Building a Strong Foundation for Senior Design Courses

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1. Introduction

The inclusion of a capstone project course is one of the most universal elements of curricula throughout the widely diverse Engineering Technology programs in the country, Yet at the same time, probably no single course in those curricula has more variation in approach, structure, assumptions, and resources than the capstone design course.

The University of Dayton's approach to senior capstone projects is just one of many used throughout higher education, The one-semester capstone class provides engineering technology students with industry-sponsored projects that allow students to apply engineering principles learned through four years of coursework. Each semester, diverse teams of three to five students with complementary skills in the areas of computer, electronic, industrial, and mechanical engineering technology apply the product realization process to research, brainstorm, design, build, test and validate project deliverables. The authors of this paper have both taught this capstone design project and provide an analysis of the characteristics of this model and its outcomes,

A particular opportunity arose when the authors co-taught the course in spring 2020 and this model was exposed to more extreme conditions resulting from the pandemic. Even though the sudden move to online-only format clearly presented a major challenge for hands-on projects, it also enabled a "testing" of the UD's system analogous to overloading a prototype to determine its robustness, The prototype survived the more rigorous conditions and those results are highlighted in the analysis.

This paper looks at key features that lead to success in capstone project courses, It does this through a brief survey of available literature, an analysis of the general operation of the course and typical outcomes, and then through special insights gained from teaching the course when the operating guidelines almost completely changed halfway through a semester.

2. Background

ABET [1] requires engineering technology baccalaureate degree programs to "provide a capstone or integrating experience that develops student competencies in applying both technical and non-technical skills in solving problems." In fulfilling this mandate, many institutions offer a one or two-semester culminating capstone project for seniors where they work with a project sponsor to produce the desired deliverable. Capstone projects provide a great experiential learning opportunity for students to own the project and their learning while applying the desired technical and non-technical skills to solve problems [2]. Team capstone projects provide engineering technology programs a unique opportunity to assess the 1 – 5 student outcomes [3]. For example, students, working in teams can apply modern engineering and mathematics tools to design a system or components of a system for "broadly-defined" problems, utilize different communication modes and technical literature, build, test, and validate prototypes while leading

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or functioning effectively as a team member [1]. Franchetti et al. (2012) explain that capstone projects help to improve teamwork, problem-solving skills, and communication [4].

Industry-sponsored capstone projects help to prepare engineering technology students for their engineering career [5]. These projects are preferred by engineering technology programs for their students who typically are more exposed to hands-on problems or applied engineering. On such projects, students learn to work with stakeholders to scope the project, clarify requirements, and iteratively work through the product realization to execute the project. Reifenberg and Long (2017) explain that industry-sponsored team capstone projects create value for the client and are more valued by students. However, the broadly-defined nature of most client-based capstone projects can also lead to higher frustrations when the stakeholders (faculty members, sponsors, and student teams) are unable to develop and execute an effective communication plan as well as when there is a mismatch of the project expectations [6]. Therefore, allowing students to negotiate sections of the project can dynamically create value for the client, leading to a better learning experience than approaching capstone projects as static problems to be solved [6].

Detailed project planning is required to minimize frustrations in undergraduate engineering technology capstone courses. Mosher (2015) explains that project stakeholders must be flexible and tolerate ambiguity. Also, students must have a voice in team and project selection [7]. Viswanathan (2017) observed that a meticulous project plan and execution are ingredients for successful capstone courses [8]. Hauhart and Grahe (2014) observed that successful capstone projects help students to identify the important connections between professional life and their academic experience. This is how value is created for the client [9].

The desired benefits of industry-sponsored hands-on capstone projects can be derailed by undergraduate students' lack of professional experience. For example, moments such as the advent of the COVID-19 pandemic, which required students to e-collaborate across different time zones was extremely challenging for some students. Projects that require the building of physical artifacts may not be ideal for e-collaboration. However, through faculty mentoring with timely feedback, and students ability to negotiate project deliverables, students will be better positioned to enhance their learning experience and create value for the client [9]; thus, engineering technology students may still be able to remotely execute some client-based capstone projects in a manner that meets the desired ABET 1 – 5 student outcomes as well as sponsors' expectations.

3. UD's System for Capstone Project Courses

The University of Dayton is a comprehensive, residential, undergraduate-focused institution of about 8,300 full-time undergraduate students located in Dayton, Ohio, The School of Engineering comprises roughly twenty percent of the university in terms of students, faculty, and resources, Within the School of Engineering, The Department of Engineering Management, Systems and Technology houses programs in Electronic/Computer, Industrial, and Mechanical Engineering Technology programs, all offering the BSET degree. Currently, there are fourteen full-time faculty members within the department and about 320 full time students.

3.1 Curricular Approach

The University of Dayton was an early leader in Engineering Technology education, and has long embraced a practical and applied, industry-focused education. Engineering Technology at the University of Dayton has long been closely linked with the region's strong industrial base

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and its rich tradition of innovation and manufacturing. While much of the automotive manufacturing has left the Dayton area, there is no shortage of manufacturing, aerospace, medical, plastic, and other industrial enterprises in the area. Linkages between academics and industry have included, for decades, Industrial Advisory Committees, cooperative education, University of Dayton contracts, sabbatical connections, part-time faculty opportunities, industrial mentor programs, and many others, These connections, of course, made it quite natural as curricula began to move toward industry-sponsored projects for a senior-level course.

