2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #33317

Investigating Impact of Disruption to Biological and Agricultural Engineering Senior Design Capstone Courses Due to Covid-19

Dr. Lucie Guertault, North Carolina State University
Dr. Tamecia R. Jones, North Carolina State University at Raleigh

Tamecia Jones is an assistant professor in the STEM Education Department at North Carolina State University College of Education with a research focus on K-12 engineering education, assessment, and informal and formal learning environments. She is a graduate of Johns Hopkins, Stanford, and Purdue University. Originally trained as a biomedical engineer, she spent years in the middle school classroom, teaching math and science, and consulting with nonprofits, museums, and summer programs.

Mr. Eric Steven Hall, North Carolina State University

Eric S. Hall

Education: • PhD (Student), Education, North Carolina State University (Expected Graduation: 2023) • M.C.E., (Master of Civil Engineering), North Carolina State University, 2011 • M.A., Business, Webster University, 1992 • B.A., Mathematics, Syracuse University, 1983 • B.S., Aerospace Engineering, Syracuse University, 1983

Areas of Expertise: Exposure Science; Air Pollution Monitoring; Mercury (Hg) Air Pollution Analysis; Environmental Justice; Environmental Public Health Tracking; Ultraviolet Radiation; Sustainability; Statistical Programming. Managed $28.70 million dollars of environmental and public health research at EPA. Doctoral Emphasis: STEM Education

Publications (32): journal articles, technical reports, book chapter

Reviewer: 44 peer-reviewed journals

Narrative: I develop statistical models to make temporal and spatial estimates of ambient air pollution concentrations, linked to health outcomes (e.g., pulmonary, cardiovascular, birth outcomes, etc.). I develop methodological approaches and models to support remediation of polluted waterbodies, especially those experiencing Harmful Algal Blooms (HABs) and cyanobacteria. My dissertation focus is on developing standard problem solving approaches for engineering and mathematics undergraduates.

Dr. Praveen Kolar, North Carolina State University

Investigating Impact of Disruption to Biological and Agricultural Engineering Senior Design Capstone Courses due to COVID-19

Abstract

Senior Capstone Design is a culminating course of the undergraduate engineering curriculum which gives students the opportunity to work in teams on designing a solution to real-world problems submitted and mentored by industrial and research project sponsors. In Biological and Agricultural Engineering disciplines, these projects can involve tasks such as field data collection, laboratory experiments or fabrication of prototypes that require access to specific laboratories and equipment.

In the Spring 2020, Universities across the US shut down to prevent the spread of COVID-19 and transitioned to remote or virtual courses. The objective of this study was to investigate the impact of the transition to remote and virtual courses on senior design or capstone courses in Biological and Agricultural Engineering to find lessons learned and help plan for future disruption in these courses. Four Senior Design Capstone Course instructors from different Biological and Agricultural Engineering departments were interviewed to gather their perspectives and experiences regarding changes in instruction; student projects' management and outcomes; as well as students' learning and performance in the course.

The shift to remote learning triggered frustration on both students and instructors' sides. They also faced unprecedented challenges with technology and access. Instructors acknowledged student resilience and adaptability to the situation. The creative flexibility that instructors applied to course delivery, project deliverables and assessment is a key tool that allowed them to maintain the real-world experiential nature of BAE capstone programs.

Introduction

Biological and Agricultural Engineering (BAE), also called Agricultural and Biological Engineering or Biosystems Engineering, is a four-year, ABET-accredited undergraduate engineering program offered by over 32 universities in the United States. The BAE program is usually jointly administered by the colleges of engineering and agriculture and integrates engineering with agricultural, biological, food, ecological, environmental, and chemical systems to develop innovative solutions to sustainable food, fuel, and fiber. As a part of this program, students in their final year are required to complete a capstone design project that fulfills the degree requirements. These capstone design projects, as also suggested by [1] [2], involve addressing engineering problems by combining theoretical and practical, and critical thinking skills acquired in the classroom, laboratories, and field visits during the preceding three years. Besides, soft skills such as team building, written and oral communications, project and time management are also emphasized [3]. Further, these capstone projects are also expected to serve as a conduit that connects theoretical learning in classrooms with applied problem-solving in the

industry and prepare the graduating seniors to take on professional responsibilities immediately after graduation [4] [5].

