2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #36841

Student Peer Lecture in Capstone Design Project

Dr. Xiaobin Le, Wentworth Institute of Technology

Professor, Ph.D, PE., Department of Mechanical Engineering and Technology, Wentworth Institute of Technology, Boston, MA 02115, Phone: 617-989-4223, Email: Lex@wit.edu, Specialization in Computer Aided Design, Mechanical Design, Finite Element Analysis, F

STUDENT PEER LECTURES IN CAPSTONE DESIGN PROJECTS

Xaiobin Le
Wentworth Institute of Technology

1. INTRODUCTION

The mechanical capstone design project course is one of the most important courses for any mechanical engineering program curriculum. The settings for capstone design projects are that students are assumed to be design engineers and instructors serve as consultants. Students look for ideas as design projects or secure an industry-sponsored design project, define the design projects, use all they have learned to conduct design projects, build & test prototypes, and finally provide engineering documents for the design project including presentation, technical report, technical posters, and engineering drawings [1~5].

Capstone design projects are typically open-ended projects. Students as design engineers not only use what they have learned but also need to learn new skills and knowledge, when necessary, through the design process to complete their capstone design projects. Students can nourish their life-long learning ability and gain some life-long learning experiences [6~8]. Some capstone design projects are industrial-sponsored. Therefore, this is the best approach to facilitate and initiate students' transition from academic to industrial reality [9~13]. Due to the properties of capstone design project courses, capstone design project courses are always the best course for assessing ABET (the Accreditation Board for Engineering and Technology) student outcomes [14~16].

In 2015, our mechanical engineering curriculum converted a one-semester capstone design project course into a two-semester capstone design project course. Therefore, student design teams have more time to pursue bigger or more complicated design projects. In the last several years, it was found that students usually self-learned some new skills and knowledge for completing design projects. These might be useful to other design teams. But they didn't have a proper way to share their self-learned content and life-long learning experience. After discussions among faculty and with student design teams, we proposed to add a new activity-student peer lectures to the senior capstone design project course in the second semester. This paper will describe and explain the reasoning for adding this new activity, the objectives, and the implementation of this activity.

2. STUDENT PEER LECTURES IN A CAPSTONE DESIGN PROJECT COURSE

2.1 BACKGROUNDS

The primary objective of a capstone design project course is that students implement all they have learned to complete a meaningful and useful design project. Therefore, the main activities of all capstone design project courses are very similar in different mechanical engineering programs. Some programs use one semester for this course. But some programs use two semesters for this course. Following is a concise description of our capstone design project.

Since 2015, our mechanical capstone design project course has been converted into a two-semester course including MECH5000-mechanical capstone analysis in a spring semester and MECH5500-mechanical capstone project in a summer semester.

MECH5000-mechanical capstone analysis has one hour of lecture and four-hour labs per week with a total of three credits. In this course, students form design teams with two to four team members. They are guided to follow the five-phase design process which is Phase One: Needs assessment, Phase Two – Design specifications, Phase Three– Conceptual designs, Phase Four-Detailed design, and Phase Five-Implementation [1, 17]. They generate meaningful and feasible ideas for design projects in Phase One -Needs assessment or secure an available industry-sponsored project in the first three weeks. In the MECH5000-mechanical capstone analysis, they complete Phase One-needs assessment to Phase Four-details design without building & testing prototypes. There are five key activities this spring semester. The first one is a weekly one-hour lecture that is used to discuss the five-phase design process and common questions. The second activity is a thirty-minute weekly meeting between each design team and their instructor where the project progresses or some issues are discussed and checked. The third activities are that design teams are required to work together on design projects for at least four hours per week. The fourth activity is that they need to prepare engineering documentation including technical reports, technical posters, and 3D models and drawings. The fifth activity is the presentations including two informal presentations and one formal presentation. The concise description of these presentations are:

- The first informal presentation is a presentation of a pre-proposal held in the fourth week. It is focused on Phase One - needs assessment. The self-chosen ideas for mechanical capstone projects must be mechanical-related, practical, and feasible for two semesters.
- The second informal presentation is a presentation of a formal proposal in the eighth week. It is focused on Phase Two- design specifications and Phase Three- conceptual design.
- The third presentation is the formal presentation of capstone design projects in the last week of the spring semester. it is focused on Phase Four- details design without building & testing prototypes. But necessary theoretical calculations and numerical simulation must have been completed so that the paper design of the capstone design projects can theoretically satisfy all required design specifications such as the function requirement and the required factor of safety.

