Pragmatic Framework for Graduate-level Sustainability Capstone Projects

Mr. Ben D. Radhakrishnan, National University

Prof. Ben D Radhakrishnan is currently a full time Faculty in the School of Engineering, Technology and Media (SETM), National University, San Diego, California, USA. He is the Program Director/Lead Faculty for MS Sustainability Management Program. He develops and teaches Engineering and Sustainability Management graduate level courses. Ben has taught Sustainability workshops in Los Angeles (Army) and San Diego (SDGE). His special interests and research include promoting Leadership in Sustainability Practices, energy management of Data Centers and to establish Sustainable strategies for enterprises. He is an Affiliate Researcher at Lawrence Berkeley National Laboratory, Berkeley, CA, focusing on the energy efficiency of IT Equipment in a Data Centers. As a means of promoting student-centric learning, Prof. Radhakrishnan has successfully introduced games in to his sustainability classes where students demonstrate the 3s of sustainability, namely, Environment, Economics and Equity, through games. Students learn about conservation (energy, water, waste, equity, etc.) through games and quantifying the results. He has published papers on this subject and presented them in conferences. Before his teaching career, he had a very successful corporate management career working in R&D at Lucent Technologies and as the Director of Global Technology Management at Qualcomm. He had initiated and managed software development for both the companies in India. Prof. Radhakrishnan holds Masters Degrees (M.Tech, M.S., M.B.A) and Sustainable Business Practices certification from University of California San Diego.
Pragmatic Framework for Graduate Level Sustainability Capstone Projects

Ben D Radhakrishnan, M.Tech., M.S., M.B.A.
Program Director, MS Sustainability Management Program,
Applied Engineering Department

National University,
San Diego, CA
Abstract

The Sustainability Management graduate program objective is to train future leaders of corporations, government agencies, non-profits etc., who will strive to demonstrate a balance among the three elements of sustainability, namely, Environment, Economics and Equity/Social Justice (generally referred to as 3 Es). Implementation of sustainability projects bring in elements of technical and management aspects.

Sustainability Management capstone projects bring to fruition all the knowledge and skills from the coursework to solving a real-world problem. The project is key to students’ academic success, develop future leaders’ planning and implementation skills. Students in this program come from a variety of educational background – science, engineering, management, economics, liberal arts, etc. The methodology framework for the capstone projects is not the only key to the success of their projects but should be broad applicable to solve real-world sustainability problems.

This paper will demonstrate a pragmatic capstone framework and specific tools for the program that focuses on both technical and management aspects of sustainability. The capstone framework, assessment and feedback aspects will be discussed. It includes graduate research attributes such as sustainability modelling, project implementation, quantifications and process flows. In addition, management attributes with tools such as sustainable SWOT, risk analyses, Best Management Practices, etc., are also part of the methodology. The ultimate goal of the capstone project is to help demonstrate the viability of the three sustainability principles (3 Es) and to quantify the results. Projects are executed in teams and majority of the projects are industry-sponsored projects.

This paper will present the capstone project framework, duration and phases with examples of successfully completed capstone projects along with assessment and evaluation processes of the capstone course. Students’ feedback will also be discussed along with further potential enhancements and the framework’s potential for other programs.

Tags: capstone project, sustainability, framework, methodology, leaders, management, engineering, economics, environment, equity, social impacts

Introduction

Well established engineering fields tend to have a firm graduate program capstone methodologies defining clear inputs, process methods and outputs. With a new graduate program in the new field of sustainability management, university faced some challenges and adopted an existing process details. Over the last five years, the capstone courses have gone through some changes fine tuning the initial approach to a practical framework and tools that are more suited to sustainability capstone projects, but still remaining within the university’s time frame for capstone courses, rigor and other requirements.

Sustainability Management graduate program encompasses both technical and management aspects of solving problems relating to environment, economics and people’s equity aspects.
A graduate program’s final course, a capstone project, is the culmination of knowledge gained from all the course work resulting in a clear objective driven deliverable, a project report. Generally, the objective of a capstone project is to solve a real-world problem. Universities generally establish their own capstone project methodologies for specific programs.

This paper will present a well evolved capstone framework for MS in Sustainability Management program. Unlike established graduate engineering or business areas, this subject area is relatively new with no firm methodology established. The paper will present all the elements of the framework particularly suited to sustainability and the process can be used for both online and onsite offerings of the program.