In about 1991, Engineering Technology began including a capstone design project in its programs, and the model was working well enough that the School of Engineering decided to institutionalize it to include the engineering programs as well, In 1996, the University established the "Innovation Center" as a central resource for this type of venture, Today, individual courses are, of course, still headquartered academically in their home departments, but the Innovation Center acts as a common resource for all capstone projects, The Engineering Programs operate a bit differently than Engineering Technology, Students in Mechanical Engineering and Electrical Engineering both take a shared capstone which is a two-semester sequence typically divided into one semester of research and design, with a second semester focused on project build, Neither Civil nor Chemical engineering participate in an interdisciplinary course involving the Innovation Center.

This paper, of course, focuses on the Engineering Technology capstone design course, That course is numbered ECT/IET/MCT 490 depending on a student's major, but all majors are combined into a single course and join interdisciplinary teams, The course is a single 16-week semester course of three credit hours, It typically meets twice per week for three hours each session, There are typically two sections of the course per semester, There are approximately 28 students in each section which is divided into teams of about 4 students, Therefore about seven projects are needed for each section, so a total of about 14 client-sponsored projects are needed each semester for Engineering Technology.

In the months preceding the semester, it is the responsibility of the Innovation Center to secure projects from industry, Sponsors are varied and include major corporations with local engineering and manufacturing operations, private entrepreneurs with an idea for a new product, or a division of the nearby Air Force Research Lab, Before a semester begins, the Innovation Center and the client develop a two-page project statement with general parameters, requirements and expected deliverables articulated, Much of the funding for the Innovation Center comes from the $3000 fee that sponsors pay to have a student team work on their project. The course convenes on the first day of the semester and among other tasks, each of the projects is briefly outlined and students specify in the *project entrance survey* (in the appendix(I)) their personal skill sets, times unavailable for team meetings, and submit their preferences for projects and teammates before leaving class the first day. This way, students get a say in the project and team assignments.

3.2 The Innovation Center

The Innovation Center was established in 1996, It is a common resource for all capstone design project courses, The director is a faculty member from the School of Engineering who commits full time to this position, A full-time administrative assistant and technician also support this work and there is budgeting for other part time assistance from local experts, The physical space of the Innovation Center includes excellent flexible teaching/meeting space for the entire class

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since there is some time in every session that the entire class meets together, That space, however, is easily broken up into team areas as well since most of the meeting time is for individual teams to collaborate, Across the hall, four small conference rooms are available during class time and well-used for a variety of small group meetings, Next door there is a Design Studio that has large horizontal work surfaces, a variety of common hand tools, basic power tools, air and power lines, sink, and other resources, There is space in this room for those teams who need to house a large piece of hardware for the entire term, Another small room has individual team lockers in which teams can store smaller items that need to be secured, One floor below is the Maker Space that is also staffed and can facilitate 3D printing, welding, basic machining, and other capabilities. In the last 10 years, about 52% of all project sponsors have returned to sponsor other projects through the Innovation Center. Further details can be found in Figure 1.

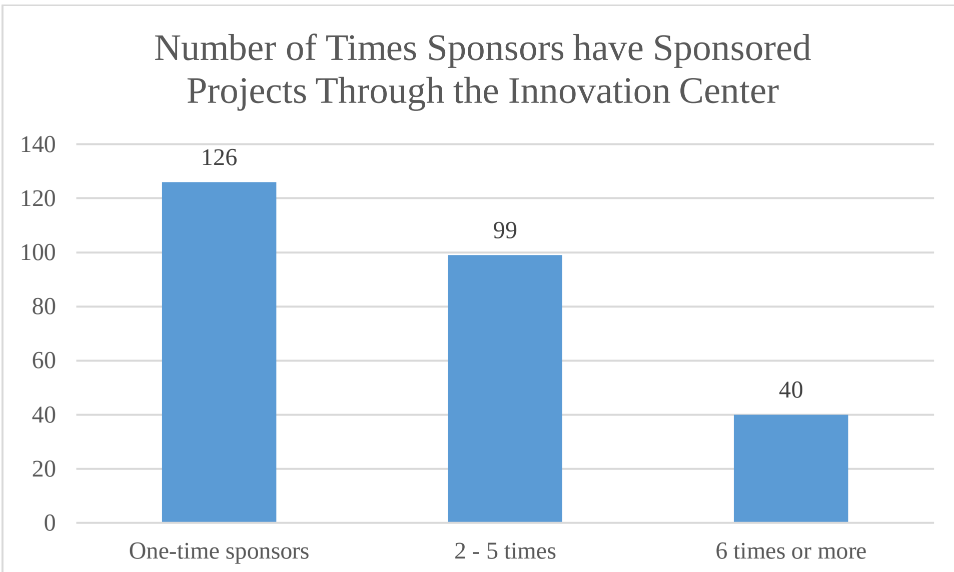

Fig. 1. Number of times sponsors have returned to the Innovation Center.

