Panel 5C: Different Course Structures in Capstone

Facilitator: Sarah Oman (Oregon State)

Panelists: Emily Larsen (Washington State), Kannathal Natarajan (Rensselaer), Micah Lande (South Dakota Mines)

Description: There are as many ways to organize Capstone courses as there are institutions that offer Capstone. Compare notes with our panelists and come away with new ideas.

Prepared Questions for Panelists:

- Describe the structure of your capstone course(s). Is it one semester? Two semesters? A series of linked courses? What is the basic outline of your capstone experience? Walk us through.
- Have you had to make any changes to your course structure? What drove those changes? What was the result?
- What are the biggest benefits and drawbacks of your current course structure? Think about staffing, funding, student issues, sponsors, or anything else that stands out.
- What, if anything, would you change about your course structure?

Panelist Introductions:

- Emily Larsen
  - Scholarly Assistant Professor, School of Mechanical/Materials Engineering, WSU
  - Role in Capstone: Gathers industry projects and teaches the mechanical engineering capstone course at WSU.
- Kanna Natarajan
  - Sr. Project Advisor, RPI
  - Role in Capstone: Ran capstone in New York and previously in Singapore, multidisciplinary programs
- Micah Lande
  - Assistant Professor and E.R. Stensaas Chair for Engineering Education, Department of Mechanical Engineering at South Dakota Mines.
  - Role in Capstone: Regularly coaches capstone design teams and researches design education and prototyping.

Q: Describe the structure of your capstone course(s). Is it one semester? Two semesters? A series of linked courses? What is the basic outline of your capstone experience? Walk us through.

- Kanna: One-semester program
- Emily: Two-semester program - separate courses
- Micah: Has a design spine throughout the curriculum. Two-semester Capstone program. Excited to learn. He misses the quarter system. No one is around to pick up projects and move them to the final

stage.

- Sarah: Two terms but other folks at Oregon State do three terms. [Each term is 10 weeks]
- Kanna: There is a prerequisite course - Intro to Engineering Design. Refresher at the beginning of senior capstone. 6 months. Each team will have 2-3 disciplines. They start with planning before getting into the technical stuff.
- Emily: Two-course sequence. How do you find a minimum-viable product? Several design cycles. One is done every year - a cardboard prototype. During the second term, they hit the ground running with an industry project.
- Micah: Two-semester senior capstone. Semester 1 learn how to fabricate, the design process. They use non-profits and such. This happens Junior year. In the fall semester, they have milestones to hit, and the second semester has less structure. Less didactic instruction in Capstone.

Q: Is capstone a required class?

- Yes for the most part. Required for ABET.
- Sarah: Also required at Oregon State. ABET requirements, BaccCore requirements, and Writing Intensive Course requirements all dictate portions of the structure. Sarah is a fan of transparency - the whole class structure in the LMS one week before class starts. Begin with structure but there is flexibility. It has bitten her in the behind a couple of times, but as long as students communicate it is ok.

Q: Does anyone do anything different?

- Michigan Tech guy: Enterprise program is a multidisciplinary alternative to capstone. They pick this instead of their department's capstone. Can join as 2nd-semester students. Work on industrial projects for at least 4 semesters. They go through an approval process for the final project. This is unique because it is multi-year and has all 5 colleges in it. It is completely optional but they have over 950 students in the program. 26 different 'enterprise teams' which can be computational-based or prototype-based. The other unique thing is that there are 80 students in Aerospace. They have an e-board for the team and advisors. Most of the day-to-day decisions are made by an elected e-board such as sponsor communication, budget, first line for solving conflict, mentoring for younger students, etc. We get inputs from sponsors, faculty, and industry folks for assessment. This is useful for satisfying ABET (5 of 7 SOs)
- Micah: We have competition teams that have projects, but we have to work on parts of things to fit into the capstone structure.
- Mike Kensinger from Smith: A handful of students do an individual project for or like an honors thesis. We encourage students to have design as a part of it. These are students who want research experience prior to grad school. It still fulfills ABET - they do the teamwork SO in different courses. When he works with students he follows a structure but not all faculty members do that. Structure varies between advisors. For students who need the structure, this can be a problem.