The paper will also present assessments of the capstone course and evaluations on student learning, successes in achieving the program learning outcomes and the usefulness of the program in solving real world problems. The paper will also discuss ideas on the potential to expand this framework for other programs and additional enhancements.

**Graduate Capstone Methodologies**

Capstone projects by definition serve two audiences namely, the academic and the sponsor or the client. Academic audience look for a well laid out research: formal systematic application of scientific methods to the study of problems [1, 2]. Project sponsor/client, on the other hand, look for well laid pragmatic project implementation details along with profitability so they can make informed decisions. With the approach taken in this program where projects have industry sponsors, the students have a challenge to meet both academic and sponsor needs.

Pure research (i.e. thesis) processes generally focus on a thorough literature survey followed by quantitative and qualitative analysis, surveys (as applicable) and correlations [1]. For solving real world problems through the capstone approach not only includes the above details, but also focuses on the practical implementation analysis such factors as, issues and risks, monetary quantification factors such as, net present value, pay back periods, and return on investment and project schedule. Sponsors want a detailed process laid out for the technology/science/procedure supporting the project and its implementation details. As an example, for a sustainability project such as ISO 14001 Environmental Management System certification, sponsors want to know the pre-requisites and procedural details of ISO 14001 following by how the project can be implemented in the company along with costs, training needed and benefit to the company from the 3 Es perspective.

The capstone methodology implemented in this sustainability management program covers all the above characteristics to satisfy both the academic and the sponsor/client needs.

**Sustainability Management (MS) Capstone Overview**

MS Sustainability Management is a new program in the university established five years ago. The goal is to train future leaders to be responsible stewards in managing our planet’s resources towards balancing the three elements of modern sustainability [3, 11], namely, Environment,
Economics and Equity (or social justice), commonly referred to as 3 Es. Students are trained to incorporate ecological, economic and sociological conditions with the goal of reconciling the needs of the present generation without compromising the needs of future generations [3]. This is a blended program between engineering and business schools in the university. Courses are taught by faculty from both schools.

**Sustainability Management Program Learning Outcomes (PLOs)**

Upon successful completion of the program, students will be able to:

- Apply scientific knowledge and methods required to evaluate sustainability concepts and systems.
- Design, manufacture, and manage processes in an environmentally conducive manner.
- Analyze engineering and management problems in their social and environmental context.
- Develop economic, environmental, and social sound sustainable decisions.
- Evaluate the impact of products, processes, and activities through life cycle assessment.
- Develop written communication skills required for this profession.
- Demonstrate professional, legal, and ethical responsibility in decision making practices

PLOs clearly enunciate both the technical and the management skills needed to be a leader in an organization. The objective of capstone course(s) focus on achieving a blend of these skills applied to the real-world sustainability issues. The final output of the capstone project, a project report will specifically highlight how the 3 Es were addressed and met. Upon appropriate reviews by the university faculty, the report is ready for submission to the sponsor for implementation. The capstone projects are generally done in student teams of 3.

**Capstone Project Framework**

University has a unique model for adult education. Regular courses are taught at the rate of one course at a time over a 4-week period. The program is accredited and approved by Western Association of Schools and Colleges (WASC) for both onsite and online offerings. As each program course string starts, a student cohort go through the required program curriculum in both onsite live classes or online. Students take the capstone project courses after successfully completing all other required course work.

Capstone courses are divided in two parts, Part A (Course SEM610A Project I) and Part B (Course SEM610B Project II), as shown in Figure 1. Each part is a course by itself and the output of Part A, a project proposal, is graded, and each student team project must pass Part A before they can dwell in to Part B to implement the project.
The course outline for Part A clearly lays out the details for both parts of the capstone including the presentations to be made at the end of each part by all members of a student team.

Teams also select a Faculty Advisor during Part A. The Advisor is Subject Matte Expert (SME) in the field. The Advisor can be any one of the Instructors from their course work or an external industry expert. While the course instructor focuses on the capstone project’s methodology, special instructions, assessment and general guidance, Advisor focuses on the specific project related technical advice and guidance. An Advisor’s role as an SME is important and key to the success of the capstone project.

During Part A, Instructor meets twice a week with the class (applies to both live onsite and online classes). During Part B, class meets once a week, starting with the whole class and then meeting with individual teams. Instructor meeting with the students – as a full class and with individual teams is key to keeping the projects moving per requirements and to help the teams. In addition, the teams also meet with the Advisor to get his/her advice.