In line with other engineering disciplines in the country, capstone design in biological and agricultural engineering programs is also a two-semester course. The design projects are typically conceived by the faculty sponsors and sometimes advised by the members of the departmental industrial advisory board. In the first semester, the students actively form groups and select projects that are aligned with their interests (e.g., environmental-design of a pumping system for an aquacultural facility, designing a small anaerobic digester for converting food waste into biogas and biofertilizer, and others). Subsequently, they perform an in-depth literature review, and after consultation with the faculty sponsor, develop a design (and budget) proposal at the end of the semester. In the following semester, the student teams actively fabricate the system and test for its efficacy, and compare it with the original design parameters. However, due to the COVID-19 pandemic in the spring of 2019, the second part of the spring semester which is typically focused on fabrication and testing was completely shifted to an online mode of instruction, which was unprecedented. Many researchers have contested the compatibility of online learning with engineering where hands-on practical experiences are required as part of instructional activities [6]. Considering that the fabrication and testing is the culmination point of the students' four-year learning process, it is critical to understand how shifting to an all-online format impacted student learning (students' perspective) and teaching effectiveness (instructors' perspective).

Therefore, the main objective of this research was to study the impacts of online instruction of second-semester capstone design courses on student learning and outcomes, and faculty teaching effectiveness. Based on the course structure and deliverables, it was hypothesized that moving capstone design to an online format impacted faculty teaching effectiveness. In order to determine faculty perceptions of the impact the pandemic had, the research team collected data from faculty from various capstone design instructors via surveys and interviews as described in the subsequent sections.

Methods

This exploratory qualitative study used an inductive approach [7], [8] to investigate the following question: *How did the COVID19 disruption impact biological and agricultural engineering senior capstone courses?*

Since the population of BAE departments is small (about 40 departments) and the number of senior capstone courses is approximately 1 per university, we used multiple methods for data collection. The research design included a 30-question electronic survey of the faculty of senior capstone courses. Within the survey, we recruited volunteers for 60-minute focus groups at the virtual annual conference and/or individual semi-structured interviews to ask follow-up

questions inspired by survey responses. In this design, there was potential for surveys, focus groups participation, and then individual interviews from any given university, offering multiple data points with which we could triangulate. We recruited within the biological and agricultural engineering community via email invitation.

Instrument development

The research team developed a survey to gather course details and demographic information from universities. Surveys inquired about course components, organization, assessment plans and industry partner-project group meeting structure, and changes that took place within the course after the disruption via multiple-choice and open-ended questions. We also asked instructors to share de-identified course evaluations if they were comfortable. We generated focus group and semi-structured interview protocols and received IRB approval.

Data Collection

The surveys were given through Qualtrics software. The response rate to surveys was low (n=4). When the surveys revealed willing participants for the focus group and interview, contact information was given and participants were invited to schedule interviews with the research team. The research team used survey data to inform the interview questions beyond the original protocol for semi-structured interviews. In particular, open-ended questions created opportunities for further inquiry. Interviews were conducted via Zoom and recorded.

Analysis

The interviews were transcribed and distributed to the research team members. Research team members analyzed the interview transcripts and thematic analysis. Four team members read transcripts for emergent themes multiple times, entered themes and evidence into a shared document for review, and then had a meeting to rank themes as convergent and divergent. A theme was ranked as convergent when the four interviewees expressed similar opinions, or if three of them expressed similar opinions and the topic was not discussed by the fourth interviewee. A theme was ranked as divergent if at least two interviewees had different opinions.

Results

Description of Courses

Four Biological and Agricultural Engineering Senior Design instructors answered the survey and agreed to participate in the interview. Represented universities include a R1 and a R2 from the South and a R1 and a R2 from the Midwest. A description of the Senior Design Capstone courses is presented in Table 1. Class size ranged from 15 to 50 students and the number of senior design project teams ranged from 4 to 17. Three courses followed a traditional 2 semester course sequence starting in Fall and ending in Spring. All instructors had prior teaching experience in Spring 2020. Interestingly, one participant was teaching the Senior Design course for the first time in Spring 2020. Conversely, two instructors had a long record as Senior Design

Instructors. Each surveyed course included a design component sponsored by industry partners. All universities pivoted their courses online after their Spring Break in 2020.

