Capstone Design CONFERENCE 2022
JUNE 6–8, 2022 ▸ DALLAS, TEXAS

Panel 5B Multi or Interdisciplinary capstone

Facilitator: Sarah Brownell – Rochester Institute of Technology

Panelists:
1. Noe Vargas-Hernandez – University of Texas Rio Grande Valley
2. Cassie Bowman – Arizona State University
3. Dean Nieusma – Colorado School of Mines

Description: Real world problems often involve multiple disciplines to solve but managing logistics, expectations, and requirements can be difficult. Panelists will share examples of their own multi- or interdisciplinary programs and how they overcome the challenges associated with these programs.

Bios:

Dr. Vargas Hernandez is an Assistant Professor in Mechanical Engineering at UTexas Rio Grande Valley with expertise on product innovation and entrepreneurship, design thinking, sustainable design, biomedical design, and design education. He has ample experience teaching design and innovation to student teams currently at UTRGV, and previously at UT El Paso and Carnegie Mellon University. He is currently leading an effort to promote Innovation and Entrepreneurship at the departmental and College levels at UTRGV and collaborating with the College of Business. Dr. Vargas has various patents, and over 20 years of expertise and leadership in engineering design, creativity, and innovation.

Dean Nieusma is Department Head of Engineering, Design, and Society (EDS) at the Colorado School of Mines. EDS is a broadly interdisciplinary academic department, with expertise in engineering, design, and the social sciences. Dean's education includes engineering and social sciences, and he has years' experience teaching in and administering interdisciplinary design programs at the intersection of engineering, creative design, and social sciences.

Cassie Bowman is an Associate Research Professor in the School of Earth and Space Exploration at Arizona State University. She is a Co-Investigator on the NASA Psyche Mission, leading the Student Collaborations program, including Psyche Capstone. To date, the Psyche Student Collaborations program has worked with more than 1200 undergraduate students from around the U.S., including more than 1,000 senior design and capstone students at 15 universities since 2017.

Capstone Design CONFERENCE 2022

JUNE 6–8, 2022 ▸ DALLAS, TEXAS

Panel 5B Multi or Interdisciplinary capstone

Notes:

Q: How do you feel student (or faculty) experiences are enriched by participating in a multidisciplinary project?

Noe: It was a revelation, coming from traditional engineering education background. I keep learning "there is more, there is more." It is important to teach the context, sustainability, economics, but need to balance that need with various constituents…they want new stuff but also hardcore engineering results. But in reality it is all "one product." Nobody owns design. Mech Eng is only one point of view. ME is important but not the only one. You can be a better ME if you understand these points of view.

Dean: We all understand real world problems are not disciplinary. Capstone serves as a traditional transition to career. But it is still a course, it is our responsibility. Students don't understand yet what their discipline does, so it is hard for them to see what others do. We need structures to show them what it means to be part of a disciplinary.

(Audience additions)

The world of game design is agile. Engineering students are waterfall. So seeing these two worlds fight was bewildering.

I transferred from industry to engineering, and first added Project Management to (the capstone program) then moved to making it interdisciplinary. From a student's perspective, the impact is significant. Students are happy for experience, but there are challenges from the instructor perspective. Academic structures get in the way. The systems they design are more complex and more exciting.

ME students struggle with circuits and mechatronics, Arduino. Should you increase these topics in the curriculum or do you bring in other disciplines to work on these parts of the project. Many students got into ME to do hands on and build products, but then realize that they don't actually do it. Industrial Design and ME working together can sober both parties.

Dean: I was comfortable with working with all kinds of students and both Undergrad and Grad, but the learning journey forced me to collaborate with others who are open in principle but don't have industry experience, who are so steeped in disciplinary thinking. They WANT to be good

partners, but are so deep in their discipline and they report to peers who are already questioning the value of design.

(Audience)

There is an on-going struggle. In project vetting—they argue that the project does not have "enough" ME.

Dave Schwartz: Interdisciplinary game design has included civil engineering, library science, but we need work with other departments. The game world has become arrogant…we think we know what we are doing. We are naturally aligned with Comp sci. We need game faculty to show up to these kinds of conferences.

What challenges has your program faced (classroom, organizationally), and how have you managed that challenge?

Cassie: When we started at ASU, there was no central body to coordinate. A student employee scraped the course list to find all the capstones in order to create a community. At the faculty level, there is willingness to try. But if you go higher, people are concerned about ABET, course structure. Multidisciplinary Capstone was too much at ASU, so now we put together teams in a less formal way.

How many of you are the single point failure for multidisciplinary capstone at your institution?

Q: How does ABET impact this?

Cassie: Internalization of stress of ABET is a factor (not necessarily what ABET thinks).