**Sustainability Capstone Implementation Framework**

The pragmatic capstone framework discussed in this paper is built on five pillars as listed below:

1. Industry/Company Sponsorship
2. Sustainability Specific Models and Tools
3. Team Engagement with Critical Thinking
4. Solution for Sustainability elements
5. Solution for Management elements

Details on each of the above first four pillars are described below with examples and assessment procedures. Students doing their MS in Sustainability Management need that extra passion for...
the care of the planet we live in and understand the three elements of sustainability and its principles [11]. Although one could argue that the fifth pillar is more subjective, these students realize that the outcome from this sustainability education is stewardship of the planet and it is more than a degree or a job. Passion is the center pillar for successful sustainability project.

Project Sponsorship

Most all capstone projects in the program have been sponsored from companies where one of the students in a team already works. The goal here is give the student teams a big taste of solving real-world sustainability issues and at the same time helping their own company towards its sustainability goal realization. The company sponsor is usually a high level manager (e.g. President, Vice President, and Director). This is a great collaboration between academia and industry. This process is also an engaging experience for the sponsor. The sponsor writes a ‘Sponsorship Letter’ along with a commitment to give the required data to the student team in a timely manner. As noted earlier, the output of the capstone project has two clients [2], the academia faculty who will evaluate the course output to meet the required university requirements and standards, and the industry project sponsor. Both the sponsor and the advisor stay on with the team till the project is completed.

Capstone Project Proposal (Part A – SEM610A Project I)

The main goal of this phase ‘Part A Project I’ is for the student team to develop and complete a project proposal document with all the necessary key elements to go in to implementation in Part B Project II. The student team and the sponsor should have a clear understanding of what the project will deliver from their project. No effort is spent by the student team to implement any part of the project. The output project proposal is relatively a small document (range of 20-25 pages), with the following content:

- Introduction
- Background
- Project Objective(s) and Scope
- Stakeholders
- Research Questions
- Brief Literature Review
- Project Impact on the 3 Es of Sustainability (high level)
  - Economics, Environment and Equity (or Social Justice relating to people)
- Issues and Risks (high level)
- List of Tools (to quantify sustainability elements in Part B)
- Conclusion
- References
- Project Schedule

It is important to note that the capstone deals with project objectives as opposed to a hypothesis statements. The proposal document is developed in stages over the four weeks duration of Part A. Every week students complete portion of the document starting with the first three sections. They can continue to refine objectives and scope as they get in researching, developing the
project concept working with their sponsor, and writing other sections. All completed sections are due at the end of four weeks. Students also make a presentation to the Instructor and the class on their proposal. A template for the Part A with the content is also given to the students for consistency. These essentially are the minimum requirements for completing the output for Part A. Students are encourage to add any additional sections, if they feel will enhance the proposal.

The introduction and background section essentially lays down the ground work for setting up the objective(s) and scope of the capstone project. For solving a real world issue with a sponsored project, the scope of the project is significant given the time frame. In addition to the objective which could be at a higher level, the scope will indicate what is included in the implementation and what is not. This prevents any misunderstanding by all parties. As an example, if one of the objectives of the project is to reduce energy consumption by 10-15% annually, scope will indicate specific areas of energy consumption that will be targeted for reducing energy, and what areas may not be included.

The stakeholders section identifies the beneficiaries of the project. Since the topic of sustainable operations in an organization is still new, identifying all the stakeholders brings a level of clarity to the project objectives. The sponsor can bring in the requirements of their end-customer (e.g. Chief Sustainability Officer, Facility Manager, or others, as needed).

Research questions are fundamental to any research project and the questions help to determine the literature survey, methodology, guides inquiry, analysis and reporting [4]. Student teams will develop a set of initial research questions in Part A that will address various aspects of the objective(s) and scope of the project and its implementation. Use of students’ critical thinking skills strongly come in to play in developing the research questions and helps the team to see the purpose of the project more clearly. Research questions also help in identifying the level and types of detailed literature review to be done and the types of data to be collected for the project. Questions can also identify some areas of concern or obstacles. Generally at this stage there could 5-7 high level and broad research questions (the set of research questions gets expanded in Part B).

In Part A students will do an initial brief literature search on topics and fields related to the project they are proposing. Student teams will do a more exhaustive extensive literature survey during Part B, but this is to get the students to do real introductory literature survey. University has extensive library support facilities onsite and online to support capstone research. Library school liaison makes a presentation showing all support services and databases available from the library.