3.3 Finances

Each student team has a standard budget of $1000 for the semester, The Innovation Center staff accepts student invoices for mileage and other expenses, and commonly processes purchase orders (P.O) to Grainger or other industrial suppliers, If a sponsor is having a more expensive specialty machine built for example, that company can make those purchases or add money to the university fee so that students can process purchasing orders and the Innovation Center make those purchases.

3.4 Faculty

Each section of the 490 courses is co-taught by two full-time engineering technology faculty, Faculty get a brief preview of the projects, but usually, the lead time is only a day or so before the semester begins, Both faculty members are in class for the entirety of each session, and the faculty work hard not to be identified by major, Faculty typically divide labor in logical ways, but not by discipline since one goal of the course is to model the inherent interdisciplinarity of engineering work, Both faculty work on all projects and stay updated on all projects, but each team does have one “lead” faculty person who is somewhat more dedicated to that individual

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project and keeps stronger ties to the sponsoring client. In spring 2020, the authors co-taught the capstone course and the structure used is described below.

4. Senior Capstone Course Structure – Spring 2020

The senior capstone course follows a structured approach in achieving the project deliverables. At the beginning of the semester, a course calendar (Figure 2) showing the due dates of various deliverables, observed holidays, and other project milestones are shared with the students. The students then prepare a detailed project schedule with Project Professional (Microsoft Project) based on the basic outline in Figure 3 to meet the milestones stated on the calendar. On the second day of class when projects are assigned to student teams, team leaders contact their respective project sponsors/clients to schedule the initial client/kick off meeting. At least one instructor (also referred to as faculty advisor) attends the initial client meeting to also get conversant with the client and the details of the project.

The students use this meeting to appropriately scope the project and clarify project requirements. After the initial client meeting, student teams submit a project proposal to the faculty advisors as well as the client. Once the proposal is approved by faculty advisors and project sponsors, the students report their progress through biweekly written reports and oral presentations. In addition to the written reports, students are also required to maintain a logbook which is used to document individual contributions to the project. This may be used as evidence to support ABET student outcome 3 as it is a demonstration of student's ability to apply written communication to document engineering processes utilized in solving a broadly-defined engineering problem.

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Spring 20	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
JAN			1	2	3
	6	7	8	9	10
	13	14	15	16	17
	Spring Classes Begin	First Day of Class Project Selection		Project Teams Identified	
	20	21	22	23	24
		Client Visits		Client Visits Project Proposal	
	27	28	29	30	31
		Project Proposal Due, Presetation, 04		Faculty Advisor Presentation 1, 2	Weekly Status Report 3, 4, 5, 6
FEB					
	3	4	5	6	7
		Safety Presentation (15 min) Presentation, 3, 7		Presentation Update 1st Peer Review Due, 5, 6	Weekly Status Report 1,2,7
	10	11	12	13	14
		Presentation Update, 7		Presentation Update, 1, 2	Weekly Status Report 3, 4, 5, 6
	17	18	19	20	21
		Presentation, Design Review 3, 4		Presentation Design Review, 5, 6	Weekly Status Report 1,2,7
	24	25	26	27	28
		Presentation Design Review, 7		Presentation Design Review, 1, 2	Weekly Status Report 3, 4, 5, 6
MAR	2	3	4	5	6
		Presentation Update 2nd Peer Review Due, 3, 4		Presentation Update, 5, 6	Weekly Status Report 1,2,7
	9	10	11	12	13
		Presentation Update, 7	Weekly Status Report 3, 4, 5, 6	Presentation Update, 1, 2	Spring Break Begins after last class
	16	17	18	19	20
	SPRING BREAK!!				
	23	24	25	26	27
	Classes resume at 8:00am	Presentation Update, 3, 4		Presentation Update, 5, 6	Weekly Status Report 1,2,7
	30	31			
		Presentation Update, 7			
APR			1	2	3
				Presentation Update 3rd Peer Review Due, 1, 2	Weekly Status Report 3, 4, 5, 6
	6	7	8	9	10
	Last Day Drop Classes with Record of W	Presentation Update, 3, 4	Break Begins After Last Class, Weekly Status Report, 1, 2, 5, 6, 7	**Easter Holiday Break**	**Good Friday** **University Closed**
	13	14	15	16	17
	No Classes Easter Monday	Work on Draft Reports Dry Run Presentations		Dry Run Presentations Draft Report Due	Weekly Status Report, 1, 2, 3, 4, 5, 6, 7
	20	21	22	23	24
		Dry Run Presentations	**Stander Symposium No Classes**	Dry Run Presentations	
	27	28	29	30	
			Final Reports Uploaded to Google Drive by NOON!	Design Symposium. Final Presentations, Logbooks turned in: ***Final Peer Review***	
MAY					1
					Spring Classes End
	4	5	6	7	8
	Finals Exam Week	Project Closeout 10:10 AM	**Finals Exam Week**	**Finals Exam Week**	
	11	12	13	14	15
	18	19	20	21	22
	25	26	27	28	29

Fig. 2. Spring 2020 senior capstone calendar.

