UF Leveling Up Project-Based Learning
Teaching Beyond the Podium Podcast

Alexandra

Hello. My name is Alexandra Bitton-Bailey and welcome to the Teaching Beyond the Podium podcast series. This podcast is on teaching and learning and our guests offer their best tips, strategies, innovations, and stories about teaching. Sean Niemi teaches the mechanical engineering capstone design sequence, a culminating capstone experience.

A course in which students use all of their knowledge and skills to reverse engineer something, taking that item apart, putting it back together with their new and improved ideas. Shawn came to teaching specifically for this course, because he sees it as an integral part of the student's learning experience. It's a course in which students finally get to put it all together.

Sean Niemi

That's the first class is getting through the designing process of creating something on the computer that will serve the new function that you want them to do. And then the second class in the sequence is to actually build it. And we're currently working on spooling the class up.

It was a big part of why I actually applied for the job here was I'm a very strong believer in hands on experiences and actually giving students the opportunity to build the things that they've conceptualized on a computer. I think that there's a huge lack in the student experience when they don't have an opportunity to realize something that they've been working on.

And when the position opened, I was a couple months out from finishing my PhD, I had already taught it once as the lab instructor for a semester during my PhD. And I was like, if I'm going to teach anything, if I'm going to go into academia, this is what I'm going to do. And so now I'm essentially doing research on better ways to effectively teach engineering design and mechanical engineering design and get students to be better engineers when they graduate.

Alexandra

Education, or school really, did not come easy for Sean In fact, for most of his undergraduate studies, he barely survived. Really, he made it by the skin of his teeth.

Sean Niemi

My freshman year at UF I was actually kicked out of the department. I legitimately pretty much failed out of college my freshman year. And so this is the story of, UF continuously trying to kick me out, as I was always on the verge of my grades being just good enough to stay in. And

I just fought tooth and nail through undergrad, got to a point where I could either go into industry or go to grad school just on the cusp of being able to get into the master's program. And on the way there, I got involved in the Formula SAE team, Gator Motorsports. It's a group of students who build a race car from ground up.

So I got that really hands on experience and start to really realize, I love this. I love getting my hands on things. I love working on these hard problems. Had an internship, took a break from the master's degree to go to SpaceX.

Finished up the masters, the lab I was in we started to do some really cool research with bio and mechanical engineering mixed with biology, mixed with materials science, mixed with design. It was just really just fun, mixed with manufacturing. This really fun space to be in. I said, I'm going to do a PhD.

Alexandra

It was joining the Gator Motorsports team that sealed the deal for Sean. School, classes, coursework, finally clicked and made sense for him, because he saw the real world applications.

Sean Niemi

Seeing how things apply and actually putting your hands on how-- you can teach somebody equations all day long, and equations are just numbers and letters, typically, Greek letters on a board. And they don't mean anything. And when you actually have to design something to suit a purpose, and then make it. And then test it and make sure it actually works, all the sudden you go, wait, this stuff actually matters. This stuff is actually real. It's not just equations and numbers.

I think that was-- you can actually look at my transcripts, you can see a turning point to the semester. I joined the team and started getting involved there. My average GPA skyrocketed and it stayed at that level for the rest of my time. Because I finally gave a shit, for lack of a better term. I finally actually cared.

I think it was because I was like, this is why it's important. I was no longer struggling to try and improve my GPA just so I could not get kicked out, I was wanting to learn the things and classes because I had something that was real that they would apply to.

Alexandra

When Sean joined the UF faculty, he brought some innovative ideas with him. One of those great ideas is MERGE, mechanical engineering design pedagogy.

Sean Niemi

MERGE is it's actually brand new. It stemmed from realizing that UF really does something very different here and something very unique compared to a lot of other universities. So mechanical and aerospace engineering is the largest academic unit on campus-- the largest department on campus. We have over 2,000 enrolled students.

In the department, and every semester that means that we're teaching about 200 or so students senior design. And there are other institutions that have similar numbers that go through senior design, but they do everything with a slightly different structure for how they structure the classes. In their case, they bring the class down into small groups, and each group gets a different project.

And what we've done here is said, hey, I can give them all the exact same design problem. And at the end of the day, I've got 24 groups. And I'm going to have 24 unique different designs. They're all going to end up working on a different design. But now I don't need 24 faculty supporting the class, I can have two or three faculty.

Alexandra

So how does MERGE work? How did Sean create an environment and project that not only mimicked what students would do in their industry, but also fostered a collaborative learning environment?

Sean Niemi

So there's this software called PDM. It's common in all of engineering industry. It's project data management software, and students go and say, I want to edit this part. They take control of it, when they're done editing it, they put it back on the server so somebody else can edit it. And it's very common in industry.

And when we set it up, SolidWorks told us we were the first academic institution to request licenses of this for a classroom purpose. So that's the other side of the pedagogy is, how can we bring these modern tools that students are going to get their hands on in the real world, give them early access to it?