TABLE 1 - Course characteristics and instructor background

University	***Number of students***	***Number of student teams***	***Length of course***	***Experience of instructor (years)***	***Tenure Teaching course (yrs)***
A	*20*	*8*	*2 semester sequence (Fall - Spring)*	*>20 years*	*> 20 years*
B	*15*	*4*	*2 semester sequence (Fall - Spring)*	*3-6 years*	*3-6 years*
C	*50*	*17*	*2 semester sequence (Fall - Spring)*	*>20 years*	*7 - 12 years*
D	*40*	*12*	*Spring only*	*7 - 12 years*	*1st year*

Converging themes

Six converging themes were identified from the interviews (Table 2). Those themes were student-related, instructor-related, and university response-related. Themes related to students were adaptability and resilience, student frustration and disappointment, impact on student skills. Themes related to the instructor were transition planning and response and changes in expectation. The sole university theme was based on the immediacy or tardive response.

The strongest common theme that emerged from the interviews was instructors' acknowledgment of students' adaptability and resilience. This idea was discussed multiple times by each instructor. Instructors were impressed by their students' ability to adjust to the situation, get used to technology and devise solutions to complete their projects. Instructors recognized that the unexpected disruption in the course and project was a beneficial learning experience that raised students' awareness in their capacity to adapt and prepared them to manage the setbacks common to industry projects.

All instructors noticed strong student frustration and disappointment at the announcement of the online emergency transition, and these feelings were expressed in a variety of behaviors. Instructors estimated that 25% to 100% of the students had slightly to significantly lower motivation to complete the course after the online shift.

Instructors reported that the lack of face-to-face interactions was detrimental to students' communication skills. Under normal circumstances, instructors incite their students to have

in-person meetings to discuss the project components as well as to meet with their client in person as much as possible. Three out of four instructors also reported a decrease in interactions with industry partners after the online transition. In addition, the final project presentation delivery was changed from in-person presentations in front of large audiences that typically include classmates, industry mentors, department advisor board members, as well as family and friends to either online-synchronous presentations or pre-recorded presentations.

The instructors reported lowering their expectations, being more lenient with deadlines and placing more emphasis on early semester assignments. Instructors recognized the difficulties faced by students and their distress regarding the outcomes of the senior design course and more broadly graduation and what comes after. This softening of assessment also echoes the Pass/Fail grading policies that have been implemented by the universities.

Instructors perceived their universities' decision making regarding the continuity of instruction after Spring Break as tardive. The unprecedented situation combined with Universities' tardive decisions left the instructors very little time to create a plan to pivot their courses online.

TABLE 2: Convergent Themes

	Themes	**Examples Quotes**
Student	Student resilience/adaptability	- They're very resilient, I think they are more resilient than faculty members. - They got through the course because they were able to adapt, rebound. - The students adapted to the situation and their frustration. - I have to give the students a lot of credit because they hung in there, they stuck to it. They did what they needed to do. They demonstrated the ability to adapt. They may be more resilient than you think they are.
	Students' initial frustration / disappointment	- One very good student said their senior year has been ruined. - They did not feel they had the experience of previous years. - I could see very quickly a lot of students just looked really, really discouraged. - Disappointment, frustration

	Impact on students' soft skills	- The only thing I think was lost is face to face interactions. - They missed their interactions with teammates. - The skill I think already kind of mentioned was the teamwork. - They lost the formal public speaking opportunity in front of a big group in a very formal setting.
Instructor	Transition planning and response	- There were no plans. - I didn't have one. It was kind of minute day by day, week by week. - There was lots of confusion on who is going to make what decision when. Probably work on senior design ceased for about three weeks. - And so it left us with one week to start scrambling to re-emphasize and how to execute the rest of the semester.
	Change in instructor level of expectations	-I'm not hammering them as hard on issues that I probably would have in the past. I'm probably being more lax than I have been in the past. - We ended up softening our assessment of students tremendously, I became much more relaxed about accepting late assignments. - I adjusted my expectations because usually I set them as to what their goals are for the semester, and instead of that, we kind of looked at the early semester and then documents. - I tended to give students [the] benefit of the doubt a little bit more because I knew how incredibly stressful it must be to be looking forward to the big end of your college career, only to have it melt in front of you.
University	Tardive university decisions	- University was also slow in providing answers. - We were getting misinformation or incomplete information from different sources on campus, I probably misinformed students multiple times because I was misinformed. There was lots of confusion on who is going to make that decision when. - University shutdown was announced Thursday or Friday of spring break. I was thinking they're not going to do anything.

