach

Capstone Process

Since the Capstone project duration is short, National University has a detailed Capstone process. The infrastructure and associated assistance are built in for students and faculty members to get assistance as and when required. The project class is conducted by instructors. They are typically in charge of the capstone process including student progress. The project advising is done by project supervisors who are also faculty members. However, in some instances, the capstone instructors and project supervisors could be one and the same. The steps developed for students, instructors, and project supervisors to follow are listed below.

All students are expected to

1. consult with a faculty member of their choice (project supervisors), select a project, and find a sponsor from an external organization (Typically, the sponsor could be from either a student's workplace or from an organization with which he/she may have some contact),
2. develop a proposal that defines the focus and scope of the project in consultation with the project advisor and instructor for the capstone class,
3. obtain a detailed letter of support from the external organization project sponsor,
4. develop the project individually or collaboratively with other students from the class
5. submit for approval, one month prior to defense, a customized, deliverable rubric for project assessment created in consultation with a Capstone Project Advisor,
6. deliver a project report on or before the final presentation.

The instructors will

1. ensure that the project selected is relevant to the student's area of specialization, has academic relevance, and will produce learning outcomes relevant to the program,
2. review that the project selected can be completed within the timeframe allotted,
3. help refine the project goals and outcomes as needed,
4. identify and provide any help required to have a good start on the project,
5. consult with the project sponsor with regard to all issues including project goals, access to data, confidentiality, and project details,
6. provide a clear assessment system with minimal ambiguity,
7. monitor the students' progress on a weekly basis to ensure a successful capstone experience

The project supervsiors will

1. let the students know whether the project selected is in their field of expertise, and whether they are interested in supervising the work,
2. review that the project selected is feasible within the timeframe allotted,

3. help refine the project goals and outcomes by working with students, project sponsors, and instructors,
4. identify and provide any help required to have a good start on the project,
5. consult with the project sponsor with regard to all issues including project goals, access to data, confidentiality, and project details,
6. monitor the students' progress on a weekly basis to ensure a successful Capstone experience,
7. ensure that the project is the student's original work,
8. ensure that the project meets the requirements specified in the description and guidelines.

Selecting a Capstone:

Students are encouraged to pick a client organization that fits their goals for the program [1]. Since most of the students in National University are working adults, the students often pick their current employer for doing their Capstone project. If a student is interested in entering into a new area of specialty, he/she is encouraged to select an organization of his/her choice (this organization could either be a prospective employer or one that is representative of an industry that he/she would like to explore). Typically, the instructor or lead faculty will help the students to reach an organization of their choice and interest. Since the goal of the Capstone project is to demonstrate a student's mastery over all aspects of the area of his/her specialty including problem identification, technology selection and integration, risk analysis, project management, and implementation, the student is advised to pick a discipline emphasis that caters to his/her interests.

Finding a Sponsor

One way of finding a sponsor is by tapping the sponsors who willingly contact National University's Dean or leading faculty with potential projects (see the list of current projects). Besides this, students are also encouraged to seek their own sponsors as well. The recommended process for obtaining sponsorship follows the sequence presented below:

- Identify a potential sponsor with the help of faculty, colleagues, fellow students, employers, or other means.
- Ensure that the student and sponsor clearly understand the Capstone project's process, timelines, and guidelines.
- Develop a written list of questions about the organization and available potential projects.
- Provide potential sponsor information regarding the students' qualifications.
- Meet face to face with the potential sponsor and discuss project details.
- Take careful notes about the potential sponsor's project, including contact information, scope, completion dates, and relevant details (some projects may include monetary stipend).

- Communicate clearly with the potential sponsor about the goals for a Capstone Project, and seek to match students' proposed solution with a problem faced by the prospective sponsoring organization.
- Evaluate the feasibility of completing the project through discussions with the potential sponsor, instructors, colleagues, fellow students, and lead faculty.
- Contact the potential sponsor on or before the agreed-upon date to convey students' decisions.

It is important to make sure that the sponsor selected (or a designee) will be the principal contact for the entire duration of the project. Typically, a letter of support from the organization that lays out the terms of the project along with mutual expectations is obtained.