Joe: We work as folks who are desperate to find projects. We needed to invent multidisciplinary projects to accommodate projects.. We have sponsors who want a children's museum on campus—we need design, dance, art, etc. to create a children's museum. The sponsors mainly want to know "what did you spend the money on" to get their write off, cost is not as much a concern.. 100 projects a year are needed, trying to find sponsors. We are asking: Is there a way to join forces? Can I use your sponsorship. It seems natural to find a way to share projects among faculty – fewer sponsors, maximum number of projects. But there is a need for staff person at higher level, at provost level, to make it happen.

Panel 5B Multi or Interdisciplinary capstone

Dean: I agree ABET structurally provides flexibility. But it depends who is on the review panel…so there is risk aversion among the administration to being too experimental.

Jill: Our capstone is run out of individual departments. So who's class do they sign up for, whose assignments do they do, who grades it? We are working on a committee to make "best practices" but can't say "this is how you do it" to the different departments. Our discussion on common learning outcomes went nowhere because of ABET. Now we are taking a step down to best practices of how one can make it happen. Our sponsors called mid project stream asking for all projects to be multidisciplinary projects. Need to educate sponsors also on what is needed for each discipline. Maybe there is a ME piece but not enough for a capstone. Can you just have one person from a discipline on a team to represent their discipline? Should there also be 2.

Joe: Canvas can be used for uploading specific assignments, every class has their own canvas.

Patty: Students see different assignments as unfair. Sharing workload, depending on the number of students on the team, can also be unfair. Need to make everyone do the same workload.

Dean: We have one course, common for all majors, but outside of our department different majors have different courses, or students jump to the course to join a multidisciplinary team.

Audience: We tried to do multidisciplinary at the college level, but got a lot of pushback on workload and structure. Theory—if you have more multidisciplinary projects and more students doing it, there will be a bigger need for the solution. Teams need to come before the structure.

Jill: Sponsors suggest staffing numbers, but faculty review it.

Scott: Academic structures get in the way of a unified team. If they are separate structures, the students work separately, not for a unified integrated project. (But it is a learning moment for the students). Other things matter like how faculty are given credit – is it volunteer or required? Funding is also an issue—travel funding covered by one discipline but not the other. But in industry teams everyone would go together.

On student complaints: workload, fairness, should not remain just in their discipline.

Capstone Design CONFERENCE 2022

JUNE 6–8, 2022 ▸ DALLAS, TEXAS

Panel 5B Multi or Interdisciplinary capstone

Bridget: Set expectations. Tell them in the beginning that they need to learn from the other disciplines. Make it explicit in the beginning.

Noe: Mechanical Engineers are a special case. They know a bit of everything, but they don't understand their limits.

Who is collaborating out of engineering.

Bridget: App design, Arts Media and Design.

Scott: Water bottle filling station. Arts + Design did graphics and colors. Business students do business plans but do not integrate with the rest of the team.

Marquette: ID students from another institution work with engineers at Marquette. They learn about one another's disciplines.

Noe: Harder to work with other engineering disciplines vs. working with business. Biz and engineering work closely and influence each other and have gone to competitions. Depts and colleges are territorial by tradition.

David: They say, "Share more to do more," but that makes departments paranoid – They think "He's trying to get something from us."

Noe: If you have dedicated staff then you are really ahead. I am a one person show, no staff. Inspired by what you are doing.

Audience: Product-side projects from industry already have customer discovery and market research done, so there is not too much for business students to do.

Noe: We are very selective. The project needs to have space for students to learn skills. We mostly use internal projects rather than industry. Proposing a business model is one thing, but companies are not interested in I-corp or other innovation experiences. In engineering, the mindset is, if you pivot you fail. But in entrepreneurship, the projects change a lot. In engineering we are so stiff.

Q: Is there specific structure to help the students break disciplinary silos.

Capstone Design CONFERENCE 2022
JUNE 6–8, 2022 ▸ DALLAS, TEXAS

Panel 5B Multi or Interdisciplinary capstone

Dean: How not to recreate disciplinary silos in the teams: Have same course for everyone and use two other mechanisms. 1. Every project has a specific representative and 2. provide structure to develop the relationship—communication. We use a faculty lead who is from industry. The person doing the grading is not embedded in the disciplinary structure. Many projects are external, but some are internal.

Noe: Science of team science. They need to have a common language, a rosetta stone. Both engineers and business care about value proposition and customer segments.

Cassie: Even working with an adjacent discipline it is more work for students and more pain, but in the end they appreciate it. They realize they are explaining things in ways that only work for their discipline.

Noe: "Design the spine" approach. If you write it in the syllabus, it helps. Other places have multidisciplinary projects but lack integration.