Divergent themes

Three divergent themes were identified. These themes were distribution of project completion trajectories, use of technology and project deliverable changes.

In the four courses studied, senior design projects were at different stages when the emergency remote instruction was implemented. Three instructors pointed out that in their courses, the period following the Spring Break is typically focused on the building component of students' projects. One instructor even stated that 'it was probably the worst time to not be able to be on campus.' Conversely, one instructor explained that their strategy is to have students' projects mostly completed before Spring Break, as their experience teaching the course taught them that students were typically less motivated after Spring Break.

As a logical consequence of the difference in project stages between courses, different levels of modification of project deliverables were implemented by instructors. Instructors whose students' projects were paused before reaching the building phase shifted towards more theoretical deliverables, such as solid modeling of the projects and development of testing protocols. While an adequate virtual substitute for hands-on practical activities does not seem to exist, the adoption of simulation tools has been identified by a national survey of faculty during Covid-19 conducted by [10] as one of the most frequent adjustments made by instructors teaching practical courses.

Difference was also observed in how instructors used technology to support the transition to remote learning. While all the instructors used the visioconference platform (Zoom) provided by their University to set up their course activities, two of them searched for and used additional technological solutions for specific aspects of their courses. For example, one instructor leveraged the Solidworks instructor platform to provide solid modeling instruction. Another instructor used an open source virtual platform to host the course final trade show during which students present their work to a broad audience, including their family and friends.

Table 3 shows examples of these themes.

TABLE 3: Divergent Themes

Themes	**Perspective 1 Examples Quotes**	**Perspective 2 Examples Quotes**
Projects were at different	***Projects were mostly completed***	***A significant amount of work was still needed***

stages when universities shut down	- They get their projects 90 to 95 % done before spring break.	- that time period, especially for most of our projects, are heavy build time - some of them had projects where they were working with the client in their own science labs and suddenly those labs were shut down. They couldn't go off site to the research part and work with their client - we were really right in the middle of building things and doing a lot of testing, a lot of hands on work when everything started to happen last March
Assessment methods	***No significant change***	***Significant changes in assignments and deliverables***
	- The delivery process was a little different but the assignments really didn't change that much	- We placed emphasis on putting together documentation packages on how to finish the project, detailed protocols on how to test the design - We shifted to a solidworks drafting. We actually shifted material dramatically.
Implementation of online teaching tools	***Instructors use their University default tools and platforms***	***Instructors search for alternative tools that better meet their needs***
	- we pretty much went to straight zoom from then on for the rest of the semester. - the senior design students and I started zooming	- I put a lot of extra time into learning the technology, finding tools. - II ended up finding a virtual traditional platform and made the local news because we set it up so that the students could invite family and friends to view their final project presentations - We use the Solidworks professor platform, that has a certification path from beginning to end.

Additional Lessons Learned

Though there were convergent and divergent themes from interviews, there were also reflective lessons from instructors.

Two out of four instructors explained that they communicated their transition plan to the students and polled students to get their input on the plan. Both reported that the students responded well to their suggestions and engaged in the proposed activities. One instructor reported that 'almost one hundred percent of those students said: we wanted to proceed ahead as planned.'. The other instructor had planned to shift significantly the course content and project deliverables to SolidWork simulations. They reported that this solution kept the students motivated: 'many of them worked towards their SolidWorks certification instead of arm twisting.'. Keeping students engaged during remote instruction has been a major priority of instructors [10] and it appears that inviting students to provide feedback on the online plan helped in doing so.