As noted earlier, modern sustainability definition is driven by the 3 Es. In this proposal, student team will research and write about how the objective of the project will impact each of the 3 Es. At this stage it will be more a qualitative discussion. Specific quantification of the 3 Es will be developed in Part B.

Like in any real-world situation, student teams will list issues (problems/obstacles that already exist) and risks (future anticipated obstacles) at a high level in this Part A of the capstone.
Identifying these will help them to address them to solve and mitigate in Part B and will not become a surprise that might affect the progress of the project.

As noted earlier, a key goal of sustainability related projects is to quantify the different elements with appropriate tools. Given the objective and scope, students will research for tools to be used for the project from their course work, journal publications and nationally published sustainability tools (e.g. EPA). These include solar calculation tools, carbon di oxide (and other Green House Gases) emission calculation tools and recognized sustainability models. Students are also encouraged to develop their own specific tools and models depending on their project. Again, the goal here is to get ahead with tools in order to quantify in Part B.

Student teams also generate a schedule identifying tasks that each team member will do for Part A proposal completion and will also generate a high level schedule for Part B at the end of Part A. The schedule tasks will include meetings with the sponsor and team meetings in addition to document generation. All documents are done according to American Psychological Association (APA) standards.

Capstone Project Implementation (Part B – SEM610B Project II)

The major Course Learning Outcomes (CLOs) for Part B are highlighted below:

- Develop clear and achievable project objectives and scope (input from SEM610A)
- Complete and document advanced literature review relevant to the project
- Identify sources of data for the analysis, gather and analyze relevant data
- Develop methodologies for project implementation and agreement with the client organization, if applicable.
- Demonstrate and document project implementation along with data analysis (appropriate qualitative, quantitative and analytical models for drawing conclusions)
- Complete project conclusion, recommendations and next steps.
- Write a Masters level research project document based on the findings that include all essential elements of good environmental and sustainable practices, per the guidelines provided for each section of the document.
- Defend the project findings during oral presentation to faculty, sponsors/clients and class.

Project Report, the main output of this phase ‘Part B Project II’ is for the student team to document the implementation of the project proposal that was completed in Part A. Detailed of the two outputs of this second phase are:

a) A full comprehensive project report with all the details of implementation documented in five chapters, as noted below:

   Chapter 1 – Introduction
   Chapter 2 – Literature Review
   Chapter 3 – Methodology
   Chapter 4 – Implementation & Analyses
Chapter 5 – Conclusion and Recommendations

b) Formal Presentation Slide set

Both the outputs are assessed and part of the final grade for the course. The general chapter layout of the final project report is not inconsistent with those developed and practiced in other leading universities [3]. This format supports the dual audience for a capstone project - academicians and the sponsor/client. Teams also develop a schedule with detailed tasks for each section of each chapter. Focus is on research first and then writing. With only 8 weeks for Phase B, every two weeks, teams deliver a draft of the project report. Instructor reviews the content and gives feedback to the teams along with Advisor. Instructor and teams once a week and discuss the review comments, progress and issues or obstacles the teams might be facing.

Much of the information documented in Phase A project proposal document is carried forward into chapters 1 and 2 for this Phase B project report and expanded with additional data (e.g. more Research Questions). Teams expand on their research questions in the first chapter.

The initial literature survey documented in Phase A provides the seed for a more complete and thorough literature survey (Chapter 2) in the Phase B. In addition, student teams are also required to document at least three case studies as a part of the literature survey on projects which are similar or closely related to the current project. Reviewing and documenting case studies expands the students’ knowledge on similar project outcomes and can influence their current implementation. Teams learn how quantifications were done in the case study projects.

Methodology (Chapter 3) documents all the theoretical analysis of the body of methods and principles associated with sustainability and their application to the current project. Specifically, chapter 3 documents data collection process, sustainability model(s), tools, qualitative and quantitative techniques and other procedures. Both types of audience get a clear picture of the methodology that will be expanded into quantification to meet project objectives, hence this is a key chapter. Students get clear guidance on sustainability models, tools and techniques and their adaptation for the given project. Many tools and techniques learned during the course work also comes in to play here.

