Investigating the Development of Engineering Students into Design Practitioners as a Result of Interdisciplinary Design Team Experiences

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"[I]t is long past time that we rip engineering education out of the lecture hall and place it instead in the discovery environment of the laboratory, the design studio, or the experiential environment of practice." (Duderstadt, 2008)

The New Engineering Skill Set

Today's (young) engineering professional should be prepared to:

- Compete globally, not simply do "commoditized" design work
- Work across disciplinary, geographic and cultural boundaries
- Be a *life-long learner*
- "See the big picture" to solve complex problems
- Hit the ground running

Research Questions

- How do students with multi-disciplinary design practice talk about their experiences?
  - What advantages do they perceive?
  - What challenges do they encounter?
- How do students' conceptions compare to novices and more advanced practitioners in school and industry? What areas would we want to support additional growth?
- How do students' conceptions inform a larger set of questions that could be used to investigate differences between students who have these types of experiences and those who do not?

Research Methods

- Semi-structured interviews contextualized in concrete experiences
  - "Think about an experience you've had working on a design project with others from different disciplines."
  - Students were asked to describe their experiences and approaches both to design and working with those from other disciplines.
- Transcribed and analyzed using constant comparative methods (Cuba & Lincoln, 1998)

Participant	Gender	Major	Current Status	Years Of Multidisciplinary Design Experience
P1	F	AOSS	3 years post-school	1 year experience
P2	M	ME	Senior	3 years experience
P3	F	Civil E	Junior	3 years experience
P4	F	AOSS	Senior	4 years experience
P5	M	AOSS	Senior	3 years experience
P6	F	AOSS	Master's	5 years experience
P7	M	AOSS	Senior	4 years experience

Findings

Theme	Example Data Excerpt
Iteration leading to improvement Participants reported a broader understanding of the design experience from beginning to end. They recognized that the first design outcome is not necessarily the "end of the design, and they could learn something from the first attempt to improve their designs.	P5: The nice thing about balloons is you design it, and you work on it, and then you can actually fly it, and so you can see how it works. And then when you get it back, you can figure out okay, what went wrong. How do we make it better next time? So the whole process of design, build, test-fly's a lot quicker. And so then I feel like it also makes it more rewarding because you can see the fruits of your labor.
Awareness of the reality of failure Failure existed in all of the students' multidisciplinary design experiences. The opportunity to fail in these contexts supported participants' awareness or the reality of failure, and transforming failure into learning opportunities, in design work.	P1: Sometimes, you are gonna have to fail. We knew what was wrong. It's not like we weren't gonna be able to fix it remotely. It's just we didn't have the equipment there with us, so it's learning to be resourceful in areas where you don't have everything with you or you didn't plan certain things to happen…Sometimes, yeah, things will run a lot smoother if it's structured, but will the students be getting the same experience? Probably not. Will some of them fail? Yes. But again, like I said before, they'll learn a lot from failure because we're all gonna fail at some point, and you need to be able to handle that and then move forward and keep working.
Recognition of the need for multiple disciplines The necessity of learning from other disciplines was evident to participants as a result of their MD experiences. They were challenged to cross disciplinary boundaries and recognized the importance of improving at these skills.	P2: The controls, the straight just mechanics of the controls, is very sound for mechanical, but then the hydrodynamics and that interaction is just – I sometimes am at a loss to get my head around that. But you have to tie them together, and then the mechanics of the controls of the naval isn't nearly as straightforward, so there's always that boundary of the interaction that makes things interesting. But that's pretty much where engineering's going these days, so if you can get good at that, you can get good at everything else.
The value of testing for ultimate success The time and context provided participants with the opportunity to attempt to create a working design with multiple attempts, whereas in the constraints of classes, this is often a limiting factor. They explained testing and iteration as an important aspect of a successful design strategy.	P7: The most important thing for that project specifically was just testing, so kind of the whole process of design building and then you're testing it and then it's failing and so you redesign it and rebuild it. So the testing was the most important thing because, you know, if we had only designed it once and not tested it and built one of them and not tested it, it would have failed on a flight, so the iterative process really helped.

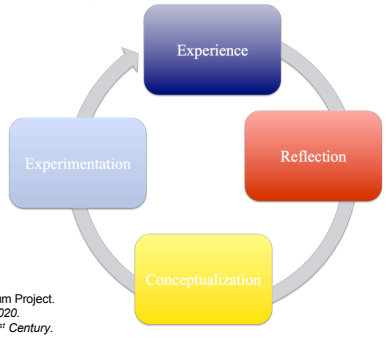
Additional Themes

- Participants had a high self-efficacy about their ability to succeed in their future multidisciplinary design work. This was a result both of the increased knowledge and skills associated with their experiences as well as having had an authentic experiences with real outcomes and hurdles.
- Participants struggled with having to make difficult decisions on their own and while they felt that could have benefits for their future, desired additional mentorship.
- It was evident that students had not reflected on many of their experiences on a deeper level until they were asked to unpack their conceptions as part of the interview.

Implications

- Programmatic Improvements: Seminar Course to support deeper reflection, based on Kolb's Experiential Learning Theory
- In-depth study comparison of students with and without MD experiences to identify key differences in conceptions and understand the development of MD skills and knowledge.

MULTIDISCIPLINARY DESIGN PROGRAM
Design. Build. Test.



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