Q: Have you had to make any changes to your course structure? What drove those changes? What was the result? (When we have control)

- Kanna: We don't have control over credits and such. We can change how we make sure students achieve learning objectives. Every year there is a changing mix of student abilities. The way we

assess things changes every year. We ask them to refresh things. They can't choose the project - we need to get them interested in the project and in the outcomes. Projects may run for multiple semesters so they need to catch up on what the previous group did. This is closer to a real-world scenario. You were hired to do this project for 6 months. You need to document it so that the next group can pick it up.

- Emily: Industry in second semester. Historically there is no structure in the second semester. She started co-teaching and found that people weren't making progress. Decided to try Agile. Taught Agile while forming teams and assigning projects. It worked really well. Teams were reliably providing output every two weeks so the sponsor could see the progress. The projects came out much better.
- Sarah: Make changes every term and every AY. Use the students as change guinea pigs (just don't tell them that explicitly). Many changes are trials of things learned at previous CDC, and other changes based on student exit surveys each year. Tell the students that the course is structured based on what their past peers have said works, doesn't work (they appreciate knowing that - knowing that they can directly influence change for the better in the immediate future). I made the mistake of trying to make all the changes at once - do not recommend it. Make incremental changes. She does exit surveys every year. The course is structured based on past feedback from students. They really like that
    - Some changes work great!
    - Others fail miserably and aren't used again. But failure produces information
- Micah: Some of the motivation was similar - students not getting far enough. Used to be a critical design review in Jan/February. Now we do it in December. Trying to get students to think about what their critical function is, think about fabrication earlier. Seems to be more satisfying for instructors. The second semester is still rather freeform.
- Bridget: One change we made was reducing the number of reports. There used to be three total and they took a lot of time to grade and write. It reduced stress on the faculty and the students. We have shorter progress reports and pitches during the term.
- Kanna: We also reduced the number of reports. We'd like to use some Agile in the future - we are still in the process.
- Micah: Because of COVID we did more Zoom meetings. A lot easier to connect with people outside of rural South Dakota that way.
- We used to have two design reviews but they didn't do much between. We had to add 15-minute standup meetings at the group's desk. Can you justify why you are doing that? What is your strategy? This was in the first semester. More structure at the beginning of the class, and then back off.
- We have 15 teams, 6 people per team, 2 semesters. They did a show and tell a week or two right before the Expo. Half of the students demonstrated, then the other one so they could practice and get more feedback before the final presentation.
- Bridget: We do something similar, and they love it. We call it prototype show-off day. They use that time to vote for a student choice award.
- Sarah: Eli has an Inclusive Teamwork award that students have to nominate other students for (great motivation award for team building and championing). Nomination after show and tell to be delivered at the Expo

Q: What are the biggest benefits and drawbacks with your current course structure? Think about staffing, funding, student issues, sponsors, or anything else that stands out.

- Kanna: We think we prepared them to go out to work. They learn how to pass projects from one group to another when they're done. They can pull in the required different disciplines. They learn documentation, project management, interacting with a client, getting feedback from them, etc. Students may feel stressed, but they appreciate it later. They use the experience when they graduate.
- Emily: The biggest benefit is the type of projects - real projects that matter. 25K per project - something the sponsor actually wants. We avoid open-ended projects. We want them to have the ability to finish something. We have enough funding to get them to explore and experiment. We still get immature students who need to learn client interactions
- Micah: They get to dive deeply into their projects. They think about things more. It's satisfying and they have something tangible to show for it at the end. They start to roll their eyes about teamwork but they benefit from it. One of the problems is mapping the right mentor to the project. They need guidance to sort their ideas. The funding is different from one project to another. Depends on the sponsor. This can drive problem-solving.
- As people said, we can't change the semesters or credits. But we can change how we teach it, what sort of lectures we provide, what assessments we use and how we grade them, how many assignments, when they are due, and so on.
- Some disciplines have many iterative prototypes. Civil engineering, for example, doesn't do that. They have a progression rather than an iteration. Agile won't necessarily work with these non-prototype projects. Possibly provide multiple ways to organize or manage the process.
- Micah: It is interesting to see teams working in parallel to benchmark off each other. Some students rise to the occasion if you give them a good start.

Q: What, if anything, would you change about your course structure?

