Capstone Design
CONFERENCE 2024
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Panel 2C: Multidisciplinary Capstone

Facilitator: Jay Goldberg (Marquette)

Panelists: Megan Conrad (University of Detroit Mercy), Matthew Turner (Purdue), Kristina Kennedy (Ohio State)

Description: Capstone courses can get complicated when multiple disciplines come together, but multidisciplinary teams enable students to take on more complex and real-world projects. Come learn how others manage this challenge.

Q: Course background and how connected?

- Kristina - Ohio State; Honda R&D, Integrated business and engineering capstone, part of a 4-year educational track (each are earning their major and a minor in the discipline)
- Megan - Detroit Mercy; biomedical focused projects, engineers (primarily mechanical), med college, participate in at least 1 semester for the minor and bring in some electrical or biology students
- Matthew - Purdue; one department with multiple majors (ME, Manufacturing, Industrial), 2 semester sequence required circa 600 students per year for over 12 years
- Jay - Marquette; 24 years multidisciplinary, co-taught by himself (biomed), and electrical and mechanical professors; 4 years of business students involved from information technology program; champion from business school retired (need champion!), also combined with industrial design students for about 8 weeks due to Junior level ID students and curriculum structure (quarterly structure)

Q: Do you share projects and lectures?

- Kristina - yes, business and engineering students in class together; work on teams as a group and all lecture content covered by both. Some non-IBE students can join if any openings who require capstone course for degree.
- Megan - Engineers and nurses; important to have champion in other department. Nursing scheduled in different course number to meet curriculum. “Everyone’s voice is important.”
- Matt - All students attend same lectures (mechanical, electrical, computer); important to prepare students for real world work to understand as part of a team. Make sure all students are exposed to the materials. Projects scoped heavily in advance with sponsors to make sure not an imbalance in work to be done between disciplines (i.e., no IETs on a specific project if no process involved).

Q: What value do you see in this approach?

- Matt - Eye opening for the students - recognize if work in industry there are outside of discipline requirements needed (wear different hats). Discipline specific languages - how do you communicate to others who may be a 3D communicator bs mathematical – helps them practice different forms of communication. Easier to sell to customers when bidding projects out - industry knows no project can be completed by a single discipline.

- Megan - More robust design and different perspectives bring value; simple observations could make a different (i.e., engineering project observation by nursing student that design would rub and create ulcer)
- Kristina - Diversity of thought; don't know what blinders could be. Many aim to go into consulting world and can talk to these things in interviews. Sense of appreciation to other disciplines and "why" to understand the ROI or consumer need of a project vs technical design that goes into something.
- Matt - had to do quality control process electrical would have been overly complicated with driver, etc. and mechanical just added blowoff valve to sort out non-conformance
- Jay - Shared industrial design students vs engineers design for a specific device and students could tell which drawings were done by whom showing diversity of thought and process between the two disciplines

Q: Have you identified technical skills outside of engineering discipline that came through in these projects?

- Megan - Nursing students working with individual clients and meeting them; some engineering students find this scary whereas the nurses guide initial interaction. Throughout the semester see engineers picking up skills from nursing students and still have relationships they've built. End of year walking by nursing students in the machine shop working next to the engineers. A lot of skills cross.
- Kristina - Building out business case so pieces embedded in lecture (ROI, 5 year financial models, identifying supply chain implications, data analytics) they are bringing to table

Q: Disadvantages or challenges?

- Matt - Difficult for semester plan in syllabus that may allow them to contribute unequally as the capstone project goes; some give project requirements at beginning where Purdue has more exploratory process to define requirements. Peaking and valleying throughout semester where certain disciplines may contribute more to one area than another (i.e., gantt charting for IEs, technical modeling for MEs, etc.)
- Kristina - Project scoping including technical components can be a challenge; share past client scopes with new to get a feel for what type of project can be successful. Technical depth also a challenge (i.e., all ME team may go deeper in a specific design)
- Megan - If one nurse disappears when a team is not comfortable interacting (since 2 nursing vs 4-5 engineering strategies) may shuffle resources from another team to support patient background and indications for the lead role.
- Jay - Bioelectronics, mechanics, computers – some students raise "we can't do that" for an electrical component design; multidisciplinary team could let them off the hook or use as an excuse not to learn it. Human factors in design lecture - turned several students off because of title. Tell speakers to not focus on one specific discipline vs just one area and tie to other students
- Audience - Virginia Tech - recruiting students from other departments tricky because not required, ABET documentation required to be provided to each department is very tricky

Q: Specific instruction design for specific disciplines?

