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Bridging Theory and Innovation Through the DLSU Mechanical Engineering Thesis and Capstone Programs

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ABSTRACT

BACKGROUND & CONTEXT

The experience of undergraduate students in research and design is essential in the cross over from theory to practice. In the field of Mechanical Engineering, the quality of this experience plays a critical role in developing problem-solving skills and fostering innovation. However, students often face challenges in engaging with research and design, which can influence their academic growth and career trajectories. Understanding their perspectives can provide valuable insights into how research and design are perceived and integrated into their academic journey.

PURPOSE OR GOAL

This study aims to explore the impact of the changes implemented in the DLSU Mechanical Engineering thesis program. Specifically, it seeks to identify the key challenges these changes present and how the students navigate through the program to achieve their desired outcomes.

APPROACH OR METHODOLOGY

This study employed a survey-based methodology to gather insights from students actively engaged in research and capstone projects in the De La Salle University (DLSU) mechanical engineering program. The survey captured their perspectives on research and design engagement, challenges faced, and perceived relevance of their experience to their academic and professional development.

OUTCOMES

The results of the study reveal that, while students acknowledge the significance of research and design, they face several barriers. These include the technical complexity of research, limited prior exposure to research methodologies, and time constraints due to academic workload. Despite these challenges, students find motivation in hands-on projects, industry-relevant applications, and mentorship from faculty and peers.

CONCLUSIONS

The study underscores the need for curriculum enhancements that integrate research opportunities into the Mechanical Engineering program from an early stage. Strategies such as structured mentorship programs, industry collaboration, and project-based learning can help bridge the gap between research and practical applications.

KEYWORDS

Capstone Projects; Curriculum Revision; Undergraduate Thesis Program.

Background of the DLSU ME Thesis Program

In the previous DLSU BSME curriculum, before its ABET accreditation, the thesis program consisted of a 4-term timeframe of thesis courses, THSMEEA, THSMEEB and THSMEEC with a one term gap (no enrolment) between THSMEEB and THSMEEC. While design activities were already embodied in this thesis program, the outcomes-based education (OBE) accreditation needed an emphasis on a design course. As such, the capstone course (THSMCAP) was developed to highlight and formalize the realistic engineering design experience of undergraduate mechanical engineering students in the DLSU BSME program. This was to support the requirements of international accreditation boards such as the Accreditation Board for Engineering and Technology (ABET), and local accreditation boards such as the Philippine Technological Council Accreditation and Certification Board for Engineering and Technology (PTC ACBET).

Specifically, this is stated in the ABET guidelines (2025) under Criterion 5 Curriculum, letter (d), which states:

Criterion 5. Curriculum

(d) a culminating major engineering design experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work.

and in the PTC ACBET Self-Study Report Guidelines (2021) under Criterion 5 Curriculum, item A. Program Curriculum, number 8, which states:

A. Program Curriculum

8. Describe the major design experience that prepares students for engineering practice. Describe how this experience is based upon the knowledge and skills acquired in earlier coursework, specialized courses and incorporate appropriate engineering standards and multiple design constraints.

In their paper “A Multidisciplinary Capstone Design Project to Satisfy ABET Student Outcomes”, Meah et al. (2020) described the Capstone course as “a training ground where students develop ability to work in a team, apply fundamentals of engineering and sciences, seek new knowledge, analyze an open-ended problem with design alternatives, and create documentations.”

All these characteristics as described by Meah et al. (2020) were already present in the previous thesis program. Thus, the strategy adapted to develop the capstone course THSMCAP was to streamline and highlight the design component of the students' approved thesis project to be the capstone course (THSMCAP) and the research component to remain under the thesis courses, THSMEC1 and THSMEC2 of the undergraduate thesis program. Thus, the revised thesis program now consists of the proposal stage of the thesis (THSMEC1), the capstone course (THSMCAP), and then the completion stage and final oral defense stage (THSMEC2) offered in 3-consecutive terms in a trimestral calendar.

This strategy was deemed advantageous for the following reasons:

1. The students will not have to work on a separate project different from their thesis, thus eliminating additional expenses, time, and resources.
2. The capstone results will complement and support their thesis work.
3. The mentor/adviser for the capstone and thesis is the same thus shall have an overview of the integration of the capstone work and the research work.
4. The Capstone course will enhance project-based and experiential learning.

Previous Thesis Program: Course Descriptions

The DLSU ME Thesis Program is intended for the students to integrate and to deepen the theoretical and technical knowledge with the practical and application skills and research capabilities they have developed throughout their undergraduate program. These are embodied in the course descriptions of the ME thesis courses.