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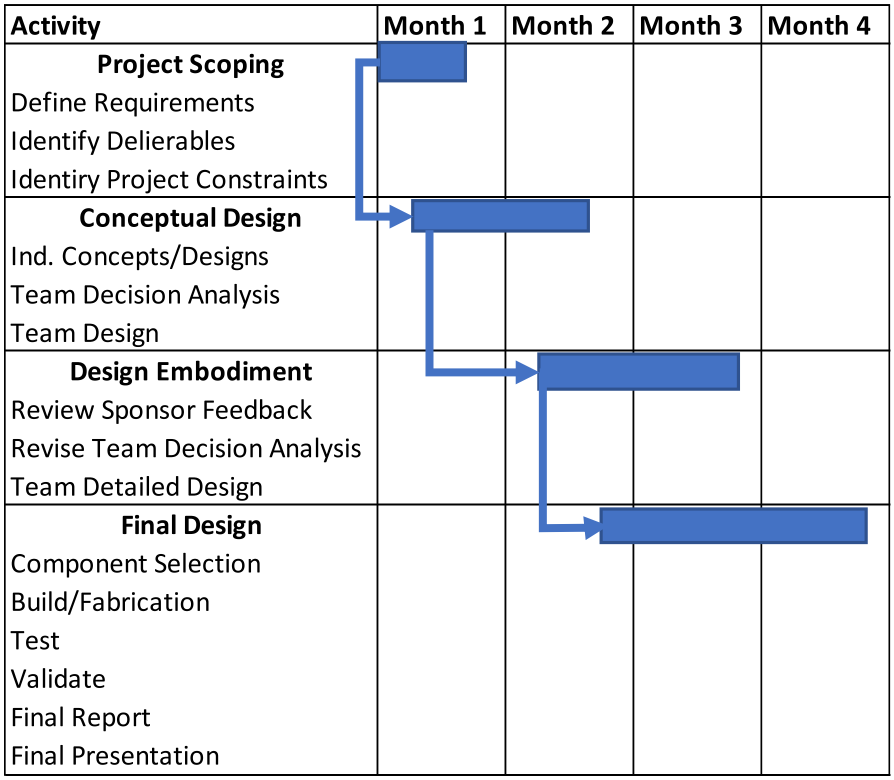

Fig. 3. Basic term schedule.

As can be seen in Figure 2, the due dates for the written reports and oral presentations for each team alternates. When written updates are due, team leaders provide a summary progress report which is also shared with the project sponsor. The other team members each write individual reports to demonstrate their efforts. The individual report has four main areas: *activities from the previous week* (since the last progress report), *significant accomplishments*, *problems encountered*, and *immediate future actions*. The team leader's report also covers these four areas as well as the status of the project (schedule), and conclusion. On the due date, the team leader collates and sends all reports to the faculty advisors.

Throughout the semester, four peer reviews (one every four weeks) are completed by each student. The form can be found in appendix II. This allows the students to reflect and review their project performance relative to the other team members. As part of the peer review, each student assigns three attribute codes (such as *late for meetings, effective team member*) to each member. Once the peer reviews are received and reviewed, the faculty advisors populate them and discuss the anonymous summary with each team member. This provides the faculty advisors the opportunity to appraise the team dynamics which helps in addressing most team and individual challenges. In the middle of the semester, faculty advisors complete and review with each team their *strengths, weakness, opportunities, and threats* (SWOT), during which time a team midterm grade is assigned. The SWOT form can be found in appendix II.

Project-related purchases are done through the Innovation center after the faculty advisors have approved the purchase. Students are encouraged to purchase from preapproved suppliers. However, if the items needed are not sold by a preapproved supplier or if it is more expensive, students can still purchase the items from other suppliers with faculty advisors' approval.

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Students are always reimbursed for personal expenses as long as they are project-related and were approved by faculty advisors.

Two weeks towards the end of the project, teams submit a draft final report to faculty advisors for feedback. They also go through a dry-run presentation to prepare them for the design symposium where all student teams take turns to present their projects to stakeholders. Typically, administrative deliverables such as final reports are uploaded into a Google drive folder which is accessible by the respective project sponsors. At the end of the project presentation, project sponsors take possession of all deliverables and complete an after project survey which will be discussed later in this paper. The results from the spring 2020 section taught by the authors are shown below in table 1. Six of the seven sponsors completed the survey. The numbers in the table represent the number of sponsors whose responses fell under each corresponding question.

As a result of the advent of the COVID-19 pandemic, the capstone course was completed virtually for the second part of the spring 2020 semester. From March 12, 2020, student teams collaborated virtually to complete their projects. This was a great challenge for the Engineering Technology program where the capstone requires students to design, build, test, and validate a physical deliverable. At that time, almost all of the teams were at the build phase of their project where they had ordered supplies, and or started fabrication and 3D printing, Therefore, the biweekly oral presentation was changed to weekly updates which provided the opportunity for the faculty advisors to provide timely feedback for the students. Written reports were still submitted biweekly.