Project Logistics

A typical Capstone course is completed within a two or three month period. During this time, students meet with the instructor in charge of this course twice a week. On the first day, students make a short presentation regarding their projects, their team members, project sponsor and timeline of activities. After each presentation, faculty members along with other students ask questions relating to the topic chosen and discuss possible problems that could be researched and the outcomes they anticipate. Drawing on the information obtained from this discussion, students and their instructors may refine the angle, scope, goals and outcomes of the selected project [2]. Since the entire project has to be completed in two or three months, all details pertinent to the project including expected assignments on a weekly basis are laid out. After this introductory meeting, teams schedule weekly status meetings with the instructor. These are formal meetings in which each team member presents a report on his/her particular activities and the status of his/her individual deliverables during the preceding week. Attendance at these meetings is mandatory unless specifically excused. Students who fail to attend the meeting or show chronic inactivity, which is determined from the weekly status report, will lose participation credit. Teams are also expected to meet twice a month with their project sponsor to ensure that they continue to align with the sponsor's vision and have not deviated from the sponsor's expectations. Sponsors are viewed first as a customer and only secondly as a resource. Hence it is the team's responsibility to make sure that the work is proceeding as per the plan. At the end of each month, all teams have to present their project progress to the rest of the class. A project post-mortem is held to ensure that the proposed results are indeed the best solutions to the problem proposed. A final public presentation is made to the committee and sponsors at the end of the project.

Class Structure

A major goal of the Capstone project is to familiarize students with a corporate team environment, where responsibility for getting things done belongs to the team and its members. A typical class has 12 – 15 students, and these students are grouped into five project teams. This size provides students with opportunities to get personal attention from the faculty supervising their project. Initially, the Capstone class has a structure

similar to that of other classes. Each meeting consists of a lecture and class interaction. The goal of these lectures is to help reinforce students' knowledge of the program specialization and project management practices. However, by the third week of the Capstone course, each team meets the instructor alone to review the progress made and obtain answers to relevant questions. This 30-45 minute status meeting each week gives students a chance to allow their instructor to gain first hand knowledge of the team's performance, dynamics, and the effort invested by individual team members. In addition, the status meetings help the instructor know that each team is making steady, consistent progress towards completing the project.

Grading Policies

Upon completion of the Capstone Course, students will receive a grade designation of "H," "S," or "U." as described below:

H = Honors	Equivalent to a "B" or better.
S = Satisfactory	Equivalent to a "C," i.e., student met all requirements
U = Unsatisfactory	Equivalent to a "D" or less, student did not meet requirements

Incomplete ("I") will only be granted to students who meet National University's requirements for an "Incomplete" designation ("due to uncontrollable and unforeseen circumstances"). An "Incomplete" must be removed no later than the second complete quarter following the original course completion date.

Capstone Project Written Paper Structure:

The Capstone project has to follow an APA format as described below.

Abstract: An abstract is a brief, comprehensive summary of the contents of the paper.

Text: Chapter 1: Introduction - The statement of the problem, background of why this problem needs to be studied.

Text: Chapter 2: Literature Review – This section should contain all work related to the proposed topic including chronological research progress made to date.

Text: Chapter 3: Methodology – Answers the question "How?"

Text: Chapter 4: Findings – Answers the question "What?"

Text: Chapter 5: Conclusions and Recommendations – Answers the question "So what?"
References: At least five critical references must be from published peer reviewed documents published within the last five years.

The Responsibilities of the Instructor

There are a number of responsibilities that fall under the tutelage of the instructor. They include the following:

Length of Capstone Project

The word length for a thesis does not include footnotes, references or appendices, nor does it include equations, tables, diagrams, and other illustrations. The expected length for a master's project is 30,000 words and for a bachelor's project is 20,000 words. This does not include footnotes, references or appendices, equations, tables, diagrams and other illustrations.

Peer Evaluation

During the process of carrying out his/her project, each student will be asked to provide information relating to team member activities. This information will provide a picture of team dynamics and other pertinent challenges that a team may be facing. This information will be kept confidential; the instructor who has access to this information will use it to identify specific issues that may be hindering healthy team dynamics.