Implementation & Analysis (Chapter 4) gets down to the real detailed execution and verification of the models and tools identified in chapter 3 and analyzing their value towards the goals of the project. In addition, teams develop a project process and project implementation flow charts. Process flow chart lays down the technical details behind the project from start to finish, while the project flow charts lays down the project execution details. Both these diagrams are of great interest to the project sponsors since it visually presents the project details from two different perspectives. For example, for a building Leadership in Energy and Environmental Design (LEED) project, processes defining categories and their associated points, will be described. For project execution diagram, all major tasks will be identified including management and other approvals.

The set of tools identified under methodology and implemented are listed below and each is specifically tailored to a given project.
- Sustainability Model: Pacific Northwest National Laboratory (PNNL) Model [5, Figure 2]
- Sustainability Strength, Weaknesses, Opportunities and Threats (sSWOT) analysis [6]
- LEED scoring spreadsheet for building certification [7]
- National Renewable Energy Laboratory (NREL) Solar power generation calculator [8]
- Life Cycle Assessment [10]

Many of the course work in the program train the students in using these tools. As can be seen from the list above, many tools from National Laboratories are used and also brings key management tools (e.g. SWOT) to these projects. PNNL sustainability generic model is shown in Figure 2. Teams explore and modify this model to suit their project and quantify all sub-areas impacted by the environment, economics and equity/social responsibility (the 3 Es) as shown in the model.

Figure 2. Sustainability Model from Pacific Northwest National Laboratory [5]
Both chapters 3 and 4 explore the potential sustainability Best Management Practices (BMPs) is use for similar projects and the projects recommends a full set of BMPs for the current project. Identification of project risks and mitigations are a part of chapter 4. The quantifications done in Chapter 4 will indicate whether the project objectives were achieved (or not).

For quantifications relating to process improvements or savings specific calculations are done for the following: energy, water, waste management, land management (e.g. LEED Neighborhood Development), greenhouse gas emissions (e.g. Carbon dioxide). Teams also create project implementation check lists to make it clearer for execution and any training manual, as needed (e.g. ISO 14001). Life Cycle Cost Analysis (LLCA) is done for solar plant implementations and for other projects as needed to quantify financial Return on Investment and Payback period. Life Cycle assessment is done to quantify the environmental emissions (e.g., Carbon dioxide) as a result of implementing a project.

The Conclusion chapter will not only clarify successful project achievements as it related to the objectives, but will also discuss any shortfalls. Conclusion will also focus on how the 3 Es of sustainability were achieved with quantification. The team will clearly identify the Sustainability Principles [11] that were met as a result of implementing the project.

Student teams will make a formal presentation at the end of the Phase B where all school Faculty (Dean, Chair included), Adjunct Faculty, Sponsors, Advisors and other students are invited. All team members are required to be a part of the presentation and each attending Faculty will also evaluate/score the presentation. Students’ passion for sustainability becomes visible in their presentations.

**Types of Sustainability Management Capstone Projects**

Over the last five years, many different types of sustainability projects were implemented with majority of them being industry sponsored projects. The list below provides the different types of project completed by student teams.

- LEED Building Certification projects
- ISO 14001 Implementations [12]
- Renewable Solar Power Plant Implementations
- Sustainable Solutions for Cyanobacteria Reduction for Municipal Water Districts
- Wellness Buildings Certification (for hospital buildings)
- Global Reporting Initiative Analysis
- Sustainability Driven Postal Products
- Sustainable Specialty Coffee Processing for Farmers in Honduras
- Infusing Sustainability into Camping Cherry Valley

There were multiple LEED, Solar and ISO14001 projects over the last five years.

**Capstone Project Assessment**

Student performance assessment is done both the capstone course output quality, teamwork and individual contribution. The project report output has rubrics for project content quality and
writing quality. Appendix 1 had the rubrics for the project content quality and Appendix 2 has the rubric for written quality of the project report.

Capstone projects are done in teams, generally a team of 3 students. The teams also select a team leader (project leader). The coordination required for a successful capstone project is not insignificant. Teamwork, better planning and work distribution among members are very important for the success of the project and to avoid major. Capstone students, having gone through the course curriculum, generally already have a team, and many continue with the same team members. For project leaders, this is also a worthwhile experience - leading a team in capstone project planning and implementation, adding to their leadership skills.

For any team issues, if they cannot work it out among themselves, any team member can bring it up to the Instructor to intervene to help remedy teamwork or inadequate contribution issues. To assess teamwork and contribution, team members fill out a team-evaluation form for each member and a self-evaluation. This feedback is shared with members and also is a part of the course assessment (see rubric in Appendix 1).