One beneficial outcome that came out of this emergency shift to remote learning was that it incited instructors to familiarize themselves with technology. Instructors admitted that they started to or planned to use more technology and in a more intentional manner in the classroom in the Fall 2020 and Spring 2021 semester, whether they were teaching their senior design course in person or online. This observation is consistent with the findings of [10] showing the shift to remove learning has driven the adoption of new digital tools in the classroom.
Though they may have been initially underprepared, several engaged in additional training offered by their Universities during the Summer. Their reflections are shared below:

- Next semester (*Spring 2021*), we are going to try to use a lot of the same tools and technologies that we used on the fly last year because in the end, they really worked well.
  ● Probably a big change I made this year (*Spring 2021*) is that we implemented Microsoft Teams. That keeps all the notes together, shares files. It has done a great job of trying to make students accountable. It gives them tools that at any point in time we can jump on if we have to be remotely."
- Finally, I just said I got to pick Zoom and I really got to learn how to do that one[software]. And hopefully that'll work. And so I had a lot of help from my TA.
- So I was practicing my Zoom skills by recording things offsite so I wouldn't be in front of them screwing up.
- the university gave us all kinds of training on the different elements
- I actually did over the summer participate in an academy for online and hybrid teachers

Second, instructors also reflected on the obstacles that remain regarding online delivery and use of technology in their senior design courses. One obstacle identified by the instructors was the internet and technology issues faced by students . "Many students didn't have all the tech needed (wifi, computer, webcams, etc)." One instructor also revealed that they were struggling with the same issues. "So I live twenty two miles outside of town and our Internet is not the best, and so I got special consideration to be on campus every day". Many studies identified technology issues and inadequate learning environments (such as the lack of a dedicated workspace) as major obstacles to student learning during the online shift. These challenges have been

disproportionately experienced by students from marginalized backgrounds, which has enhanced inequalities in student achievements [10-12].

Two instructors also highlighted the difficulty to adapt their teaching styles to online or hybrid delivery modes. “Since you're not standing in front of a group you're not getting any kind of feedback. Even with [the] camera on. I don't get hardly anything in the chat session if I’m going too fast, too slow, even when I do polling.”

One instructor has experimented with hybrid delivery mode in Fall 2020 and Spring 2021 to allow students who could not be on campus to attend their courses, but acknowledges the difficulty to make the course work for the different audiences. “I try to be really flexible about that by offering it in person online, plus recording it so students who can't make the class can watch it asynchronously. The technology is incredibly difficult. What I haven't figured out how to do yet is to be able to have a discussion across a zoom room and a classroom.” Later they added, “So I spent half the class repeating information to each other [in the two different settings].” This observation aligns with the experiences of the majority of instructors, especially STEM instructors teaching hands-on courses, who found that adjusting their teaching practice was a major challenge [10].

Finally, several instructors reported an increase in the number of students reaching out to them to express their concerns and seeking out support. Some instructors indicated that they shifted or played additional roles during this transition. Beyond normal instruction or expert, they sometimes felt like they adopted familial or social roles as parent, coach, or counselor. One instructor even revealed that several students in their course showed concerning behavior and were taken in hand by the University Prevention Services.

Discussion and Conclusion

We learned in this project that the stability and frustration of capstone students in the midst of the disruption was related to the instructor’s ability to plan and communicate effectively, and the instructor’s ability to plan was related to the decisions at the university level. We learned that both students and instructors were resilient and made concessions regarding delivery, scope, sequence, deliverables, and presentation of courses and final projects. We also learned that both faculty and students faced unprecedented challenges with technology and access, and this impacted their ability to interact and perform as they might have intended.

Based on observations of the descriptions and structures of the respective courses, the capstone courses that traditionally distributed prototype development and construction before Spring Break and iterations after Spring Break had a less disruptive pivot than those courses where manufacture of prototypes happen in the later portion of the course. There was also a difference in the single-semester compared to the yearlong capstone courses, where the yearlong courses

had fewer problems building community and sustaining relationships between team members and external project mentors than second-semester courses. These observations can help faculty as they plan the curriculum scope and sequence and project timelines in the future, and consider the pros and cons of single-semester versus whole year capstone courses.

Instructors described the diminished communication skills due to reduced interactions and meetings and loss of opportunity to publicly present, but they also reflected about improved student project reports compared to past years. This implies that communication skills developed in capstone courses should be broken down into categories (interpersonal, verbal, and written) and assessed separately as well as collectively. Lessons learned from innovatives strategies for communicating and higher quality written project reports should be implemented in future traditional courses.