When it was decided that students will not return for the rest of the semester, the student teams were empowered to renegotiate the project deliverables with the sponsors as this helps in the creation of value for project sponsors (Reifenberg and Long, 2017). Out of the seven projects, six were able to continue and completed the project without any modification to the original scope. With the support of the faculty advisors, some teams were able to complete the built phase from their homes, tested and delivered the product to the client. When a student was building a component, others worked on the software and documentation. This divide-and-conquer approach ensured that each student had a role to play and was accountable for the individual sections completed, For the physical part that required multiple expertise from students, the instructors facilitated and shipped the parts to the students. The Innovation Center also coordinated with student teams and shipped project-related orders that were delivered to the Innovation Center at the University of Dayton. At the end of the semester, all deliverables were returned to the Innovation Center and arrangements were made for the sponsor's delivery/pickup. Other administrative deliverables were shared with project sponsors in a Google drive.

Table 1. Spring 2020 sponsor survey results.

Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The students were well prepared academically.				2	4
The student team communicated well (oral and written) with us during the course of this project					6
The student team seemed very committed to this project with professional and ethical responsibility.					6
The oral presentations were informative, and professional				1	5
The students on this team were able to apply their knowledge of math, science and engineering in the solution of problems and develop designs				1	5
The project demonstrated that the students were able to design and conduct experiments as well as analyze and interpret data				1	5
This project demonstrated that the students/team were able to design and conduct experiments/testing				2	4
The students demonstrated the ability to identify, formulate and solve engineering problems using modern engineering tools					6
The team demonstrated an ability to be creative and innovative through their design concepts				1	5
The team demonstrated an understanding of the impact of the ethical engineering solutions in a global and societal context				1	4

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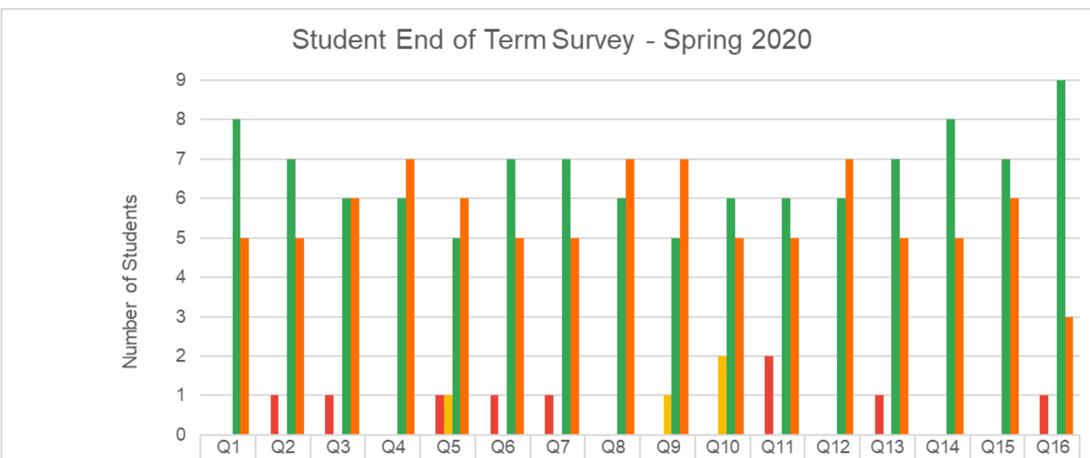
Three out of the six sponsors who responded to the survey also added the comments below:

"It was very well done; the students and faculty were a pleasure to work with?"

"The team was not able to completely finish this project due to closures related to the COVID-19 pandemic. With an additional 3 weeks the team would have met and probably exceeded expectations. The team continued to make progress even with the schedule challenges. They worked diligently and proved the concept. I wish that I could work with them for one more complete semester. Good luck to them all."

"The team did an excellent job given the current COVID-19 situation. We were expecting to have to postpone the project, but we were VERY happy to see the students take initiative and take the project home with them. Their presentation was very informative and well laid out as well. Great job team!"

During the project closeout stage, student teams submit any University of Dayton's possession (locker keys, hand tools, etc.), logbook, and ensures that the project sponsor has access to all deliverables, Also, faculty advisors and the student teams ascertain that labs used during the project execution are organized and restored to their original clean and usable state. A successful project closeout marks the official end of the project. The students then complete an after project survey, the results of which can be seen in figure 4. The 16 survey questions (Q1 – Q16) can be found in appendix III. Only 13 out of the 29 students in spring 2019 responded to the survey.



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
Strongly Disagree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Disagree	0	1	1	0	1	1	1	0	0	0	2	0	1	0	0	1
Neutral	0	0	0	0	1	0	0	0	1	2	0	0	0	0	0	0
Agree	8	7	6	6	5	7	7	6	5	6	6	6	7	8	7	9
Strongly Agree	5	5	6	7	6	5	5	7	7	5	5	7	5	5	6	3

Fig. 4. Spring 2020 student end of term survey.