As noted above, the team’s final presentation is also assessed by all the Faculty who attend the formal presentation (Dean, Chair and other school faculty). There is a separate presentation evaluation-scoring form that each faculty fills out for each team along with specific comments. The instructor takes this into consideration towards overall assessment and for the final grade to each student in the team. The final three grades given to each student is one of the following: Honors (H), Satisfactory (S) and Unsatisfactory (U). U is a failing grade.

**Capstone Project Student Evaluations**

Student course feedback is obtained from different official surveys conducted by the university. At the end of each course (Part A and Part B), students complete a course evaluation on both learning and teaching. Since the capstone is the final course in the program, the university also conducts a program exit survey to get a feedback on students achieving the needed skills from the PLOs, and how the program helped them for the personal and professional growth.

Course student-learning and teaching evaluations is important since it gives feedback on the quality student learning the instruction. Learning evaluation includes: the capstone CLOs, students own understanding of the framework, processes and confidence in their own implementation. Teaching evaluations includes: instructor’s course organization, timely responses, assignment grading clarity, course explanations and effectiveness and student engagement. Student evaluations are scored on a scale 1 to 5 (5 being the highest or the best) for both student-learning and teaching.

As shown in Figure 3, Students’ evaluation feedback for both the courses (Part A and Part B) on learning and instruction were very good, all above a rating of 4.
Capstone project implementation is the ultimate stage for students to develop and demonstrate the competencies described in the PLOs, and they provide this feedback at the end of the program. This feedback is also important because they do this evaluation right after the capstone courses. This feedback is shown in Table 1. PLOs directly reflect the full curriculum and the capstone projects in particular. Overall the student population feedback on the capstone courses in particular and the PLOs, is very positive demonstrating the value of the framework and its outcome in the capstone projects.

Table 1 – Student Evaluation on Achieving PLO Competencies

<table>
<thead>
<tr>
<th>PLO#</th>
<th>Competency</th>
<th>Total # of Survey Responses</th>
<th>% of Responses: 'Strongly Agree' and 'Agree'</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLO#1</td>
<td>Apply scientific knowledge and methods required to evaluate sustainability concepts and systems.</td>
<td>30</td>
<td>96.7%</td>
</tr>
<tr>
<td>PLO#2</td>
<td>Design, manufacture, and manage processes in an environmentally conducive manner.</td>
<td>30</td>
<td>96.7%</td>
</tr>
<tr>
<td>PLO#3</td>
<td>Analyze engineering and management problems in their social and environmental context.</td>
<td>30</td>
<td>96.7%</td>
</tr>
<tr>
<td>PLO#4</td>
<td>Develop economic, environmental, and social sound sustainable decisions.</td>
<td>30</td>
<td>100.0%</td>
</tr>
<tr>
<td>PLO#5</td>
<td>Evaluate the impact of products, processes, and activities through life cycle assessment.</td>
<td>30</td>
<td>100.0%</td>
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</tr>
<tr>
<td>PLO#6</td>
<td>Develop written communication skills required for this profession.</td>
<td>30</td>
<td>96.7%</td>
</tr>
<tr>
<td>PLO#7</td>
<td>Demonstrate professional, legal, and ethical responsibility in decision making practices.</td>
<td>30</td>
<td>93.3%</td>
</tr>
</tbody>
</table>

**Conclusion**

This paper described a very pragmatic evolved framework and approach to a capstone project for a graduate level course in sustainability, a relative new area in higher education. This approach adopted and modified some standard practices and introduced specific sustainability processes and tools from National laboratories. The specific tools and national laboratory models used are unique to sustainability. The use of BMPs and following through with the implementation in a project management approach makes the framework effective and easier for student teams. The approach addresses both technical and management aspects.

The feedback from students on learning in the capstone course, achieving PLO competencies and feedback on the instruction were very positive. Projects output focuses on quantifying on how the 3 Es of sustainability were achieved.

With the constantly changing teaching and learning environments and the need for faster processes, another practical approach that can be looked at will be an Agile Capstone process. This approach has been well adopted and documented in other many other areas (e.g. software development). One major advantage with the agile approach could be that a more complex project can be implemented in a shorter period of time (i.e. to fit the course schedule). But the disadvantage may the availability of sponsor’s and Advisor’s time since they need to become a part of the implementation team (similar to how agile is implemented in the hi-tech world works). There needs to be more research on this approach and a pilot done first before it can be implemented.