The following are the course descriptions of the original 3 courses in the thesis program as stated in the course syllabus.

THSMEEA Course Description

This is the first part of the three term ME project study program. In this stage, the students enrolled will go through the planning stage of their thesis proposals. Planning involves project management concepts and a comprehensive application of technical, economic and management aspects of a project. Departmental assistance and monitoring will be given through the group's respective advisers. A panel evaluation through a proposal defense is set at the end of the term.

THSMEEB Course Description

This is the second part in the three-term ME project study program. In this stage, the students enrolled will go through the implementation stage of their thesis proposals. Departmental assistance and monitoring will be given through the group's respective advisers.

THSMEEC Course Description

This is the third part of the three-term ME project study program. This is the synthesis and evaluation stage. The students enrolled will go through the process of validating their claims which they have made in their thesis proposal. These will be presented in a formal report and defended through a panel.

This is further detailed in the Student Outcomes (SOs), as shown in Table 1.

Table 1: Student outcomes for the previous DLSU ME thesis program

SO	Student Outcomes
A	An ability to apply knowledge of mathematics, science, and engineering
B	An ability to design and conduct experiments, as well as to analyze and interpret data
C	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
D	An ability to function on multidisciplinary teams
E	An ability to identify, formulate, and solve engineering problems
G	An ability to communicate effectively
K	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The major classes of realistic design constraints are outlined in SO-C but a basic checklist and analysis of possible constraints for undergraduate capstone projects are discussed by Lyon (2021).

To give a broad summary of the scope of the BSME thesis program, the program is intended to develop in the students:

- Skills for identification and analysis of open-ended problems with consideration for alternative designs
- Project management skills
- Use of modern engineering tools such computer modeling and simulation skills (as in SO K and specific course guidelines)
- Ability to work in a team

Desire and ability to seek new knowledge
Oral presentation skills
Documentation and report writing skills

New Thesis Program: Course Descriptions

The new ME Thesis Program makes a delineation between the design component and the research component of the approved thesis topic. The research component includes the setting of the initial hypothesis, the conceptual framework, research methodology and design of experiment. These are the scope of THSMEC1 (with same description as THSMEEA). The design component leading to a physical prototype or computer simulation/model is now the scope of the Capstone course, THSMCAP (description below). Using the model/prototype developed in THSMCAP, the design of experiment will be implemented which involve conducting experiments or computer simulations, gathering and analysis of data, and conclusion and recommendations. These comprise the scope of the THSMEC2 (with the same description as THSMEEC) which culminates in the Final Thesis Defense.

THSMCAP Course Description

This course is intended to provide a realistic experience in the practice of engineering design for senior mechanical engineering students. In this course the student performs the design and computations needed or related to their thesis project, applying realistic constraints and using appropriate design codes and standards.

Specifically, the student outcomes (SOs) targeted and learning outcomes (LOs) for the course embody the goals of the course. These are given in Table 2 and Table 3.

Table 2: Student outcomes in the capstone course, THSMCAP

SO	Student Outcomes
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3	An ability to communicate effectively with a range of audiences.
4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative environment, establish goals, plan tasks, and meet objectives.
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Table 3: Learning outcomes in the capstone course, THSMCAP

LO	Learning Outcomes
LO1	Prepare a comprehensive background and review related literature on their capstone project.
LO2	Apply codes and design standards applicable to their capstone project
LO3	Prepare all computations to support their design decisions.
LO4	Prepare design drawings and bill of materials.
LO5	Completes the design of their project. LO5: Fabricate/ execute the design.
LO6	Demonstrate operation of their design.

Implementation of the Revised Thesis Program

In the first year of full implementation of the revised thesis program with the THSMEC1-THSMCAP (Capstone course)-THSMEC2 sequence, there were twenty-two (22) groups with a total of 82 students. In its second year of full implementation, there were twenty-seven (27) groups with a total of 118 students. The groups were assigned to thesis advisers. There were fourteen (14) advisers available currently, and an adviser has at most four (4) groups.

For both batches, all twenty-two (22) groups in the first batch and all twenty-seven (27) groups in the second batch successfully defended their thesis proposals and continued on to the Capstone course, THSMCAP.

In the capstone course, the students in all the groups were able to define and characterize the scope of their Capstone project as the design component of their main thesis project, implement the plans for its design and execution, prepare reports and presentation all in consultation with their adviser. As far as the monitoring of these milestones, all groups performed and met the requirements satisfactorily with the submissions within the set period and with all groups able to finish and give their oral presentations on the scheduled day and time.