MECH5500 -mechanical capstone project has one hour of lecture and six-hour labs per week with a total of four credits. The same student's design team will be kept and do the same capstone design projects. But the primary objective of this course is to manufacture, test, and modify their prototypes. In other words, they will complete Phase Four-detailed design, and Phase Five - implementation. In the first three weeks, student design teams can make necessary modifications to their final design options that have been completed in the previous spring semester. After that, they will start to order raw materials or purchase parts and build & test prototypes. There are the same types of five key activities for this course in the summer semester. The first one is a weekly one-hour lecture hour which is used to discuss project management, manufacturing, and prototype testing including virtual simulation and /or physical

tests and some common issues. The second activity is a thirty-minute weekly meeting between each design team and their instructor where the status of prototype construction and/or some issues such as manufacturing, and testing are discussed and checked. The third activities are that design teams are required to work together on design projects for at least six hours per week. The fourth activity is that they need to prepare engineering documentation including technical reports, technical posters, and 3D models and drawings. The fifth activity is the presentations including two informal presentations and one formal presentation as described concisely below.

- The first informal presentation is to present modified final design options and project construction plans in the third week.
- The second information presentation is the presentation of the status of the prototypes' building and some testing on some subassemblies in the eighth week.
- The third presentation is the final presentation of the capstone design projects in the last week of the summer semester.

The informal presentations in capstone design projects are typically around 15 minutes and they need to cover directly related information such as reasoning, options, and status reports for capstone projects. The final formal presentations are around 20 minutes and a sell-style presentation. Therefore, it was obvious that students typically didn't have a proper chance to share their self-learning content and to promote & share their lifelong learning experience. Life-long learning ability is extremely important for students and will make them competent in their future careers. Their self-learned content and life-long learning experience might be also useful to other students. When the capstone design project becomes a two-semester course, we have a chance to let students for sharing their self-learned content and their life-long learning experience. In a summary, some additional new activities should be added to the MECH5500 - mechanical capstone project for promoting self-learning and sharing self-learning content.

2.2 THE ADDED ACTIVITY: STUDNET PEER LECTURES

When we brainstormed some new activities for our capstone design project course, we believe that four fundamental requirements for new activities are (1) It is still a presentation, (2) It can promote active learning, (3) Each design team can benefit from new activities, and (4) They can share their self-learned contents and life-long learning experience. We believe that student peer lectures can satisfy all the above requirements [18-21]. After discussions among faculty and student design teams, we added a student peer lecture to the senior capstone design project course in the second semester.

The primary objectives of the students' peer lectures are to promote and share their self-learning knowledge and skills and to activate active learning. Student design teams will have a group discussion and select a topic for their student peer lectures. The choice of student peer lectures will be one key technique or analysis that is used in their design projects. Every team member must collaboratively deliver part of the peer lectures. Student design teams must actively learn more about the topics in depth because they will be instructors to prepare and deliver a peer lecture to the class on selected topics. Because the selected topics for peer lectures are quite different, student teams can choose a suitable duration for their peer lectures which can be a minimum of 30 minutes to a maximum of 100 minutes.

At the end of the MECH5000 -mechanical capstone analysis in the spring semester, each design team discusses with their instructor and will submit the choice of peer lectures with a concise summary that includes: (1) a description of the peer lecture topics, (2) the application of the peer lecture topics in their capstone design projects and (3) the duration of the peer-lecture.

