Report of the CECS Senior Design Task Force

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I. Executive Summary

This report provides an update on how senior design (a.k.a., capstone) course instructors in the College of Engineering and Computer Science responded to the Covid-19 "stay at home" challenge during the Spring 2020 semester and on plans for transitioning to remote learning and teaching in Summer 2020.

Overall senior design course instructors made a relatively smooth transition to remote teaching in Spring 2020. Instructors and faculty advisors utilized a combination of video-conference software applications, such as Zoom, Skype and YouTube for lectures and weekly meetings with students. Student end of semester presentations and project demonstrations were also conducted on the same platforms, although predominantly via Zoom. Webcourses was used for submission of project reports and design documentation. This report presents lessons learned and actions taken by each department in Spring 2020 that will ease the transition to remote teaching and learning for Summer 2020.

Looking forward to Summer 2020 and beyond, the senior design task force identified the following potential issues that require further investigation:

1. A perennial issue for engineering senior design instructors is finding relevant and engaging projects for students. The pandemic will only exacerbate this situation, since many projects are done in collaboration with stakeholders and sponsors, who define problems and in some cases provide funding for senior design projects.

2. Capstone senior design courses play an important role in demonstrating student abilities to function effectively on a team. The potential impacts of remote teaching and learning on assessment and facilitation of student teamwork needs further exploration.

3. Capstone instruction tends to be impromptu, hands-on and project-based, which may not always be conducive for remote instruction. CECS and MAE senior design courses utilize industry adjuncts for clinical instruction and student team advisement, who share their real world professional experience with students. In some cases, the adjunct instructors we have engaged in the past may not be prepared to transition to remote instruction. With the transition, we may need to identify new approaches for providing clinical experience to our students. Both CECE and MAE have expressed concerns about staffing, both for Summer 2020 and, should the "stay at home" directive continue, into Fall 2020.

4. In the past, access to computers, software and the internet has been readily available to all students on campus. We will need to consider the individual capabilities of each student to connect to computer resources as we move forward. For the case of advanced engineering software applications (e.g., ICPR, ANSYS,STAR-CCM), there will likely be additional costs associated with providing remote software access.

II. Mission, Approach and Assumptions

The task force mission was to review lessons learned from the transition to remote instruction in Spring 2020, make recommendations for CECS Senior Design course improvements for Summer 2020, and to identify issues in moving forward. The general approach for accomplishing the mission included the following elements:

1. Identify CECS course offerings for Summer 2020 courses
2. Review current senior design courses in the Spring 2020 term to identify best practices, issues and challenges.
3. Reach out to the faculty that are involved in the current term and gather their feedback.
4. Review similar operations at other universities.
5. Review available resources for virtual design projects, presentations etc.

The senior design task force assumed that there would be no on-campus meetings and that the stay at home and social distancing directives would remain in effect for Summer 2020.

III. Summer 2020 CECS Senior Design Courses

The following lists identify the CECS senior design courses by department to be offered in Summer 2020:

Civil, Environmental and Construction Engineering

- CEG 4801C/1, GEOTECH DESIGN
- CGN 4808C/1, CAPSTONE DESIGN
- CWR 4812C/1, WATER RES DESIGN
- ENV 4433C/1, WASTEWATER DESIGN

Computer Science

- COP4934, SENIOR DESIGN I
- COP4935, SENIOR DESIGN II

Electrical and Computer Engineering

- EEL4914, SENIOR DESIGN I
- EEL4914, SENIOR DESIGN I
- EEL4915L, SENIOR DESIGN II
- EEL4915L, SENIOR DESIGN II

Mechanical and Aerospace Engineering

- EAS4700C, SENIOR DESIGN I
- EML4501C, SENIOR DESIGN I

IEMS and MSE **will not** offer Senior Design courses in Summer 2020.

IV. Senior Design Transition to Remote Teaching and Learning

The following sections highlight by department the actions taken to transition CECS senior design courses to remote teaching and learning during the Spring 2020 semester, along with plans for Summer 2020 and the challenges that may be faced moving forward.

Civil, Environmental & Construction Engineering

CECE Spring 2020

- CECE senior design courses adapted to Zoom lectures and presentation formats using a variety of modes.
- There is concern over issues related to remote teaching including:
    - Instructor and student connectivity issues (wi-fi); dropped signals lowers overall educational quality
    - Unsupported equipment (microphone/camera) and inadequate broadband capacity causes issues
    - Webcourses class/Zoom limitations related to need for multiple guests access for outside peer review purposes
- Components of CECE design courses vary, but in some cases, require computer software, laboratory sample analysis, or treatment plant and environmental-related site tours.