While this research was taking place, educators gathered to discuss best practices. BME IDEA (alliance of professors teaching design in Biomedical Engineering departments to improve instruction) hosted a session on *Teaching Capstone Design in a Remote Model* at their annual meeting in 2020. They identified strategies for teaching capstone design remotely, which include helping students build strong, supporting teams; lowering expectations on the prototypes and deliverables; considering alternative ways of grading such as the three-level scale: high pass, pass, and no pass, with the letter grade requiring that students try again, implemented by Dr. Ann Saterbak at Duke University [13], that takes students' focus away from the grade into skills and expertise development. Future research will determine the effectiveness of those shared strategies. Besides, additional future research includes investigating how assessment should have changed, the influence of experience of the faculty with technology, how teamwork can be best facilitated remotely, and what projects have the robustness to be either virtual or in person.

Now that faculty have shifted abruptly and learned lessons about their pedagogical skills and technology, senior capstone courses in the discipline have the potential to evolve and include the best aspects of technology delivery, project management, and teamwork. The creative flexibility—whether applied to course delivery, assessment, project deliverables, remains one key tool faculty have as they try to maintain the real-world experiential nature of BAE capstone programs.

References

[1] J. A. Marin, J. E. Armstrong and J. L. Kays, "Elements of an Optimal Capstone Design Experience," *Journal of Engineering Education,* vol. 88, *(1),* pp. 19-22, 1999. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/j.2168-9830.1999.tb00405.x. DOI: https://doi.org/10.1002/j.2168-9830.1999.tb00405.x.

[2] N. Hotaling *et al*, "A Quantitative Analysis of the Effects of a Multidisciplinary Engineering Capstone Design Course," *Journal of Engineering Education,* vol. 101, *(4),* pp. 630-656, 2012. Available: https://onlinelibrary-wiley-com.prox.lib.ncsu.edu/doi/abs/10.1002/j.21689830.2012.tb01122.x. DOI: 10.1002/j.2168-9830.2012.tb01122.x.

[3] B. Lutz and M. C. Paretti, "Exploring student perceptions of capstone design outcomes," *The International Journal of Engineering Education,* vol. 33, *(5),* pp. 1521-1533, 2017. Available: https://dialnet.unirioja.es/servlet/articulo?codigo=6927186.

[4] J. J. Pembridge and M. C. Paretti, "Characterizing capstone design teaching: A functional taxonomy," *Journal of Engineering Education,* vol. 108, *(2),* pp. 197-219, 2019. Available: https://onlinelibrary-wiley-com.prox.lib.ncsu.edu/doi/full/10.1002/jee.20259. DOI: 10.1002/jee.20259.

[5] S. Howe and J. Goldberg, "Engineering capstone design education: Current practices, emerging trends, and successful strategies," in *Design Education Today*Anonymous 2019, . DOI: 10.1007/978-3-030-17134-6_6.

[6] O. B. Adedoyin and E. Soykan, "COVID-19 pandemic and online learning: the challenges and opportunities," *Interactive Learning Environments,* vol. 0, *(0),* pp. 1-13, 2020. Available: https://doi.org/10.1080/10494820.2020.1813180. DOI: 10.1080/10494820.2020.1813180.

[7] A. Tashakkori and C. Teddlie, *Handbook of Mixed Methods in Social & Behavioral Research.* Thousand Oaks, CA: SAGE Publications, 2003.

[8] J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* (Fifth ed.) 2018.

[9] N. K. Denzin and Y. S. Lincoln, *Handbook of Qualitative Research.* 1994

[10]K. Fox , G. Bryant, N. Lin and N. Srinivasan *Time for class – COVID-19 edition part 1: A national survey of faculty during COVID-19.* 2020 Tyton Partners and Every Learner Everywhere.

[11] A. Bacher-Hicks, J. Goodman, and C. Mulhern. Inequality in household adaptation to schooling shocks: Covid-induced online learning engagement in real time. *Journal of Public Economics* 193 (2021): 104345.

[12] A. Gillis,and L. M. Krull. COVID-19 Remote Learning Transition in Spring 2020: Class Structures, Student Perceptions, and Inequality in College Courses." Teaching Sociology 48.4 (2020): 283-299.

[13] J. Rains, J. DesJardins, M. Oldakowski, E,Ledet, J. Tranquillo, J. Zara, Teaching Capstone Design in a Remote Model, BME IDEA meeting Workshop report 2020.