Frameworks by nature can be flexible and this framework can be adopted to challenging new programs where more than one field come in to play (here it was technical aspects and management). The rubrics presented here can also be easily modified to suit the new content. The quality of writing rubrics may need little or no change if APA format is accepted.

**References**

Appendix 1 Capstone Project Content Rubrics

<table>
<thead>
<tr>
<th>Subject Area</th>
<th>H-Honors</th>
<th>S-Satisfactory</th>
<th>Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction, background, objective and scope details incorporated into the project demonstrate high degree of knowledge and considerable familiarity with the topic. Sustainability aspects (3 Es) and attributes are well represented with quantification metrics. The team/student provided clear and accurate information relevant to the topic. Exceeded expectations on all aspects above.</td>
<td>Introduction, background, objective and scope details incorporated into the project demonstrate adequate degree of knowledge and reasonable familiarity with the topic. Sustainability aspects (3 Es) and attributes are adequately represented with quantification metrics. The team/student provided adequate information relevant to the topic. Met expectations in most if not all the above aspects.</td>
<td>Introduction, background, objective and scope details incorporated into the project demonstrate inadequate degree of knowledge and familiarity with the topic. Sustainability aspects (3 Es) and attributes are inadequately represented with little or no quantification metrics. The team/student provided inadequate or no information relevant to the topic. Did not meet expectations in most if not all the above aspects.</td>
</tr>
</tbody>
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<thead>
<tr>
<th></th>
<th>Recommendations for future work and research; References</th>
<th>The team/student has used a large variety of informative and relevant sources, and integrated them seamlessly into the literature and body of the project. Exceeded expectations on all aspects above.</th>
<th>The team/student has used adequate variety of informative sources, and integrated them into the literature and the body of the project. Met expectations in most if not all the above aspects</th>
<th>The team/student has inadequate variety of informative sources and integration into the literature and body of the project. Did not meet expectations in most if not all the above aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Research</td>
<td>The team/student demonstrated clear and accurate understanding of the models and tools (Sustainability model adoption, swOT, ISO, LCCA, ROI, invented a new tool, other project specific tools, etc.), process diagram(s), calculations with different options were described in an orderly and professional manner clearly demonstrating ‘level and scale’ required for a Master’s degree,. Excellent original and adapted work, exceeded expectations on all the above aspects.</td>
<td>The team/student demonstrated adequate understanding of the models and tools (Sustainability model adoption, swOT, ISO, LCCA, ROI, other project specific tools, etc.), process diagram(s), calculations with different options were described in an orderly and professional manner clearly demonstrating ‘level and scale’ required for a Master’s degree,. Adequate original and adapted work, met expectations in most of the above aspects.</td>
<td>The team/student demonstrated inadequate understanding of the models and tools (Sustainability model adoption, swOT, ISO, LCCA, ROI, other project specific tools, etc.), process diagram(s), calculations with different options were described in an orderly and professional manner clearly demonstrating ‘level and scale’ required for a Master’s degree,. Inadequate original and adapted work; did not meet expectations in most if not all the above aspects.</td>
</tr>
<tr>
<td></td>
<td>Methodology &amp; Tools</td>
<td>The team/student demonstrated clear path with reasons for the specific implementation with accurate calculations supporting the decisions, synthesizing various data and trends, analysis of the trends and results (positive or negative); implemented procedures and other required documentation (e.g. training and user manuals); made relevant connections to other events, people, places; the impact on 3 Es were quantified with description; documented best Management Practices and checklists. Excellent original and adapted work, exceeded expectations on all aspects above.</td>
<td>The team/student demonstrated path with reasons for the specific implementation with accurate calculations supporting the decisions, synthesizing various data and trends, analysis of the trends and results (positive or negative); implemented procedures and other required documentation (e.g. training and user manuals); made relevant connections to other events, people, places; the impact on 3 Es were quantified with description; documented best Management Practices and checklists. Adequate original and adapted work, met expectations on most of the above aspects.</td>
<td>The team/student demonstrated path with inadequate reasons for the specific implementation with accurate calculations supporting the decisions, synthesizing various data and trends, analysis of the trends and results (positive or negative); implemented procedures and other required documentation (e.g. training and user manuals); made relevant connections to other events, people, places; the impact on 3 Es were quantified with description; documented best Management Practices and checklists. Inadequate original and adapted work; did not meet expectations in most if not all the above aspects.</td>
</tr>
<tr>
<td>4</td>
<td>Implementation, Synthesis &amp; Analysis</td>
<td>The project conclusions were highly descriptive, clear reflecting complete research and project implementation focused on the 3 Es and their principles; Objective met (or not met) explained. The recommendations provide many additional steps for further research and actions, Very rich set of references for current</td>
<td>The project conclusions adequately descriptive, reflecting research and project implementation focused on the 3 Es and their principles; Objective met (or not met) explained. The recommendations provide many additional steps for further research and actions, Adequate set of references for</td>
<td>The project conclusions were not adequately descriptive, reflecting research and project implementation focused on the 3 Es and their principles; Objective met (or not met) explained. The recommendations provide many additional steps for further research and actions, Inadequate set of references for</td>
</tr>
</tbody>
</table>
Appendix 2 Capstone Writing Quality Rubrics