Program Evaluation

After the first full cycle of implementation of the revised thesis program, a survey was conducted to garner information on the student experience and to get their recommendations for further improvement. The survey was repeated in the second year of full implementation. The survey consists of four parts:

Part 1 Basic Information	gender and age
Part 2 Objectives of the Course	to check if objectives of the course were met
Part 3 Engagement	to assess interactions with adviser and coordinator
Part 4 Course Impact and Effectiveness	effect on execution of project
Part 5 Student Feedback	to obtain comments and recommendations from the respondents

This survey was sent to the students after they have completed the last stage, THSMEC2. All these students have already undergone the Final Thesis Defense.

Below are the questions and results of the evaluation survey conducted.

Part 1 Basic Information

In the first year of implementation, there were 51 respondents out of 82 enrolled students. In the second year, there were 69 respondents out of 118 enrolled students. The respondents were generally male, 88 % male to 12 % female, between 21 to 22 years old, in their last stage of the undergraduate mechanical engineering program in DLSU.

Part 2 Objectives of the Course

The responses in Part 2 are summarized in Tables 4, 5, and 6. In Table 4, there was a general agreement, in both batches, that the course objectives with emphasis on the realistic design experience were attained (49% strongly agree, 49% agree and 2% neutral), that they were able to identify the design constraints (100% for year 1, 99% for year 2). On the identification of specific design codes and standards for their projects, only 81% from year 1 and 75% from year 2 were fully able to identify and use design codes and standards.

In Table 5, it is noted that the top 2 design constraints identified were technical and economic constraints. In year 1, health and safety constraints are more identified than environment and

sustainability constraints which are expected due to the pandemic years. In year 2, many more groups were able to identify environmental and sustainability constraints above health and safety constraints. These may have been realized as more emphasis on sustainability and environment were given in the course works. For succeeding implementations, the inclusion of ethical and other constraints was recommended.

In Table 6, on design codes and standards, there is still a lot of room for improvement as some students were not able to identify Codes and Standards applicable to their design project. This was also indicated in some of the recommendations given by the students (see Part 4 below). Of the codes and standards used, the highest percentage of use is the computer simulation and modeling standards. This is a very positive confirmation of the students' advancement towards SO-K (An ability to use techniques, skills, and modern engineering tools necessary for Mechanical Engineering practice). The highest percentage of usage of technical standards are the ASHRAE and HVAC standards, the Building Codes, and the PSME Codes.

Table 4: Evaluation of course objectives

	Yr	Percent of Respondents				
		SA	A	N	D	SD
The course was able to give me and my group a realistic design experience.	1	49	49	2	0	0
	2	49	49	2	0	0
Our group was able to identify design constraints in our capstone project.	1	72.5	27.5	0	0	0
	2	38	61	1	0	0
Our group was able to identify and use suitable design codes and standard in our capstone project.	1	37	44	16	2	1
	2	59	16	25	0	0

Legend: SA – strongly agree, A – agree, N – neutral, D – disagree, SD – strongly disagree

Table 5: Identification of design constraints

Which of the following design constraints did you consider in your capstone project? Check all applicable.		
	Percent of Respondents	
	YEAR 1	YEAR 2
Technical constraints	96	93
Economic constraints	75	78
Environmental and sustainability constraints	47	61
Health and safety constraints	57	33
Social and political constraints	14	11

Table 6: Use of design codes and standards

Which of the following Codes and Standards did you use? Check all applicable.		
	Percent of Respondents	
	YEAR 1	YEAR 2
ASHRAE and other HVAC standards	37	25
Boiler and Pressure Vessels codes	2	3
Building codes	14	13
Electrical codes	6	15
PSME and other ME codes	20	39
Computer modelling and simulation standards	69	57

Part 3 Engagement with the Course Coordinator

The responses in Part 3 are shown in Table 7. There can be seen a general agreement among the students that the course delivery is very satisfactory. On all items, 90% or more of the respondents gave a positive evaluation.

Table 7: Evaluation of engagement with the course coordinator

	Yr	Percent of Respondents				
		SA	A	N	D	SD
The course objectives and expected learning outcomes were clearly presented and discussed.	1	55	37	4	2	2
	2	58	39	3	0	0
The course deliverables and schedules were clearly presented and posted for reference.	1	65	33	2	0	0
	2	68	31	1	0	0
The types of assessment, grading criteria and rubrics, and related policies were clearly presented and posted for reference.	1	71	24	4	2	0
	2	57	39	4	0	0
Our concerns and inquiries are promptly and appropriately addressed.	1	57	33	8	2	0
	2	59	37	4	0	0

Legend: SA – strongly agree, A – agree, N – neutral, D – disagree, ND – strongly disagree

Part 4 Course Impact and Effectiveness

The responses in Part 4 are summarized in Tables 8, 9, and 10. The main outcome obtained in Table 8 is that more than 94% of the respondents have signified that the capstone course and the panel evaluation during the capstone final presentation have been able to impact their work on their thesis project. Also, more than 84% of the respondents have signified that their interaction with the adviser has increased. This is significant since in the previous thesis program this has been a recurring issue. Table 9 gives the breakdown of the frequencies of interaction with the adviser which shows a marked increase in interaction by year 2.