CECE Summer 2020

- CEG 4801C Geotech Design. This class requires laboratory testing components. Dry labs could be employed, where the instructor performs the laboratory demonstration. One option is to send off the student's samples for testing; an estimate of cost would be required to see if samples can be sourced out to an outside laboratory.
- CGN 4808C Capstone Design. Software will be required; however, students can download student licenses for AutoCAD, Bentley and ICPR software online, to install on their personal computers. The Department continues to work on this need.
- CWR 4812C Water Resources Design. It appears that software will be required; students can download student licenses for ICPR software online, to install on their personal computers. The Department continues to work on this need.
- ENV 4433C Wastewater Design. The wastewater design course requires process modelling software "inCTRL"; the department does not need to host the license on the server as the software required has its own log-in network. Hence CECE will purchase a software licensure for their enrolled students (approximate cost of $1,000). IT is investigating adding this program to the UCF Apps. Environmental design courses require treatment plant site tours that may not be available during the summer; Virtual tours on tape may have to substitute. The Association of Environmental Engineers and Science Professors (AEESP) has posted on-line treatment plant tours from a number of sources and is available at https://aeesp.org/education/resources/course-materials. The AEESP has also been

providing daily updates on suggestions on-line related to Environmental Engineering related topic and lectures (and other information) on a variety of subjects: https://docs.google.com/spreadsheets/d/1oUTynT5QIx_uSlh2csOZ2GzCzTP5pyw4EAUzmilE_yg/edit#gid=0.

- Estimated costs for software and laboratory sample analysis: $2,500 to $5,000.

Computer Science

CS Senior Design I Spring 2020

- Status was largely normal
- Live Zoom lectures, Zoom TA check-ins, Webcourses quizzes
- Students were able to collaborate on design projects without physical presence using platforms such as Discord (see https://discordapp.com/)
- This was true even for interdisciplinary projects at this stage (i.e., no hardware required)
- Final Documentation will be PDF only (no hardcopies)

CS Senior Design I Summer 2020

- Plan to use Zoom as above for lectures and student status presentations
- Concern about project pitches in first week of class
    - Both getting enough Summer projects from industry & faculty during this time
    - Logistics of presenting those pitches to class (ideally will do via Zoom)
    - No interdisciplinary projects start in Summer, making it easier

CS Senior Design II Spring 2020

- Student in-class CDR presentations were already completed
- Students missed out on presenting at UCF STEM Day
- Faculty advisor (Heinrich/Leinecker) review of student demonstrations (3 weeks before end of classes) conducted via Zoom
    - Students successfully hosted meetings, presented, shared screen
- Difficulty with some interdisciplinary teams but not all
    - Some CS teams had the hardware in their possession and could integrate the CS portion
    - Others did not, but will show CS portion working in simulation and/or on a development prototype
- CS VR/AR teams were unable to use Barbara Ying VR lab and lost access to VR headsets
    - Students made the rapid transition to showing AR on the phone versus a Hololens
    - Some groups had their own AR/VR headsets and were unaffected
- Final Presentations and Demos were live over Zoom with faculty committee
    - Documentation turned in electronically (no hardcopies)
    - Zoom presentations can be recorded

CS Senior Design II Summer 2020

- Lectures live over Zoom
- Student in-class CDR presentations over Zoom
- No interdisciplinary projects finishing over Summer
- One team using Nintendo DS consoles but has HW in their possession
- Heinrich Demos (3 weeks before end) conducted via Zoom
    - Students will host meetings, present, share screen and demo as in Spring 2020
- Final Presentations and Demos will be live over Zoom w/ faculty committee
    - Documentation turned in electronically (no hardcopies)
    - Presentations will be recorded
    - Given the topics of the CS Summer SD2 teams there should be no issues in Summer

Electrical and Computer Engineering

ECE Senior Design I Spring 2020

- Lecture content completed before Spring Break
- 80% quiz content completed before Spring Break
- Remaining quiz content was completed after Spring Break using scheduled Zoom meetings for proctoring quizzes. Used online Webcourses quiz content
- Senior Design I 60 page draft document review used Zoom meetings
- Senior Design I 100 page draft document review used Webcourses email
- Senior Design I Final Document submission online using Webcourses
- Students able to collaborate on project design without physical presence
- Final Documentation will be PDF only, no printed copies

ECE Senior Design I Summer 2020

- Lecture content to be delivered synchronously (no recording) using Zoom/Skype
- Quizzes (6) to be scheduled and proctored using Zoom/Skype/Honorlock
- Senior Design I 60 page draft document review using Zoom/Skype meetings
- Senior Design I 100 page draft document review using Zoom/Skype meetings
- Senior Design I Final Document submission online using Webcourses
- Students able to collaborate on project design without physical presence
- Final Documentation will be PDF only, no printed copies