Questions 3 and 4 can be mapped to the new ABET student outcome 1 (ABET, 2020). As seen from Figure 4, all but 1 of the responders agreed or strongly agreed that the capstone course helped to provide the opportunity to apply "knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems" (ABET, 2020). Similarly, questions 5 and 6 can be mapped to ABET student outcome 2 where 11 and 12 responders (out of 13) respectively agreed or strongly agreed that the capstone experience prepared them to be able to design systems to meet customer needs. Questions 8 and 9, and 10 and 12 respectively map to ABET student outcomes 5 and 3. Question 16 also maps to

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ABET student outcome 4. All but 1 student reported that the experience prepared them to be able to conduct tests, "measurements, and experiments and to analyze and interpret the results" (ABET, 2020) for process improvement.

Figure 5 shows the sponsor responses about the level to which the project results met the original deliverables. As seen in Figure 5, within the last 5 semesters (spring 2018 – spring 2020), it can be observed that the results from the spring 2020 projects were comparable to the previous semesters. The majority of sponsors felt that the students, even though they collaborated virtually from March 12, 2020 in spring 2019, until the end of the semester, still attained or exceeded the original goals of the project. This was not surprising to the faculty advisors as most teams demonstrated resilience and tenacity and were able to find ways to complete the project even with the advent of the COVID-19 pandemic. Even though it was challenging for the students and faculty advisors to collaborate virtually on hands-on projects, timely feedback and sponsor support ensured the success of the capstone course in a virtual environment. This in no way connotates that Engineering Technology projects should be run virtually. However, it is refreshing to learn that even with such a challenging environment, Engineering Technology students were able to deliver. Thus, student outcomes for the ABET 1 – 5 outcomes were still accessed for the capstone course in a semi-virtual environment.

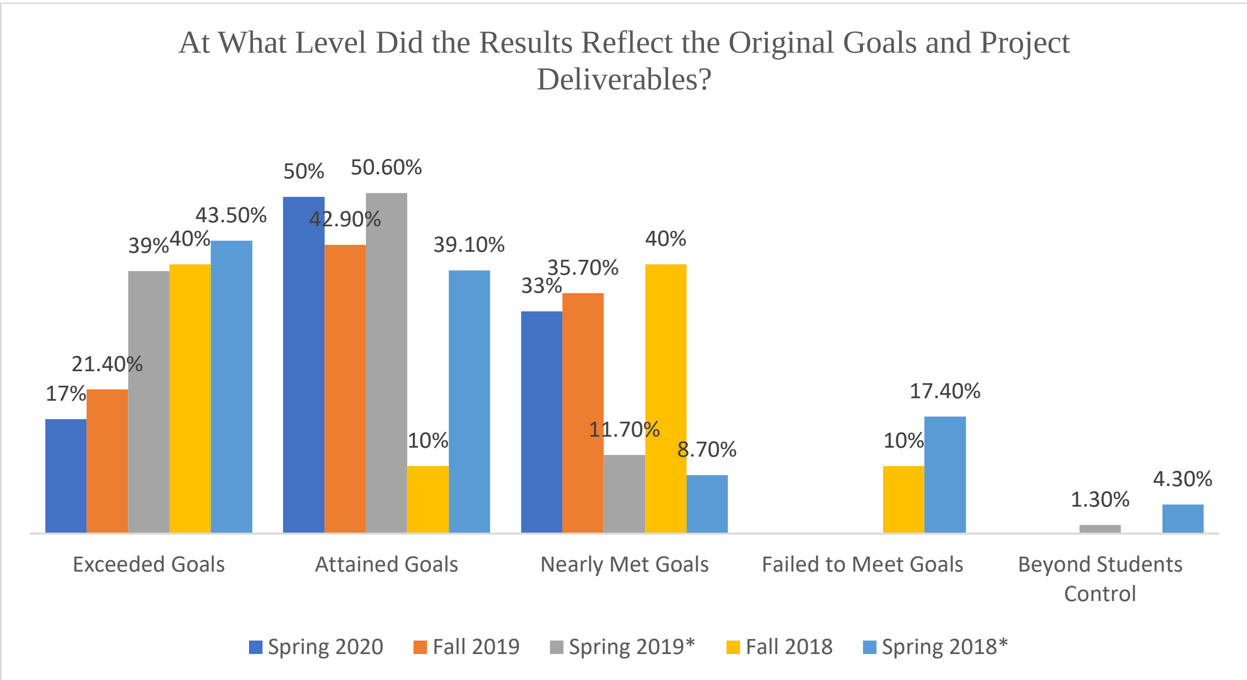

Fig. 5. Level of project satisfaction.

In spring 2018 and 2019, some sponsors rated the project results under two different categories. For example, one client selected "Nearly Met Goals" as well as "Beyond Students Control" and that is the reason why the percentages for spring 2018 and 2019 are over 100%.

5. Conclusions

There are so many ways to set up capstone design project courses for success, and University of Dayton certainly does not claim to have the perfect model that others should follow, There are, however, characteristics that we believe help to make our model successful, What are the key parts of the University of Dayton's model that provided us the underpinnings that made it successful in the unprecedented environment?

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5.1 Schoolwide Programmatic Structure with Resources

In the case of University of Dayton, the Innovation Center infrastructure with both technical and administrative support are critical in achieving consistently positive outcomes in these courses that present so many unique challenges and classic pitfalls, These courses are not just a professor's project, but rather come out of a relationship built with an organization that wants to partner at an institutional level, Dedicated space makes this course different from all the others from the first day of class. The student's ability to process P.O.'s and track shipping and to manage 3D printing, as examples, greatly enhance the chance for success every semester.