On completion time, Table 10 shows that 4% of the respondents, equivalent to 1 group out of 22 in year 1, and 13% of the respondents, equivalent to 2 groups out of 27 in year 2 were not able to defend their thesis on time.

Table 8: Evaluation of the impact of advisers and thesis panel

	Yr	Percent of Respondents				
		SA	A	N	D	SD
The panel comments and suggestions during the capstone final presentation helped in improving our thesis in THSMEC2.	1	65	35	0	0	0
	2	65	33	2	0	0
The capstone course helped our group to finish our thesis (THSMEC2) on time.	1	61	35	4	0	0
	2	65	33	2	0	0
The capstone course increased our interaction with our Thesis Adviser.	1	67	25	6	2	0
	2	54	30	13	3	0

Legend: SA – strongly agree, A – agree, N – neutral, D – disagree, ND – strongly disagree

Table 9: Evaluation of engagement with the advisers

How many times did you interact with your adviser in the duration of the capstone course?		
	Percent of Respondents	
	YEAR 1	YEAR 2
More than 3 times a month	22	45
2 to 3 times a month	33	36
Once a month	37	13
Less than once a month	8	6

Table 10: Evaluation of engagement with the advisers

Was your group able to defend your final thesis (THSMEC2) on time?		
	Percent of Respondents	
	YEAR 1	YEAR 2
Yes	96	87
No	4	13

Part 5 Student Feedback

The summary of recommendations and comments of the students are recorded below.

1. The capstone course was able to give us more time to design our project and finish our thesis on time.
2. More time should be given to complete the capstone project. One trimester is not enough.
3. More access to the ME Laboratories and the use of school facilities, especially computer labs for the use of computational and simulation software are needed.
4. Provide a list of available resources which students can freely reserve and use.
5. More monitoring of progress should be put in place. The advisers should be required to meet their thesis groups 2 to 3 times a month. Weekly progress reports would be optimal to make sure progress is done consistently.
6. The guidelines for the deliverables and milestones should be made clearer and accessible through online platforms. This should include the calendar of activities and the rubrics for capstone and thesis evaluations.
7. The use of design codes and standards should be included by the faculty in the coursework. This is to help the students familiarize themselves with codes, laws, and other standards used in actual design work.
8. Provide support for access to the standards with pay walls.
9. There should be a showcase of the capstone projects of the previous batches.

As expected, there are still students who recommend having a capstone project totally different from their thesis topic. They recommend keeping the capstone project separate from the thesis so that they can focus on creating a working prototype instead of connecting it to academic research.

Summary

In summary, the following may be stated for the implementation of the revised thesis program with the capstone course as a fully integrated design component of the undergraduate thesis program.

1. On the development of the Capstone course, THSMCAP was able to capture the traits of the Capstone course as embodied in the guidelines of the accreditation boards.
2. The Capstone course, as currently implemented, allowed for the student group to define the design component of their approved thesis topic, and make this their Capstone project. This is an advantage for the students because they do not have to work on a separate project. Furthermore, the output from the Capstone project is part of and linked to their thesis.
3. The Capstone course helped the students to improve their thesis and complete their thesis on time even without the one term gap in the previous thesis program timetable. This is an important observation because, historically, the percentage of ME undergraduate thesis groups completing on time is rather low.
4. There is data that interaction with the group adviser has increased in frequency and improved in quality. This is also significant because, in the past, the lack of adviser interaction with the group is a common complaint of the students.

Even so, from the student recommendations and practices of other institutions, there are still more to be done to improve the DLSU ME thesis program and its impact on the ME undergraduate design and research exposure. The following may be given more priority.

1. Make the use of Codes and Standards a component of the major ME courses;
2. Invite industry practitioners to become a part of the thesis program as mentors, advisers, and, if possible, as sponsors;
3. Improve further the support given by the thesis advisers to their thesis groups as far as monitoring and consultation schedules;
4. Improve and make accessible the university resources and facilities for research and fabrication services; and
5. Showcase the capstone projects and thesis outputs of the previous batches such as thru exhibits and symposia.

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