Audience: We don't have Multidiscip. As professors, why do we want to do it? Because we think the students need it? Because we think industry wants it? Our all ME projects get "amazing results."

Cassie: What is amazing about the results? Is it just the prototype? Isn't it also an amazing result to get them to learn from working with other disciplines?

Dean: There is one more stakeholder: Donors – donors want this. Foundations, alumni, corporate sponsors love this.

Scott: In our experience, project quality was actually higher with multidisciplinary teams. The sophistication level went way up. It gives ME time to work more on ME side. They also get increased satisfaction out of working on a team. We see this in our car competitions.

Audience: A group of engineers in still not multidisciplinary. True Multidisciplinary is marketing, finance, engineers, design, etc. Having business is a good first step. Students get value out of appreciating different viewpoints.

Noe: What is the future? The Battle of the Brains competition requires multidisciplinary support. In a few years maybe this is coming? We might have both multidisciplinary and

traditional ME project options. We need different kinds of engineers – researchers, designers, policy, ect.

Dean: We sometimes still get projects that are all ME. I like idea of different flavors of engineering. Our program itself is multidisciplinary but it can have some projects that are not.

Audience: Is there some value to playing the sandbox but building different castles? Doing separate things together is valuable.

Noe: Some people fear that students will be taken away from engineering. But that is good if they realize they want to be in a different department. Other voices say they should focus only on ME.

Audience: A challenge: How to include students with accommodations to give the broadest experience in capstone as possible.

You can have faculty members mentor teams or students help other teams. You can bring in other expertise.

Jill: I agree with including other disciplines, but because capstone has such a strong tie to ABET it is hard to do it at scale.

Audience: Structures already exist in businesses they are going to work at. We could do more with reflection on co-op instead of trying to address it with capstones.

Noe: Teams can have multiple advisors but they always have an ME to bring the rigor.

Cassie: Even for single discipline teams we encourage them to have students reach out. They can still connect to alumni or other disciplines. Students who make that effort have a good experience.

Dean: We have the achievement of incorporating career industry people as advisors. But the previous failure was that we tried to distribute the mentoring workload across faculty. The faculty said no. The projects were not closely tied to their interests. Now we encourage students to find technical advisors to provide expertise.

Beth: In previous capstone to work panel: Biggest challenges alumni in their early years in industry called out was the value of learning to ask someone for help.

Capstone Design CONFERENCE 2022

JUNE 6–8, 2022 ▸ DALLAS, TEXAS

Panel 5B Multi or Interdisciplinary capstone

Dean: Our first year course requires students to talk to one stranger, customer, stakeholder, and an SME related to the project.

Audience: Sending students out can help get faculty engaged to help and also help students understand there are other resources out there.

Breakout groups best practices for multidisciplinary capstones related to:

Administrative Options:

- Start small with departments that are willing; succeed with that, and then others will gradually buy in over time.
- Start with 20% excess in projects to ensure alignment of students; alternatively, gather projects specifically for the cohort of students (designated person(s) responsible for gathering projects—either a salaried single person [Colorado School of Mines, University of Washington] or a team of retired faculty/industry [RIT])
- There has to be good representation from disciplines in order to have well-fitting projects (e.g. some projects really need a CS perspective, but CS is not included in the multidisciplinary course)
- One college-level office that manages multidisciplinary capstone.
- Faculty advisor assigned to teams based on discipline.
- Some projects are industry-based, some are competition-based, some are faculty research led, student-proposed (usually from internships)
- Need a critical mass of faculty who agree to have it managed at the college-level.

- need to have a interdisciplinary person at the Deans level to go out and find sponsors and projects.

Faculty inclusion/buy in:

- Co-locate classes because of the credit hours so each gets a piece of the pie.
- Get a champion, someone with in each department

Student collaboration/curriculum:

- Challenges: Students not sharing the load. Whole curriculum is not scaffolded. Things are taught separately all through education, but then we expect them synthesize in capstone. Perhaps some content in the course on how to synthesize might help them do this.
- Eng. management: teams with a student who is a generalist, organized and a little outgoing, acting as a manager are better functioning.

Panel References:

Colorado School of Mines Capstone: https://capstone.mines.edu
Colorado School of Mines Engineering, Design & Society Department (Capstone host): https://eds.mines.edu

NASA Psyche Mission: https://psyche.asu.edu
Psyche Capstone: https://psyche.asu.edu/capstone-projects
Psyche free online courses: https://psyche.asu.edu/online-course

Currently available:

- Process and Lifetime of a Space Mission
- Inclusive Mindset: Tools for Building Positive Team Culture

In development:

- Countless Worlds in our Solar System: Asteroids, Comets, and Meteorites
- Debugging and Troubleshooting