- Megan - project planning have mapped out responsibilities for semester including leads for specific areas; they can distribute work for roles
- Matt - do role mapping exercise with students at beginning of semester
- Kristina - propose professional development they may need to support the project. Example - sending students to real estate strategy conference to support project

Q: How do we prepare students from social / interpersonal dynamics perspective? (Audience - evolution of teams, interpersonal dynamics may present higher challenge based on diversity of teams)

- Megan - if you have a team with more experiences they bring more and better solutions; focus a lot on first meeting with the client

Q: Key considerations in team formation?

- Matt - Semiconductor company sponsor project try to find projects that aren't uni-disciplinary. Need to have enough technical meat for each discipline involved. More faculty needing to be engaged. Getting student blend right once do have project – never like to have one discipline on a project but not always feasible. Getting student expertise diversity right is more of an art than a science.
- Megan - Try to double up diversity as much as you can; put one female on every team at first and then the one person became spokesperson / scribe; skillsets maybe only have 1 EE on a team but have them fill out comfort on a variety of skills to fit them into groups already formed; think less on the individuals and more on the balance between programming, communication, writing, etc.
- Kristina - Input from client important (ME, CSE, finance - advertise first day of class and ask "tell me why you would qualify" if they had an internship, etc. to fill that need). Underrepresented students - make sure do 1:1 check ins throughout semester to make sure going well, voice is heard to make sure they are getting what they need.
- Jay - Computer E signs up for Bio Med E area to get more experience, need to make sure there is enough they can do in the short term that they have the opportunity to get experience but not be under water if content domain changes

Q: What if scope changes (discipline is no longer applicable)?

- Matt - don't allow scope to change; customer signed up for something at the beginning and turn back to the contract. Sometimes dissolve projects in Capstone 1 if not going the direction it needs to go if customer changes their minds.
- Kristina - throughout student research find a different solution (app example) reframed what the project looked like (negotiated with sponsor to not provide a prototype of the app but a design would be provided). Work with other faculty if a pivot is needed.
- Megan - sometimes had to reach out to other resources in department or students teach themselves if a skills gap exists
- Jay - end of the first semester can fire a team member and add them to another project team; they are allowed to advertise for new students to leave team / new students who take a break for internship and "rehire" back onto a team. Firing policy: issue then teams talk to each other, talk to faculty advisor, talk with course coordinator. Not doing their share of the work so some. Over 200 projects, only invoked rule 3-4 times.
- Megan - having the policy there for someone who is underperforming made them figure out as a team how they would get the person to contribute more (provides precedence for actions and weigh options)

Q: How do you divide the work so everyone's doing their fair share?

- Megan - everyone's responsible for everything; some of the client background is led by nurses but it is the expectation that everyone is accountable for the outcome
- Kristina - students self select into roles they are in (head finance, head of AI, head of Tech, etc.). Learn the most when they pick a role they are less familiar with

Q: Any special requirements when working with specific client projects and scope changes? Do you use one process over the other?

- Megan - clients move or leave or go to hospital; changing scope of project. Early on take client input and then need to move forward at certain point and have less flexibility. Don't tell the students what the problem is they are going to solve, just introduce to the client. First few weeks go to client's home multiple times per week in the first two weeks where lots of different ideas come in where they identify several opportunities – they need to choose one to proceed with.
- Kristina - don't formally use one of the other. Blend of stage gate and agile method where bringing something to client every week and go-no-go every semester.

Q: Interdisciplinary with the business makes a lot of sense - when are they introduced to engineering economics?

- Kristina - 2nd semester cornerstone class introduces topic and curriculum builds from there around sophomore / junior with official course. Have business minor so will have to take these types of courses.

Q: Industry sponsors are also clients; what feedback are you getting from them?

- Matt - lots of repeat customers, huge vehicle for job hunting. Put a lot of students in jobs and a lot of positive feedback. Students may not be as positive; can be frustrating and can be even more chaotic by throwing in additional disciplines.
- Megan - general positive; goal is to take home a product at the end of the semester – sometimes is not released if unsafe or if it is not completed. Feedback saying how much they saw the students grow. Mechanical doing assistive technologies program and they were not choosing automotive project and sharing experiences to future students.
- Kristina - some sponsors would like to have multiple projects; good level of alumni engagement to share how it impacted them
- Jay - Industry Advisory Board confirm that is the approach they want to take; industry experience pulling together finance, marketing, etc. can be challenging to replicate in an academic environment but really all still engineers

Q: How to navigate when they are enthusiastic and which program to pursue?