5.2 Team-Taught Format

Students are formed into teams and it is best if faculty are also seen as a team. Challenge and debate done well, even in front of students, can be healthy and convey the spirit of truly collaborative work, This approach also helps logistically as visits to clients and work in outside labs pulls one professor away from all remaining teams, It is important that this not be "hand-off" mentality and that the division of labor NOT be along major affiliation, The mechanical faculty should be involved in instrumentation, for example, and the electrical should not shy away from time study, Both faculty should be visibly involved from the start of each session until the end.

5.3. Strong Client Partnerships

A great client understands their role well, Clients need to understand the need to push for results and help with clear expectations, At the same time, clients need to understand that the team members are pre-employment and still developing to become employees in the engineering field, Clients need to care about the project that they have assigned AND care about the development of the students working on that project. Consequently, clients should be flexible and allow student teams and faculty advisors to renegotiate expected project outcomes when the environment changes. This provides value to both the sponsor and the students.

5.*4. Support from Other Departmental Faculty*

A functional department of Engineering Technology has a faculty that works together and is interdisciplinary, This nature becomes even more apparent with capstone design projects. Students regularly reach out to department faculty in other programs for expertise in specialty areas, and it is a great exercise for students to describe a technical issue and work with an outside expert not involved in the details of the project, In Spring 2020 described in Section 4, for example, after being relegated to distance-only methods, one team building a small automated work station was struggling with ladder logic and hardware interfaces, The team was very impressed and appreciative of the long hours via phone and Zoom that two part-time faculty members provided and the thrill of success was savored much more when it was ultimately reached.

Another important role played by other faculty members comes in the final presentations, All semester-long students are told that their clients <u>AND</u> their other professors will be attending and

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will ask questions and need answers at the final presentation, Of course, that challenge from the beginning of the semester leads to a very supportive environment in the presentations, but it is an important aspect of the process nonetheless.

5.5 Robust Systems in Place

Faculty typically only teach this course once every few semesters, With this kind of turnover, it would not be appropriate to rely on individual faculty to "invent" the course each semester, Another foundational element of this course that leads to success is a consistent, complete, and robust set of tools, Forms are very helpful, Grading rubrics, standard schedules, design proposal specifications, and forms for peer review are just a few examples, Following financial processes is great practice for students, but it requires that a system is in place and supported throughout the semester. All students and sponsors had access to a Google Drive that contains electronic files including the final presentation format, design review expectations, and all the steps along the way.

5.6 Curriculum and Students That Value Practical/Applied Education

Another critical element is a curriculum and student body that is geared to industrial applications, This element, of course, not be controlled for a given semester or be put into place quickly and easily, but it is important. Some students who enter this course with a 3.8 GPA can struggle with the ambiguity and human elements of a project, Perhaps this element is not something that we control in order to have a great capstone design project, but maybe instead we can use the student performance in this course as an indicator of the success of the rest of the program, Are our courses applied enough? Is there enough teamwork challenge early in the curriculum? What can we do to encourage more students to co-op? Does our faculty have a strong foundation of industrial experience along with the theoretical foundation?

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Biographies

JOSEPH A. UNTENER is a professor emeritus at the Department of Engineering Management, Systems and Technology, University of Dayton. He is a registered professional engineer and a co-author of an *Applied Strength of Materials* book. Professor Untener is a member of the American Society for Engineering Education and the Society of Manufacturing Engineers. The design process, manufacturing design, engineering pedagogy, and mission in higher education are his research interests.

PHILIP APPIAH-KUBI is an associate professor and the director of graduate programs at the Department of Engineering Management, Systems and Technology, University of Dayton. He has a PhD. in Industrial and Systems Engineering. His research areas are data analytics, transportation, supply chain management, and engineering pedagogy.

Appendix A

(**Note: Documents and information in the appendix were all created by the Innovation Center*")

Senior Project Entrance Survey
Spring 2020 01

Name: ________________________________ email:_________________________________

Major: _______________ Minor: __________________ Cell Phone:_____________________________

Work Group Preferences:

Would you like to be a Project Manager for a Project? Yes No

If YES, Why? ____

Is there anyone you prefer to work with? ____

Is there anyone you do NOT want to work with? ____

Project Preferences: Are you a US citizen? Yes No

1st Project Choice: ____

2nd Project Choice:____

3rd Project Choice:____

4th Project Choice: ____

Personal Skill Sets:

Skills:	Excellent A	Good B	Fair C	Poor D
AutoCAD/SolidWorks/FEA				
Analytical Calculations				
Innovation/Creativity/Ideation				
Written Communications				

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Oral Communications				
Machine Shop Practices				
Electronic Applications				
Hardware –Microprocessor Digital Circuits				
-Analogue Circuits				
-Software – Programing/Coding				
Lean Manufacturing				
Six Sigma DMAIC				
Simulation				
Leadership				
Successful Project Management Experience				

After graduation, in what disciplines would you prefer your first position?