Alexandra

The course requires students to not only showcase their skills and learning, but also to work in diverse groups and develop effective teamwork practices.

Sean Niemi

This is the opportunity to put them into those diverse groups as you had mentioned. Give them something where they have to work hands on, they have to come together as a team, those soft skills that are often an afterthought. I see it as a large purpose of this class is to make sure that they have that set of skills at the end when they're going out of here, because that is the real world.

And at the end of the day, our job is to prepare all of our students for the real world inevitably, because it's going to be there. Whether we're going into academia or into industry, it's going to be the real world and they're going to be working--

They're not just can be able to pigeonhole themselves and work on stuff by themselves anymore. I see that as one of the primary purposes of this class is that type of an experience.

Alexandra

There are always challenges in student group work. In fact, those are the very same challenges faced by professional teams in industry. According to Sean, most problems boil down to two things.

Sean Niemi

The second course in the sequence, I tell them day one, the reason why your project will fail is communication and accountability. Those are the only two things, you guys. All the engineering, you guys are good at, you're never going to screw up the engineering. You might, but that's never going to be something so catastrophic that it causes failure.

The reason why things are going to fail is because you're not able to communicate effectively with your teammates or between teams. And you're not holding people accountable to get their work done. These are the exact same things why any project fails in industry.

And at the end of the semester, if you've struggled, we'll be able look at every struggle you've had and say, this was a communication issue. This was an accountability issue. And we can literally put those tags on all the issues they have through a semester, and 90% of them fall into that category.

Alexandra

For many students, learning to communicate and respond to others in person is a skill they have to develop. Communication online is very different, and Sean believes that this skill is immensely valuable.

Sean Niemi

We joke around and call them the cell phone generation. But a lot of their communications have been virtual, and forcing them to actually interact in person with other humans could be huge. These types of collaborative projects where people have to work on things together, because when you are no longer responding to somebody on a screen and you're having to tell them something face to face, it completely changes the way you judge the situation, you judge the person.

You can't just be an emotionless asshole like you can't over text. I'm notorious for being savage over text message, especially with a group Slacks for my students and they say something, it's just brutal. In person, completely different, because you get it you have to learn how to feel a room. I think a lot of people don't have that ability and they don't learn that ability in this day and age--

In this day and age? It's my day and age, too. But it's something that these things can really help with. And incorporating them, not just at the end of their experience, but incorporating them earlier and earlier into the curriculum. And maybe even every class having some aspect of this.

Alexandra

This long-term group project helps students develop an awareness, a greater understanding of their role in a collaboration in a group effort. This is something most courses don't really highlight for students, this sense of accountability towards others.

Sean Niemi

And you're able to slip through the cracks on a lot of those things, especially accountability to others, not just to yourself. In an undergraduate curriculum, you're accountable to yourself 90% of the time. It's only your grades that are being affected. If you slip up, all right, well, I got an A minus, or, I got a B on that test, whatever.

It doesn't affect me, but now others are banking on you and you have to-- if you screw up, you're going to not only affect yourself you're also going to affect your teammates, you're going to affect the project, you're going to affect everybody's grade, not just your own.

Sometimes students still don't care. I don't think there's anything you can do for that handful. But the majority of students getting adapted to that is an incredible benefit.

Alexandra

An important aspect of the success of the MERGE is the topic and the relevance and value the selected projects have to better the world. So how do these projects get selected?

Sean Niemi

This year was the first time we really gave it a trial run and we're going to see how it continues for the next couple of semesters, is surveying some of the faculty in the department and asking them, what is some piece of equipment for your lab that you don't have the manpower, you don't have the resources to develop, but that would help change the way you're able to run your research?

And it has to involve fluid flow. It has to involve controls. It has to involve structural design. It has to involve complex manufacturing. All these things that are key in a mechanical engineering curriculum, and then we take a look at all the designs and we go, that one.

Alexandra

Sean has found that topics meaningful to the students, topics that have an emotional connection to them are most interesting for him, as well as his students.

Sean Niemi

So this semester, we're partnered with the cancer research center and we're developing a 3D printer for their research lab to print micro tumors. So they're actually printing living cancer cells with these. And it's something that they'll be able to-- they've developed already a microscope topped incubator for all this. And this is the last piece of the puzzle that they need.

And so we're developing this 3D printer that'll mount on to the microscope that they use down there and print these micro tumors that they can then test all different sorts of drug therapies and whatever else it is that they need. Actually, one of my students this year come into my office like almost in tears. And I was really worried at first.

They were tears of happiness because her mother died from cancer. And she's so excited to have a chance to work on something because she's so closely tied to the effects that it can have. So it's a very real problem. So finding things, whether you can tie it into renewable energy, whether you

can tie into medicine, whether you can tie it into sustainability, helping out third world countries, whatever it is, finding a project that students can buy into is I think the biggest facet once you've covered, does it encompass all of mechanical engineering?