- Megan - saw less people were enrolling in course and phased out with changing student interest; would open up more automotive courses if there was interest. Funded through the automotive industry as part of university relations; clients don't pay for the projects. Invite them to be involved in the design reviews and give feedback – if they have a project related, they will merge.
- Kristina - asking rising seniors what their dream students post capstone; following up with company to get a project scope and capstone client.

- Matt - students should have some voice or choice in project; use a bidding process vs a lottery; very heavily utilize presentation with department head / sponsors – everyone demonstrates capstones and everyone had pride standing in front of a project and have their name tied to it
- Jay - have them pick their top 8 choices and typically get their top 2 to show their interest in it. Need a minimum of 3 people and if don't have interest they push to following year

Q: Think about multidisciplinary capstone, from a teaching perspective, is there something around co-teaching the course (transdisciplinary)

- Matt - hire professional engineers to help facilitate; continuing lecturers from different areas to coordinating
- Kristina - undergrad in engineering and MBA so pull from both fields

Q: How to start and coordinate?

- Bob founded at Ohio State - started with mechanical and industrial students so very small (2-3 projects with 6-10 students), then create for whole college – multidisciplinary is an option not a requirement. Start small, when go to different departments get their approval to recruit their students. Worked with department chairs over all 14 departments and got them all to support. Build base to get students interested and get department buy-in. It takes time (15 yrs to get 11/14 majors approved).
- Jay - create proposal and do an experimental course
- Get professor colleagues on your side and Dean of the college support

Q: How do you assign faculty mentors?

- Matt - 1 mentor per team; best for the team but still struggle to find support with assignments on who is available to do the work and who is the best fit. Quality faculty mentorship is one of the hardest things to handle after securing projects.
- Kristina - bringing in grad students for co-pi to count toward teaching requirement
- Audience - RPI has engineer and faculty member and may not know the problem but they know the questions to ask, students job to learn.
- Jay - faculty role is to advise (not design) and to guide them to the right resources and do some of the grading
- Audience - Michigan elective multidisciplinary capstone, relationships with partners to get substitutions for many areas to engage more students in this course

Q: ABET?

- Jay - never had an issue about mechanical doing biomed project
- Kristina - highest quality projects in reviewing capstone with ABET last year
- Audience - S03 meet requirement but filter out students in examples provided
- Megan - still have to take electrical capstone on top of the multidisciplinary for EEs; reporting is difficult (have to slice different ways for different areas)
- Audience- University of Georgia - capstone showcase projects that are multidisciplinary achieve higher ABET scores

Q: Advice for other instructors?

- Matt - Keep it simple, if projects are too technically complicated they can be overwhelming
- Megan - Don't be afraid to jump in; try out with a simple project and see where they take things
- Kristina - Be willing to brag about the outcomes to your university leadership (students / sponsors)

Audience Poll: List your name below if you currently have a multidisciplinary capstone:

- Bob Rhoads, Ohio State University: Multidisciplinary Capstone - all engineering and non-engineering students in one class (Rhoads.2@osu.edu)
- Robin Ott, Virginia Tech, Interdisciplinary Capstone (rso@vt.edu)
- Hrushi Godbole, Rochester Institute of Technology, Biomedical, Computer, Electrical, Industrial & Systems, and Mechanical Engineering. (Contact: Beth DeBartolo, eademe@rit.edu)
- John Greeven, Oregon State University (greevenj@oregonstate.edu)
- Todd Polk - UT Dallas - Biomed and Mechanical disciplines in a single class
- Landon Holbrook - Milligan University, Mechanical and Electrical Engineering (LTHolbrook@milligan.edu)
- Allyson Gibson - Brigham Young University, ME, ECEn, Mfg, Cybersecurity (allyson_gibson@byu.edu)
- Jenn Carlson - University of Michigan MDP (jjcarl@umich.edu)
- Shayne McConomy - FAMU/FSU (smcconomy@eng.famu.fsu.edu)
- Marie Paretti - Virginia Tech (mparetti@vt.edu) - ME, ECE, ISE, CS, MSE
- Jessica P.M. Fick - UW-Platteville - ME, IE, Sustainability, and EE in a shared lecture, projects are mentored by a team of faculty (meulbroj@uwplatt.edu)