In the MECH5500 - mechanical capstone project during the summer semester, students prepare their peer lectures in the first three weeks while they modify the design project and prepare to order raw materials and purchased parts. To help students to prepare for the peer lectures, some guidelines for peer lectures are provided to students. These guidelines are just some suggestions. Students are encouraged to follow the guidelines. But the guidelines are not mandatory requirements. The guideline for peer lectures is that the peer lecture should cover: (1) a history of the selected topics (a detailed review), (2) current status, (3) a detailed presentation of the selected topics (purposes, theory, or functions, typical applications), (4) the application of the selected topics in their capstone design projects, and (5) the future trends or expectation of selected topics.

Per the choice of their peer lectures, the peer lectures will be arranged from the 4th week to the 7th week. Students can arrange and deliver their peer lectures in their way. But each design team must provide a PowerPoint file to the class no matter how they deliver peer lectures because the preparation of a PowerPoint will help them to have better organization of the peer lecture topics and a better understanding of the peer lecture topics.

3 IMPLEMENTATION AND SURVEY DATA ANALYSIS OF STUDENT PEER LECTURES

The proposed new activity: student peer lectures has been implemented since 2019. Now, some student peer lectures will be listed as examples and then class survey data and students' comments will be displayed and analyzed.

3.1 IMPLEMENTATION AND SOME PEER LECTURE EXAMPLES

Each team was required to choose a peer lecture topic and to deliver their peer lectures. Some peer lectures were very successful and informative. For these successful peer lectures, there were lots of questions & answers. Now, several examples of peer lectures were listed and explained here.

Example one of the peer lectures: "Design for Manufacturing"

In the 2019 summer semester, a capstone project was "3D Print Grinder, Extruder & Winder", the goal of which was to create a system that would accompany a standard desktop-sized FDM 3D Printer, to recycle any unusable parts and support material. Three key sub-systems of the project were: (1) The grinder broke the recycling 3D printing plastic parts into a usable particulate size, (2) The extruder and winder heated the broken small size of recycling plastic and extruded and cooled it into the recycled filament. (3) the third subsystem was a purchased desktop-sized FDM 3D Printer.

This design team learned more facts and knowledge about DFM (design for manufacturing). They said that before DFM, the industry standard was "I designed it; You build it". They liked the concept of DFM and implemented it in their design. So, they delivered a 45-minute peer lecture " Design for Manufacturing" to the whole class. They spent more than 35 minutes explaining the definition of DFM, the history of the DFM and the key aspects of the DFM, and some typical applications or examples of the DFM implementation. Then they presented the implementation of the DFM in their design project and suggested that all mechanical students or engineers should use the DFM in their designs.

This was a successful peer lecture. The concept of DFM was mentioned and briefly discussed for a few minutes in some courses of our mechanical engineering curriculum. But this student's peer lectures used more than 35 minutes to discuss it with some implementation examples.

Example two of peer lecture: "Fundamentals of casting"

In our manufacturing center, we have a casting lab. Two persons: one instructor and one volunteer student were required to work together to complete a manual pouring process. Even though there never had been any accidents during the pouring process, some students always had some fear of possibly spilling. One group of students who went through the casting lab a few years ago proposed to design a semi-automatic pouring process in which one person could complete the pouring process. The title of their capstone project was "Small foundry casting conundrum". The objective of this project was to reduce the need for a two-person pouring system to just a one-person pouring system and to reduce the chances of an accident during the casting process.

This design team delivered a 60-minute peer lecture "Fundamentals of casting". They spent more than 45 minutes discussing the definition, history of casting, type of different casting, current applications of casting, and the relationship with their capstone project.

This was also a successful peer lecture. Every mechanical engineering student did one two-hour green-casting lab where they were guided to make the sand casting mold and watched a pouring process and got one casting part. The concept of casting was mentioned and discussed in a few minutes in some courses. But this student peer lecture spent more than 45 minutes displaying and explaining a detailed history of casting and a lot of different current applications of casting. Most of the students said that this peer lecture was very interesting and informative.

Example three of peer lectures: "Prefacbiraction process"

In 2021, a group of students worked on an industrially sponsored capstone design project which was reengineering a company's prefabrication manufacturing process, which prefabricates some mechanical assemblies such as HVAC systems, plumbing, and fire protection systems. This company was one leader company of the local regional mechanical subcontractor. This company's current processes were not up to date, causing an inefficient workflow from the beginning of each project to the end. The objectives of the design project were to analyze each step of the current process and to provide some recommendations for improving the current prefabrication processes.