Capstone Project Examination

The examination for the capstone project will include an oral presentation and a written document. The instructor will appoint a committee of faculty/non-faculty members as examiners. The oral examination will be used to test a student's level of knowledge and presentation skills. It will also give the student an opportunity to elaborate upon and defend his/her capstone project. Table 1 provides the rubric for presentation while the Table 2 summarizes the rubric for the written assessment. Typically, the oral exam will constitute 25%, the written part 65% and participation 10% of the total score. The oral examination will last 30 minutes, and further time will be allotted for questions. Copies of the capstone project will be sent to the examiners by the instructor. Each project may have a different set of examiners.

Examiners will be asked to make one of the following recommendations:

- that the candidate be awarded the degree without further examination;
- the candidate be awarded the degree without further examination, subject to insertion in the capstone project of amendments noted in accordance with the rubric shown on Table 2;
- the candidate not yet be awarded the degree but be permitted to resubmit the capstone project in a revised form.
- the candidate not be awarded the degree.

Illustrative Example:

In 2004, a capstone project titled, "An Analysis of Effects of San Diego Wildfire on Ambient Air Quality" was conducted by two masters' students from the environmental

engineering program [3]. In October 2003, Southern California was blanketed with clouds of smoke and ash which were carried over hundred of miles by the strong winds. The San Diego fires consumed an area of over 390,000 acres; burned 5,597 homes, commercial and accessory buildings; destroyed 3,773 automobiles, trucks and boats; and caused 16 deaths. Hence a capstone research project was conducted to document the quantities and effects of major gaseous pollutants and particulate matter emitted into the ambience of San Diego County by the wildfires of October 2003 and establish correlations between pollutant levels in the region and resultant health problems experienced by the county residents using medical surveillance reports compiled from various area hospitals. The rationale for this project was that establishing a nexus between the major pollutants emitted and air quality related health problems would be useful in preparing for similar events and developing preventive strategies for the future. This project was sponsored by the San Diego County Air Pollution Control District and San Diego County of Health. This project followed the process illustrated earlier. Two students who were well focused performed the work with advice from a faculty advisor (in this instance separate from class instructor) and two representatives of San Diego County Air Pollution Control District and San Diego County of Health. Since all issues relevant to the project were known to the students at every phase of this project, there were no surprises. The students were given periodic feedback on their work. The students learned a lot by applying the principles they had been introduced to in the program. Their enthusiasm and morale were high due to the support provided by the project advisor and sponsors. As a result, two technical papers were developed using this work. This work serves as an example to future participants as a way to maximize their learning potential.

Conclusions:

Based on the above project experience, it is important to recognize the following do's and don'ts.

Do's	Don'ts
➢ Define the process, roles, and make it known to all students ➢ Identify project sponsor and organization ➢ Identify all tasks and their timelines ➢ Conduct regular meetings with students ➢ Establish extensive communication between students and supervisors	➢ Don't offer projects with no practical value ➢ Don't offer projects without serious commitment from project sponsor ➢ Don't select projects that have no link to learning outcome of the program ➢ Don't allow final presentation without dry-run

Table 1: Rubric for Capstone Project Presentation

Presentation Rating

Evaluation and Feedback **Date**

Presenter(s) _____

Topic _____

Rate the presentation on the following factors by circling the number that identifies your judgment of the presenter(s) performance.