ECE Senior Design II Spring 2020

- Lecture content completed before Spring Break
- Critical Design Reviews (CDRs) completed before Spring Break

- Mid-term status demonstrations were prerecorded videos with scheduled Zoom meeting reviews
- Final Project Presentations consist of the following:
    - 22-25 minute prerecorded Powerpoint presentations
    - 8-12 minute prerecorded project demonstrations
    - 8 page Project Summary using a conference style paper format
    - 30 minute Zoom meeting with Instructor, Project Review Committee, and Project Group
- Senior Design II Final Document submission online using Webcourses
- Senior Design II Project Website developed remotely
- Final Documentation will be PDF only, no hardcopies

ECE Senior Design II Summer 2020

- Lecture content delivered synchronously using Zoom/Skype
- Critical Design Reviews (CDRs) conducted synchronously using Zoom/Skype
- Mid-term status demonstrations will be prerecorded videos with scheduled Zoom meeting reviews
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- Senior Design II Project Website developed remotely
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Industrial Engineering and Management Systems

- Senior Design in IE is single semester course offering.
- IE Senior Design is conducted in Fall and Spring (**not Summer**).
- Spring 2020 – 19 teams (all of them finished well this semester as expected).
- Followed the Spring 2020 syllabus with only minor modifications
    - Classes using Zoom
    - Showcase using Zoom for IEs (24 April 2020)

Materials Science and Engineering

- BS in Materials Science and Engineering is a new degree offering
- Senior design capstone course is currently under development

Mechanical and Aerospace Engineering

MAE Senior Design 1 & 2 Spring 2020

- Well defined syllabus, assignments and assessment rubrics previously implemented in Webcourses (2017-18)
- Transitioned lecture to video format ➔ https://www.youtube.com/watch?v=J9CeENeoc-I
- Student project teams meeting weekly with faculty advisors and stakeholders using video-conferencing apps (Zoom, Skype)
- All students make use of a variety of on-line team meeting apps for project management, communication and sharing of design documentation (e.g., Google Docs, Slack, Discord, etc.)
- Student project teams using video to demonstrate progress/status
- Purchasing of materials and supplies to use existing processes with delivery to student residences

MAE Senior Design 1 Summer 2020

- Projects to be scoped to minimize need for on-campus resources
- Open Issues:
    - Process for projects requiring use of campus facilities (i.e., machining, 3D printing, etc.) ➔ TBD
    - Working to set-up virtual access to lab computers for ANSYS and STAR-CCM using UCF APPS
    - Summer 2020 faculty advisor new hires
    - Potential impact of team size on video-conferencing

V. Interdisciplinary Design Program

- Prior to 3/15/2020 the following companies expressed interests and intentions to sponsor IDP projects for F20-S21: OUC, Siemens, Lockheed Martin, Correct Craft, ABB, Steelcase, ULA
- Aerojet Rocketdyne is a potential new sponsor for F20-S21
- Program Staffing Implications:
    - The Interdisciplinary Design Program currently supports a significant number of instructors (adjuncts, post docs, etc.) who serve as faculty advisors to senior design teams
    - An OPS UCF employee supported by IDP makes purchases for all IDP and MAE project teams
    - Plan to explore an integrated Webcourses implementation in Summer 2020

The pandemic and subsequent economic impacts will likely cause prospective Fall 20-Spring 21 sponsors to reconsider support for IDP.

VI. Distributed Learning Support Opportunities

1. CECS Virtual Labs Task Force is collecting demos, simulations, and interactive virtual labs that might be relevant to senior design. This list is now published on the iLab website: https://digitallearning.ucf.edu/ilab/remote-labs/
   The Center for Distributed Learning (CDL) can help coordinate the implementation of this software into Webcourses.
2. Zoom will continue to play an integral role in SD summer courses. Center for Distributed Learning has compiled resources specific to teaching with Zoom and encourages faculty to complete either Teaching with Lecture Capture – Zoom edition (TLC-Z) or Zoom Essentials.
3. Student Prepared Videos: Center for Distributed Learning can share resources to help improve the quality of student recordings and/or to assist with uploading student videos to Webcourses.
4. Distributed Learning is facilitating work with experts in IT to help set up virtual access to computers with specialized lab software (e.g., ANSYS, STAR-CCM, etc.) through UCF Apps.
5. Distributed Learning will assist with importing instructional materials from other universities (e.g., ASU) into Webcourses as needed.
6. Video project demonstrations:
   1. Tip sheet for recording faculty and student videos.
   2. Recording services if/when the campus restrictions are lifted.
   3. Support for video upload to UCF's Vimeo service and embed the videos into Webcourses so that they stream well for students.
7. Center for Distributed Learning has reached out to FL SUS Virtual Labs Task Force to see if anyone else is trying to solve similar challenges specifically in engineering courses and provided direct contacts to Task Force Chairs. CDL has also provided invitations to participate in the Florida Consortium of Metropolitan Research Universities' program to connect faculty by discipline.
8. Center for Distributed Learning is available to consult with individual faculty and offer specific support services based on individual course level needs.