When this team worked on this capstone project, they needed to understand the prefabrication processes. Then they proposed and delivered a 60-minute peer lecture "Prefabrication process". They spent more than 50 minutes lecture on the definition of prefabrication, challenges in construction, history of prefabrication and examples, prefabrication /modular survey: impacts of prefabrication/modular construction, prefabrication, and modular construction trend. Then, they explained the findings of that company's prefabrication process in their capstone design project.

This was also a very successful peer lecture. The concept of the prefabrication process was not specifically mentioned or discussed in our mechanical engineering curriculum. Lots of students felt that this peer lecture was very informative and they gained some wonderful information. At the end of the lecture, the class asked a lot of questions,

Example four of peer lectures: "Gas strut system"

In 2022, the capstone design project of a group of students, who liked hiking and outdoor exercise, was a "Modular assisted roof rack". The objectives of the project were to create a modular roof rack for carrying skis and snowboards, or a bike or kayak/canoe depending on the configurations.

One of the sub-systems of this capstone design project was the assisted lift system which helped users during the loading and removal of equipment to and from the top of a car. One of the key purchased components was a gas strut. This design team delivered a 30-minute peer lecture "Gas strut system." Then, they explained the application of gas struts in their capstone design project.

This was also a good peer lecture. There are thousands of typical mechanical components or mechanical systems for mechanical engineering. It is impossible to discuss every possible typical component or device in our courses. A gas strut is one of the typical mechanical devices. But it is not discussed and explained in any one of our courses. Through this peer lecture, the classmate got exposure to gas struts.

3.2 CLASS SURVEY AND STUDENTS' COMMENTS

At the end of the summer semester, we conducted a class survey about student peer lectures. During the last four years, there was a total of 76 students in my capstone design project class, and we received 65 responses. The response rate is 85.52%. The survey questions and data are listed in Table 1.

Table 1 The survey questions and data

Question #1: Peer lectures for senior design project lets us share some understanding and experience about some topics related to our project					
Options	Strongly agree	Agree	No opinion	disagree	Strongly disagree
Results	28	33	3	0	1
Percentage	43.08%	50.77%	4.62%	0.00%	1.54%
Question #2: Peer lecture lets us have a chance to understand a topic on a much broad and deep level					

Options	Strongly agree	Agree	No opinion	disagree	Strongly disagree
Results	30	31	4	0	0
Percentage	46.15%	47.69%	6.15%	0.00%	0.00%
Question #3: Peer lectures should be kept as one content for future senior capstone design course					
Options	Strongly agree	Agree	No opinion	disagree	Strongly disagree
Results	25	24	7	4	5
Percentage	38.46%	36.92%	10.77%	6.15%	7.69%

Per the survey data results listed in Table 1, the following conclusions can be drawn.

- 93.85% of students agreed or strongly agreed that peer lectures let them share some understanding and experience about some topics related to their projects. 4.62 percent of students showed no opinion about the survey question 1 statement. 1.54% of students strongly disagreed with the statement.
- 93.85% of students agreed or strongly agreed that peer lectures let them understand the lecture topic at a much broad and deep level. But 6.15% of students showed no opinion about the survey question 2 statement. No of them disagreed or strongly disagreed with the survey question 2 statement.
- The majority of students (75.38%) agreed or strongly agreed that peer lectures should be kept as one content for the future senior capstone design project. 10.77% of students selected "No Opinion". But there was still 13.85% of students who disagreed or strongly disagree with the idea of peer lectures in their capstone design courses.

We had an open-end survey question "Any suggestions or comments about the peer lecture". There were lots of different comments. Some comments were very positive. The followings are a list of their typical suggestion and comments.

- "Good way of learning about relevant topics. I learned a lot from other people's lectures."
- "I enjoyed them. I liked they were project-based. Really gave us insight to every one project."
- "It is a very informative project that helped with our skilling in lecturing."
- "Team lecturing was a fun experience. We were allowed to express our knowledge of our topic in a professional environment with some creativity."
- "I think team lecturing is very helpful in understanding your team's topic on a deeper level. While researching for the team lecturing, I came across information that could help us in the project that we didn't find before."