		Poor	Value/Quality …….				Good
Structure and Organization		**Low**	**1**	**2**	**3**	**4**	**5** **High**
1	Introduces Self + Team (Uses Topic Transition Introductions)		1	2	3	4	5
2	Provides an Overview of Topic or Agenda of Key Ideas		1	2	3	4	5
3	Identifies Benefits to Audience (Learning Outcomes)		1	2	3	4	5
Development of Main Points							
1	Organizes/Structures Ideas to Flow Together		1	2	3	4	5
2	Clearly Describes + Emphasizes Key Ideas		1	2	3	4	5
3	Illustrates Main Points with Examples, Experience, Stories, etc.		1	2	3	4	5
4	Analyzes/Compares + Evaluates Ideas		1	2	3	4	5
5	Relates Ideas to Audience's Experience + Knowledge		1	2	3	4	5
6	Uses Supporting Data, Information, Quotes + References		1	2	3	4	5
7	Interacts with + Engages Audience through Dialogue + Exercises		1	2	3	4	5
Concluding Summary							
1	Restates Objectives of Presentation		1	2	3	4	5
2	Summarizes Key Ideas		1	2	3	4	5
3	Reinforces/Repeats Benefits to Audience (Learning Outcomes)		1	2	3	4	5
4	Responds to Audience Questions + Comments		1	2	3	4	5
Delivery and Style							
1	Uses Specific Terminology/Language + Word Pictures/Images		1	2	3	4	5
2	Speaks with Appropriate Loudness, Speed, + Voice Inflection		1	2	3	4	5
3	Uses Gestures + Body Language		1	2	3	4	5
4	Demonstrates Enthusiasm for Subject + Interest in Audience		1	2	3	4	5
Technology							
1	Produces Quality Visual Aids + Uses Effectively		1	2	3	4	5
2	Provides Quality Materials + Uses Handouts Effectively		1	2	3	4	5

Total Time _____ **Final Score** _____
Add Numbers to 100

Comments

TABLE 2: CAPSTONE WRITTEN PROJECT EVALUATION FORM

Area	Outstanding (9-10)	Good (7.5-9)	Fair (6-7.5)	Poor (below 6)
Presentation	The student has adhered to all of the standards outlined in the Capstone project requirements by National University.			The student has basically ignored many of the standards outlined in the Capstone project requirements.
Facts	The detail and scope of the information incorporated into the project demonstrates considerable familiarity.	The student could have provided greater detail and scope.	The student had some difficulty furnishing sufficient evidence.	The student failed to provide information that is accurate and relevant to the project.
Analysis	Facts, key concepts and principles were presented in an orderly fashion with logically sound conclusions.	The student's presentation of facts, and principles was orderly; with one erroneous inference.	Some of the facts, are presented in a disorderly fashion with some erroneous inferences.	Presentation of facts, key concepts and principles is disorderly and there are multiple errors in reasoning.
Synthesis	The student brought together ideas around a thesis to create a meaningful, coherent essay.	The student brought together ideas around a thesis, however, sufficient context is lacking.	The essay contains satisfactory factual and conceptual content, but is presented in a disjointed, "grocery list" fashion.	The student has failed to construct a coherent essay built around an identifiable organizing theme or concept.
Vocabulary /Rhetoric	The student has demonstrated vocabulary and variety in expression superior to this grade level.	The student has demonstrated vocabulary and variety in expression expected at this grade level.	The student has not demonstrated vocabulary or variety in expression expected at this grade level.	The student has utilized a vocabulary with little or no range and/or no variety in expression.
Mechanics and sentence structure	The student consistently uses correct grammar, syntax, spelling, punctuation, and capitalization.	The student has an average of fewer than 3 errors per page in grammar, syntax, spelling, punctuation, and capitalization.	The student has an average of 3 or 4 errors per page in grammar, syntax, spelling, punctuation, and capitalization.	The student has an average of more than 4 errors per page in grammar, syntax, spelling, punctuation, and capitalization.
Form	The student has organized ideas into coherent paragraphs with smooth transitions.	Transitions are sometimes awkward, and/or the assignment does not always hold together.	There is weakness in one of the following criteria: organized paragraphs or smooth transitions.	The student has not demonstrated an understanding of paragraph structure, transitions, or unity.
Research (if applicable)	The student has used a wide variety of informative and relevant sources.	The student has used a sufficient number of sources.	The student has provided sources but had difficulty integrating them.	The student has failed to provide sufficient relevant sources for this assignment.

Bibliography

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3. Eria, L., and N. Diunugala, "The effects of San Diego Wildfire on Ambient Air Quality: Gaseous and Particulate Pollutants," Capstone Thesis, National University, La Jolla, California (2004).