Alexandra

The process if MERGE is divided into four week segments allowing for significant scaffolding. This gives the students an opportunity to brush up on needed information and teamwork skills.

Sean Niemi

Identify the project, start off the semester of give them a mini project the first four weeks of the semester. So we give them something simple-- a mechanical device that is related to the project that they will have for the rest of the semester.

So this year, I gave them a little syringe with a twist on lock adapter. Actually, even two syringes to see if they could figure out that they could make a pump with two syringes. And then taught them some of the things they hadn't learned in their courses before this to give them information that they needed, the just in time learning mechanic for some of the concepts that there's just not space in the early curriculum for.

Throughout those four weeks, they submit their report. And then once they've gone through that segment-- and it's almost like priming the pump, giving them something similar-- then we assign what the overall design project is going to be and give them something that is significantly more complicated, but related to the project.

This year, we broken into groups and they were all given a little desktop 3D printer. And I told them, take them apart. And then take the things you've learned from taking that apart and use some of those tricks and tips and everything there to design this next project.

Alexandra

During the last four weeks, the students are totally focused on generating a design. This workflow allows students to try, try again, and work out all of the kinks before they get to the actual building of their design.

Sean Niemi

For the rest of the semester, these last four weeks of the semester, we're going to be doing weekly design reviews. So I'll be meeting with each group for 15-20 minutes during their normal

lecture period and talking about their design, giving them feedback, commenting on certain areas where there's something that looks like it might not work, where it might conflict.

Ask them how they do the analysis on a certain part, and try and get them tying in all those last of all facets. So that way at the end of this semester, they'll have a final design that we can build on next semester.

Alexandra

The MERGE courses and projects are taking off. The designs are underway. But what did that students think about all of this?

Sean Niemi

I've already gotten feedback from the students this year about the project and how much they love the project and they're excited about the project. So that's a huge facet of this. They appreciate the bluntness when they're saying, oh, we're having this problem, we're having this problem, we're having this problem.

And you go, sounds to me like that's a communication problem that I warned you about on day one. They go, [SIGHS] Yep. Well, I warned you and you didn't listen. So now you got to fix it. And helping them fix it-- and they appreciate that it's not handholding, it's just treat them like adults.

Alexandra

Sean has some great advice to share with anyone wanting to implement a long-term project course like MERGE.

Sean Niemi

Let them fail. Let them screw up. Don't hold their hands and don't try and stop them from failing. You learn nothing from somebody leading you through the correct path. You learn everything from going down the wrong path and having to bushwhack back through the weeds to get to the right one.

Celebrate failure. Teach them that it's good to fail in that recovering from failure is what makes it, in this case, a good engineer, but a good worker in any industry. Owning up to your failure saying, I screwed up. I'm going to fix it. Everybody would benefit from that skill set.

I constantly tell my students, I don't care if he did something wrong, you'll lose 10-20% for doing something wrong, but if you justify your steps and you show me your thought process-- if your answer is wrong, but your thought process was sound, you're going to get credit for going through a thought process. Even your the thought process was sound and wrong, I'm still going to give you credit for having a documented thought process.

And I think it's a different way of thinking about things. They don't have to do everything right all the time, they show a thought process. And once you see a thought process you go back and go, OK, cool. At step two, you made this assumption. Why is this assumption a bad assumption? And then they're able to correct themselves, but you don't penalize them for making a bad assumption, because they don't know enough to make good assumptions yet.

And we forget about the fact that they don't know everything. Inevitably, you're going to make a bad assumption and you're going to blow something up. I have literally blown things up, physically. Like I blew apart valves at SpaceX because I did math bad.

Alexandra

As teachers we all have some memorable teaching moments. Those moments that stick with us for the rest of our lives. And for Sean, it was this spectacular culmination of teamwork determination when his students persevered despite exhaustion to see their groups project to its successful end. A beautiful shot of espresso from a student designed espresso maker.

Sean Niemi

But I think the lasting memory for me was 2 AM, the final presentation was at 8:30 or 9 AM the next morning and it's 2 AM, and every student in the class is still in the lab working on this machine to try and get it ready. And we finally managed to get everything to work. We managed to get all of the leaks figured out and everything tightened up and get that first like perfect, just beautiful shot of espresso.

And just the relief that everybody-- it was the fact that everybody was in there, every student was still there. Nobody was willing to go home. They all weren't willing to-- even though the presentation, they were going to have to be back wearing business suits in 6 hours, they didn't care.

They were they were there and they were invested in it. They wanted to see it succeed. They weren't willing to leave until they saw it work. And I think being able to instill that mindset and have the kids that dedicated to something every semester, I'll be the happiest man alive.

Alexandra

Thank you for listening to this episode of the Teaching Beyond the Podium podcast series. We're happy you joined us and we hope to see you next time for more tips, strategies, and ideas on teaching and learning at the University of Florida.