- After this conference - Everything!
- Kanna: We ask students what they want to work on. It can be hard to motivate them. We don't let them change along the way. If we could find a way for them to choose the project that would be good. We do feel that because of the short timelines they should be working on the deliverables rather than refining the project. Want them to work on the project for the project's sake.
- Micah: There are lots of things I am taking away from CDC. It would be good to broaden the types of mentors that we connect to students. What would be the slate of advisory boards for different projects? Relying on students who have already taken capstone might be more effective. Wants them to listen less to the instructor and go based on their gut or instincts. They need to be able to communicate with vendors to build what they can't. This could make them more complete.
- Emily: A big change was shifting to Agile. For design reviews: Do in smaller groups giving each other feedback. Eliminate busy work and grade on final deliverables.
- Micah: I've done competency-based grading in earlier classes. Exploring the concept of upgrading. How do we know they learned something? They build something they didn't know how to build before. Dial back on overhead for the instructor. Genuine and authentic work on their project.
- Emily: One terrible thing: It was obvious this team wasn't going to get an A. If you're not grading, you still need to give them a warning so they are not surprised with a C at the end of the course. Still need

transparency so they are not being blindsided. Even they realized it.
- Reports hold them accountable and make them document their work.
- Sarah: I'm not grading them on tech writing, I just need them to document their design and design changes. They are welcome to use earlier things and build on them.
- Kanna: One final report at the end. But they have their project management tool and monitor their activities and issues along the way so the documentation is there. This helps for the next group to take over as well. We encourage them to update their reports.
- Emily: If there are no assignments to do, how do they know if they are on track? Agile helps with that - they need to produce a deliverable at the end of each sprint. Sprint deliverables are being shared with customers for feedback. The involved customer saves her from grading.
- Micah: It would be good if they could stitch together their progress reports. Think about adding things to progress reports (defect analyses, etc) that will help their final report.
- Sarah: I need to change the mentorship scheme. Overlapping cohorts. During winter we had 22 teams finishing, 28 teams starting, and one TA for each. TAs could be mentors or Sarah, still faculty mentors, sponsors, etc. Can't manage the mental load. She has the time, not the mental capacity. She tried rapid-fire 5-minute check-ins. Asks what they did last week, what they are going to do next week, etc. She checked in with every team every week this way. Requires visual evidence. She doesn't have a solution. Biweekly meetings mean they do nothing one week, and everything the next week.

Q: Has anyone else tried requiring weekly journals?
- Template in Google Docs. Not graded, but can influence grades. The purpose is to prepare your advisor so that the meeting with them is productive. Why, what, what next? Some don't care, period, and there is nothing we can do. Some care a lot so we hope it rubs off on the others. Tell them it's not for the advisor, it's for the students. Focus on more than just the grades. Weekly activity reports.
- Kanna: They have to report what they are doing and upload some sort of proof. Not a very formal structure but they need to say what they are working on every week. We look at them and give feedback - you're on the right track, you are not.
- One person meets with teams for 45 minutes each week. Executive summaries prompted/guided. The first semester we didn't meet as regularly. Used to have weekly memos. He's gone to biweekly meetings. Good to assess whether they are making progress or not.
- Another person meets for 30 minutes every other week. Discussion posts in Canvas within the team, and has to write before they can see the other posts. If someone is writing things they haven't done, the others respond. This has helped without adding more work.
- Devil's advocate: How we facilitate the feedback loop is worth thinking about. Results from the 2-week sprint go to the sponsor. One of our partners is trying to help us make this easier to document. (Jordan Levy from Capsource) Some real inefficiencies if you don't use a PM tool - but there can be info gaps. What info are you collecting, how do you categorize and analyze work, etc? Can compare teams to each other and see who is behind. Or who is way far ahead and skipped some of the research? Key info on what is being worked on and when. Capsource is rolling these new features out this year.

Q: How do students communicate with their sponsors?

- Emily: They meet with the sponsor every week.

Q: How do we think about using industry-integrated learning elsewhere in the curriculum? Case studies, etc.

- Ultimately it can help them learn what they want to focus on or pivot to.

Closing: Want to see what others have been doing in capstone in their courses?

- Susannah Howe, et.al. do a ten-year survey of capstone programs and then publish the results. The 2015 and 2005 papers (plus others from related and earlier surveys) are available on the Capstone Design Community site (see Capstone Surveys). Watch for a survey next year for the 2025 version.