- "I really liked that team lecturing had something to do with the capstone project and really helped the group understand the project even more and I think you should continue with future sections."
- "No suggestions. Feel they are good the way they are and also helpful to everyone."

Some comments about peer lectures were not positive and provided some suggestions for improving peer lectures. The followings are some of these comments.

- "One way to improve the team lectures is to have the peer lecture presentation done in the first semester of the capstone project."
- "Spend more time discussing present-day applications. While the history is very important, it is more interesting and relevant to talk about how the technology has evolved and grown into mechanisms and processes that we are familiar with today."
- "I think it would have been better to spend that time working on our projects rather than preparing and watching team lectures."
- "I don't think the peer lecturing project is a useful exercise. If I wanted to learn something about a specific topic, I would take a course on it or ask my professor. One of the college's selling points is that all their classes are taught by trained professionals and the team lecturing project is contradictory to that principle."

We also had some direct conversations with design teams. Lots of students said that they liked peer lectures because they had a better understanding of the selected lecture topics, and they learned some new knowledge from other teams' peer lectures. It was also noticed that peer lectures activated class active learning activities. They were required to spend some time searching for information, organizing and understanding the topics, and collaborating for preparing lectures and delivering peer lectures. This did add some extra burden to students. However, the majority of students liked the peer lectures. The benefits of peer lecture were obvious: (1) It was a platform to share their self-learning skills and knowledge with the whole class; (2) It activated active learning because they needed to prepare and deliver a lecture by the group, and (3) It did help them to have a better understanding of the selected topics because they should have a much deeper understanding of the topics so that they were able to teach it.

4. DISCUSSIONS AND CONCLUSIONS

A capstone design project course is a platform where students are design engineers to implement what they have learned to complete capstone design projects. This course will facilitate students' transition from academic to industry and nourish their lifelong learning ability and team-play ability through open-ended or industry-sponsored capstone design projects. For a two-semester capstone design project course, there is a space to add student peer lectures as a new activity for promoting and nourishing students' life-long learning ability and sharing their life-long learning experience.

The objective of student peer lectures is to promote and share their self-learning knowledge and skills and to activate active learning. 93.85% of students agreed or strongly agreed that peer lectures let them share some understanding and experience about some topics related to their projects. 93.85% of students agreed or strongly agreed that peer lectures let them understand the lecture topic at a much broad and deep level. The majority of students (75.38%) agreed or strongly agreed that peer lectures should be kept as one content for the future senior capstone design project.

Our observations and direct conversations with students indicated that peer lectures activated active learning and helped them to nourish life-long learning abilities. Peer lectures let them share self-learned content and life-long learning experience and the classmates benefited from peer lectures. Some of them also mentioned that they gained a little teaching experience.

In summary, we believed that peer lecture was indeed a good activity for a two-semester capstone design project course and every team benefited and learned some skills and knowledge from peer lectures. It promoted active learning and life-long learning and shared student life-long learning experiences.

5. REFERENCES

[1]. Xiaobin Le, Anthony William Duva, Richard L. Roberts, and Ali R. Moazed, "Instructional Methodology for Capstone Senior Mechanical Design, " in *2011 ASEE Annual Conference & Exposition, Vancouver, BC, June 26-29, 2011*.

[2]. Jessica Macklin and Kylie Goodell King, "20 Years of Multidisciplinary Capstone Projects: Design, Implementation, and Assessment, " in *2015 ASEE Annual Conference & Exposition, Seattle, Washington, June 14-17, 2015*.

[3]. Janet Dong and Janak Dave, "Design-Build Test Autocross A Capstone Design Project," in *2007 Annual Conference & Exposition, Honolulu, Hawaii, June24-27, 2007*.

[4]. Emad Y. Tanbour, Molu O. Olumolade, and Oumar Rafiou Barry, "Newly Introduced Capstone Design Course for Mechanical Engineering Technology: Lessons Learned From Two Cohorts and Two Types of Projects," in *2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana, June26-28,2016*.