VII. ASEE DEED Virtual Engineering Capstone Discussion

- Live Zoom discussion held on Thursday, April 9 hosted by ASEE Design in Engineering Education Division and Kern Family Foundation to share ideas for planning and managing virtual capstone classes.
- Discussion led by Beth DeBartolo (Rochester Institute of Technology), Jay Goldberg (Marquette University), Bob Rhoads (The Ohio State University), and Yannis Yortsos (University of Southern California).
- Over 149 capstone faculty from across the country participated in an hour long discussion.

A general observation from the ASEE DEED Virtual Engineering Capstone discussion is that UCF's initiative to embrace Distributed Learning has helped to position CECS Senior Design as a leader in the transition to remote instruction.

VIII. Summary and Conclusions

CECS Senior Design courses made a relatively smooth transition to remote teaching in Spring 2020. Faculty utilized a variety of digital platforms to facilitate the transition. For example, Zoom and YouTube was used for lectures and student presentations and project demonstrations. Webcourses was used for submission of project reports and design documentation. Lessons learned and actions taken in Spring 2020 will help to ease the transition for Summer 2020.

Looking forward to Summer 2020 and beyond, the senior design task force identified the following potential issues that require further investigation:

1. A perennial issue for engineering capstone instructors is finding relevant and engaging projects for students. The pandemic will only exacerbate this situation, since many projects are done in collaboration with stakeholders and sponsors, who define problems, volunteer their time, and in some cases provide funding for senior design projects. We depend upon on our stakeholders and sponsors to provide projects that appeal to student interests. These interests vary depending upon technology areas, sponsor reputation, project scope and the perceived importance of the project[1]. The extent to which the issue of insufficient stakeholder and sponsor defined projects becomes an issue will depend upon a variety of factors; many that are out of our control. Meanwhile, we will certainly continue to work with industry partners and alumni to identify meaningful senior design projects for our students. Possible alternatives to stakeholder/sponsor defined projects include "synthetic" projects defined by faculty and projects defined by professional organizations as national design competitions.

2. Capstone senior design courses play an important role in demonstrating student abilities to function effectively on a team. While we all may be able to recognize teamwork in senior design projects, when we see it, it is clear that engineering capstone faculty do not fully understand the teaching practices that support student success as it relates to teamwork[2,3]. At this point, it is difficult to predict the potential impacts (either positive or negative) of

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[1] Hart and Polk, *An Examination of the Factors that Influence Students' Capstone Choices*, Int'l Journal of Engineering Education, 2017

[2] J. J. Pembridge and M. C. Paretti, "*Characterizing Capstone Design Teaching: A Functional Taxonomy*," Journal of Engineering Education*,* Article vol. 108, no. 2, pp. 197-219, 2019

[3] M. Borrego, J. Karlin, L. D. McNair, and K. Beddoes, "Team Effectiveness Theory from Industrial and Organizational Psychology Applied to Engineering Student Project Teams: A Research Review," *Journal of Engineering Education,* vol. 102, no. 4, pp. 472-512, 2013

remote teaching and learning on assessment and facilitation of student teamwork in a capstone setting. This is an area that deserves further exploration.

3. Capstone instruction tends to be impromptu, hands-on and project-based, which may not always be conducive for remote instruction. CECS and MAE senior design courses often rely on industry adjuncts for clinical instruction and student team advisement, who share their real world professional experience with students. In some cases, the adjunct instructors we have engaged in the past may not be prepared to transition to remote instruction. With the transition to remote teaching and learning, we may need to identify new approaches for providing clinical experience to our students. Both CECE and MAE have expressed concerns about staffing, both for Summer 2020 and, should the "stay at home" directive continue, into Fall 2020 and beyond.

4. In the past, access to computers, software and the internet has been readily available to all students on campus. We will need to consider the individual capabilities of each student to connect to computer resources as we move forward. For the case of advanced engineering software applications (e.g., ICPR, ANSYS,STAR-CCM), there will likely be additional costs associated with providing remote software access.