<table>
<thead>
<tr>
<th>Title Page, Abstract &amp; Table of Contents</th>
<th>Honors (H)</th>
<th>Satisfactory ($)</th>
<th>Unsatisfactory (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>--Contains all parts and correctly formatted</td>
<td>--No errors</td>
<td>--All items included, but lacks information</td>
<td>--Incorrect formatting</td>
</tr>
<tr>
<td>--Consistent and appropriate formal style of writing</td>
<td>--No errors in agreement or tense</td>
<td>-- Few formatting errors</td>
<td>--Several formatting errors</td>
</tr>
<tr>
<td>--No punctuation or capitalization errors</td>
<td>--Organized into excellently constructed paragraphs</td>
<td>-- No errors in agreement or tense</td>
<td></td>
</tr>
<tr>
<td>Quality of Writing</td>
<td>--Writing flows well from sentence to sentence and section to section</td>
<td>--Style mostly consistent and appropriate for formal writing</td>
<td>--Not consistent and appropriate for formal writing</td>
</tr>
<tr>
<td>--Does not include first-person language (I, me)</td>
<td>--Fairly effective word choice</td>
<td>--Includes first-person language</td>
<td></td>
</tr>
<tr>
<td>--Several errors in agreement or tense</td>
<td>--Information is very organized into paragraphs but the information is not detailed</td>
<td>--Information is not organized into paragraphs with details</td>
<td></td>
</tr>
<tr>
<td>Organization</td>
<td>--Writing mostly flows but may have a couple awkward transitions</td>
<td>--Paper mostly flows but may have a couple awkward transitions</td>
<td>--Paper does not flow and jumps from topic to topic or sentence to sentence without connecting ideas</td>
</tr>
<tr>
<td>Comprehension</td>
<td>--Sophisticated and precise word choice demonstrating clear understanding of the subject matter</td>
<td>--Has minimal awkward or unclear passages</td>
<td>--Writing is choppy, with many awkward or unclear passages</td>
</tr>
<tr>
<td>--Writing easy to comprehend</td>
<td>--Reader is able to comprehend majority of the time</td>
<td>--Reader is not able to comprehend</td>
<td></td>
</tr>
<tr>
<td>Grammar &amp; Vocabulary</td>
<td>--The paper is free of grammatical, spelling, and punctuation errors</td>
<td>--Very few grammatical, spelling or punctuation errors</td>
<td>--Grammatical errors or spelling and punctuation substantially detract from the paper</td>
</tr>
<tr>
<td>--Effective use of subject-specific terminology with vocabulary and variety (superior to graduate level)</td>
<td></td>
<td>--Effective use of subject-specific terminology with vocabulary and variety (appropriate to graduate level)</td>
<td>--Ineffective use of subject-specific terminology with vocabulary and variety (below graduate level)</td>
</tr>
<tr>
<td>APA Style</td>
<td>--No errors in APA style</td>
<td>--Rare errors in APA style that do not detract from the paper</td>
<td>--Errors in APA style detract substantially from the paper</td>
</tr>
<tr>
<td>--Scholarly style</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citations &amp; References</td>
<td>--All references and citations are correctly written and present</td>
<td>--Few references or citations missing or incorrectly written</td>
<td>--Reference and citation errors detract significantly from paper</td>
</tr>
</tbody>
</table>