[5]. Junkun Ma and Case Dakota Born, "Further Development of Capstone Design Project Courses based on a Case Study," in *2017 ASEE Annual Conference & Exposition, Columbus, Ohio, June24-28, 2017*.

[6]. Zhan, W., & Beasley, R., & Goulart, A. E., "Life Long Learning Starts In Classrooms," in 2008 *Annual Conference & Exposition, Pittsburgh, Pennsylvania, June 25-28, 2008*.

[7]. Wang, J., & Fang, A., & Johnson, M., "Enhancing And Assessing Life Long Learning Skills Through Capstone Projects," in 2008 *Annual Conference & Exposition, Pittsburgh, Pennsylvania, June 25-28, 2008*.

[8]. Turton, R., & Shaeiwitz, J., "Lifelong Learning Experiences And Simulating Multidisciplinary Teamwork Experiences Through Unusual Capstone Design Projects," in *2003 Annual Conference, Nashville, Tennessee, June 22-25, 2003.*

[9]. Brooks Byam, "An Enhanced Educational Experience For Capstone Design Projects: Using Sae Student Groups In An Industry Sponsor Role," in *2002 Annual Conference, Montreal, Canada, June 16-19, 2002*.
[10]. J. Darrell Gibson and Patricia Brackin, "Capstone Design Projects With Industry, " in *2005 Annual Conference, Portland, Oregon, June 12-15, 2005*.
[11]. Cesar Luongo and Chiang Shih. "Senior Design Projects In Mechanical Engineering – A Case Study Of Capstone Experience With Strong Industrial Participation". *2006 Annual Conference & Exposition, Chicago, Illinois, June 16-18, 2006*.
[12]. Hosni I. Abu-Mulaweh and Nusaybah Abu-Mulaweh, "Case Study: Industry-sponsored Mechanical Engineering Capstone Senior Design Projects, "in *2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, June 23-27, 2018*.
[13]. Desen Sevi Ozkan, Homero Gregorio Murzi, Alejandro Salado, and Chris Gewirtz, "Reality Gaps in Industrial Engineering Senior Design or Capstone Projects," in *2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, June 23-27, 2018*.
[14]. Betsy Aller and Andrew Kline, "Involving Industry In Capstone Design Courses: Enhancing Projects, Addressing Abet Issues, And Supporting Undergraduate Engineering Practice," in *2002 Annual Conference, Montreal, Canada, June 16-19, 2002*.
[15]. James A. Mynderse, Andrew L. Gerhart, and Liping Liu, "Assessing ABET Student Outcome 5 (Teamwork) in BSME Capstone Design Projects," in *2021 ASEE Virtual Annual Conference Content Access, Virtual Conference, July 16-19, 2021*.
[16]. Nicholas A Baine P.E., Karl Brakora, and Christopher P. Pung P.E. "Evaluating ABET Student Outcome (5) in a Multidisciplinary Capstone Project Sequence," in *2020 ASEE Virtual Annual Conference Content Access, Virtual Online, June 22-26, 2020*.
[17]. Gerad Voland, *Engineering by Design.* Second edition, Pearson Prentice Hall, 2004
[18]. Kim, E. M., & Schubert, T. F., & Jacobitz, F. G., "*Student Peer Teaching in Engineering Laboratory Situations,"* in *2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana, June 15-18, 2014.*
[19]. Bailey, J., "*Exploring an Inquiry-based Learning with Peer-teaching Pedagogy in a Physiological Signals Lab Course,"* in *2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, June 23-27, 2018*.
[20]. Torres, A., & Sriraman, V., & Humphries, E., & Adams, E., "*Peer Teaching in Construction Project Management Scheduling,"* in *2015 ASEE Annual Conference & Exposition, Seattle, Washington, June 14-17, 2015*.
[21]. Haase, E., & Goldberg, H. R. (2020, June), *Peer Instruction Can be as Effective as Lecture-based Instruction in Biomedical Engineering* Paper presented at 2020 ASEE Virtual Annual Conference Content Access,