___ Controls
___ Quality Assurance
___ Test & Evaluation Management Engineer
___ Manufacturing Design
___ Product Design
___Project Management
___Manufacturing
___ Computer Programmer
___ Additive Manufacturing
___ Operations
___Sales
___Other______
_____

Briefly describe any significant design and/or project management experience,

Name: ________________________________ Email:______________________

Major: ________________________________ Phone:______________________

Times **UNAVAILABLE** for group work, In the spaces below, please cross out the times when you will NOT be available to work outside of class on assignments with your group, Indicate specifically, class or work, Mark only genuine conflicts, such as classes or job responsibilities.

Time	M	T	W	Th	F	Sa	Su
8 AM							
9 AM							
10 AM							
11 AM							
12 PM							
1 PM							
2 PM							
3 PM							
4 PM							
5 PM							
6 PM							
7 PM							
8 PM							
9 PM							
10 PM							

Appendix B

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ETD 525

SENIOR DESIGN PROJECT
TEAM PARTICIPATION EVALUATION
(Each team member completes a separate form)

Team ________________________
Date: ________________________

In order to determine the progress and team characteristics of each group, we need to conduct peer evaluations. Please grade each of the individuals (including you) on the following performance criteria, Each **row** …***not column*** must total 100.

Team Members:	**1. (Your Name)**	2. (Team Member' s Name)	3. (Team Member' s Name)	4. (Team Member' s Name)	5. (Team Member' s Name)	6. (Team Member' s Name)	**Percentage of Total Work Completed (Row must total 100%)**
1. Quality of Individual Work (Neat, Accuracy, Well Documented)							**100%**
2. Quantity of Individual Work (Equitable Load)							**100%**
3. Professionalism (Attendance, Attitude, Communications)							**100%**
4. Productivity (Efficient use of Time)							**100%**
5. Dependability (Timeliness of Work)							**100%**
6. Communications (Written, Oral, Presentation)							**100%**
7. Initiative (Self-motivated, Direction)							**100%**
8. Contribution to Morale (Positive Criticism, Cooperation)							**100%**
9. Contribution to Written Documentation							**100%**
10. Team Player (Attitude, Avoiding Important Issues, Work for the Good of the Group)							**100%**
Add up the TOTAL Points							
List three attribute codes that apply							

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Code	Attribute		Code	Attribute
10	Poor Attendance		50	Good Team Leader
11	Late for Meeting w/ Client		51	Motivates Team
12	Late for Meetings w/ Team		52	Keeps Project on Track
			53	Direct/Straightforward
20	Poor Performance		54	Self Motivated/Directed
21	Not Prepared for Team Meetings			
22	Lack of Initiative		60	Accomplishes Tasks on Time
23	Avoiding Important Issues		61	Positive Attitude
24	Output is of poor quality		62	Performance is above expectation
25	Unorganized/sloppy		63	Motivated
			64	Excellent Team Member
30	Not a Team Player		65	Positive Contributions
31	Difficult to Get Along With			
32	Negative Attitude		70	High Quality Work
33	Untrustworthy		71	Technically Savvy
34	Poor Work Ethic		72	Intelligent Approaches to Solutions
			73	Valuable Previous Experience
40	Quiet			
41	Does Not Share Ideas		80	Communicates Effectively
42	Does not Communicate Status		81	Shares Ideas Well
43	Monopolizes Conversation			

SWOT Analysis

Project Title:

Interim Team Grade: **A, A-, B+, B, B- C+, C, C-, D, F**

Strengths:	**Weaknesses:**
Opportunities:	**Threats:**

Appendix III

Students End of Term Survey Questions

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1	I believe I have a very good understanding of the product realization process
2	I believe I learned a great deal about design and the design process in this course
3	This course helped provide experience in applying knowledge of math, science, and engineering, and because the application was done in context to a project, it helped me improve this knowledge
4	As a result of this course, I believe I have a better ability to apply techniques, skills and engineering tools necessary for modern engineering practice
5	As a result of this course, I believe I have a better 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
6	As the result of working on this project in this course, I have enhanced my ability to design components and/or processes to meet customer needs
7	Through the development of specifications, concepts, and design components, I believe I am better able to develop creative and innovative solutions to engineering problems
8	As a result of this course, I believe I have a better ability to contribute towards team goals and value others' contributions in a multidisciplinary design team
9	As a result of this course, I believe I have a better ability to fulfill individual duties assigned by a multidisciplinary design team in a responsible manner
10	Because of the communications requirement for this course, I believe I am better prepared to provide oral presentations and written reports
11	As a result of this course, I believe I have a better knowledge of product safety, product efficiency, limitations, economic feasibility, and market potential
12	I believe our team was able to communicate effectively with our sponsor
13	Our sponsor was effective in providing input to our project and answering questions in a timely fashion
14	As a result of this course, I believe I have a better ability to articulate how our team utilized an ethical approach to the design problem
15	As a result of this course, I believe I understand the importance of continuing education and lifelong learning
16	As a result of this course, I believe I am better able to design and conduct experiments, as well as to analyze and interpret data

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