"This effort has focused on creating assignments intended to teach the 3Cs within the design spine courses."

- Jeffrey Kleim, Associate Director and Associate Professor, School of Biological and Health Systems Engineering

**Case at a glance**

**Integration goals:** Integrate the 3Cs and EML assignments into our design spine curriculum

**Materials affected:** Syllabi, lectures, labs, assignments

**Lessons learned:** Thoughtful and substantial faculty and teaching staff onboarding is essential.

**Context**

The Biomedical Engineering program provides a discipline-specific design course sequence known as the “The Design Spine.” These courses focus on use-inspired project designs and cross-disciplinary interactions that span the four-year curriculum and comprise Introduction to Biomedical Engineering (BME 100), Biomedical Product Design I (BME 182), Biomedical Product Design II (BME 282), Bioengineering Product
Design (BME 300), Biomedical Product Design III (BME 382), and BME Capstone Design (BME 417 and BME 490). The sequence moves from needs identification through virtual prototyping, prototyping, and actual production.

EML integration efforts to date have focused on the assignments for BME 100, BME 282, and BME 382. For example, in BME 100, which has a lecture/lab format, the team revamped the lab component so that it is, in effect, its own mini-design spine that takes students from needs identification to market analysis to virtual prototyping to prototyping. Students address a healthcare problem, and their work includes device validation and design of experiments. The lab comprises a “module” in the newly configured curriculum, whose modular design allows for different skill sets being taught and moved around as needed. 2013 was the first-year students went through the design spine, and EML was incorporated in 2016.

BME 382: Game Lab is considered an exemplar of EM integration. The course covers physical prototyping in product design and development via a surrogate product for a medical device—in this case, board games. Students explore engaging their curiosity, making connecting, and creating value by leveraging industry partners for guidance on and validation of their projects. Each student’s curiosity and depth of engagement is measured by an industry partner, as are connection making and value creation, i.e., meeting a customer or market need. These partners come to the class throughout the year as visitors, announced or unannounced, to add content expertise and challenge and advise students. Market identification, product safety testing, and product valuation are just some of the topics introduced and covered.

Like BME 382, BME 100 has significant engagement with local industry. In BME 100, Kelvin Ning from Telluride Medical Partners (previously from MediCoventures) delivers a lecture and lab on fundability criteria and serves on a panel that judges the presentation of the final projects during an event now called BME 100 Spark Tank. Also serving on this panel are MaryAnn Guerra from Bioaccel and Kevin Coffman from W.L. Gore and Associates.

Integration details

The details of this EM integration effort are summarized in the timeline that follows:

2016
Spring: Design Spine faculty began holding weekly meetings to discuss how to implement EM into the courses by mapping specific activities and assignments to the 3Cs.
Summer: The meetings culminated in a one-day workshop in July 2016, during which ideas generated in the weekly meetings were presented to several KEEN experts (Doug Melton, Brent Sebold, Scott Shracke, and Ann McKenna). BME Design Spine faculty outlined adaptations to the structure of BME 100, BME 282, BME 300 and BME 382. The feedback from the workshop resulted in three KEEN Professorships awarded, one each to Dr. Casey Ankeny (BME 100), Dr. Michael Caplan (BME 282), and Dr. Jeff
LaBelle (BME 382). The ideas were then adapted and implemented into their respective courses, with syllabi and lectures revised and labs designed.

**Fall:** Dr. Casey Ankeny (BME 100), Dr. Michael Caplan (BME 282), and Dr. Jeff LaBelle (BME 382) implemented the curriculum modifications outlined in their KEEN Professorships in their respective courses. For example, BME 100 added several lectures and labs designed to facilitate EM through needs identification, prototyping, and market analysis assignments. The lab culminated in a venture capital pitch to our industry partners (BME 100 Spark Tank). Methods for enhancing EM in BME 282 were evaluated. Finally, in BME 382, principles of design and EML were taught through the development and marketing of a board game. Here students learned to create a business plan, target a population, and market their ideas. The first BME 100 Spark Tank event was held, involving approximately 300 freshman and 45 projects. The winners were connected with experts related to their projects and directed toward several FSE entrepreneurial programs.

**2017**

**Spring:** The second BME 100 Spark Tank event was held, and a one-day workshop on Disruptive Technologies was organized with the assistance of Dr. Michael Rust from Western New England University. The workshop focused on how to encourage EM through the development of technologies that revolutionize and redirect specific industries. Dr. Jeff LaBelle and Michael Sobrado created a set of hands-on wood and metal working classes that encouraged the 3Cs and were open to all students two days a week throughout the spring semester.

**Summer:** SBHSE recruited Michael Sobrado to be its KEEN Coordinator, as he has extensive experience both as an instructor and as an entrepreneur. He has been coordinating the hands-on curricular activities within Design Spine, assisting with implementing the EM projects and providing his entrepreneurial expertise. A follow-up workshop that included both Design Spine faculty and KEEN experts was held. Its goal was reviewing the projects implemented the previous academic year to assess how well they were executed and to make any changes for the next academic year. In addition, new projects for implementation in BME 300, BME 417, and BME 182 were discussed. Two full-day workshops that promoted EM in the context of neurorobotics were offered to high school students in anticipation of offering a version of the workshop to FSE engineering students.

**Fall:** A one-credit hour course on neurorobotics that promotes EM by having students design novel neurorobotic devices was offered. A full-day workshop promoting EM in the context of neurorobotics was offered to FSE engineering students (adapted from workshops previously offered to high school students). The BME 100 Spark Tank event was also held again.

**2018**

**Spring:** BME 100 Spark Tank event was again held and the final projects were assessed by several local entrepreneurs and industry partners including Jeff Skiba (Vomaris Innovations), Jeff Blanzy (Stryker), and Kelvin Ning (Telluride Medical Partners).

**Summer:** Further refinement of EM activities within the design spine courses were
discussed and summer mini-grants were made available to students who had developed projects during the academic year.

**NOTE:** Supporting resources for this case study can be found within its companion KEEN card (link below), which is also where the community can discuss the case and its broader topic.

**Integration outcomes**

We have been very successful in BME 100 and BME 382, less so in BME 282. The first-year capstone students were not putting it all together. After making adjustments to better help students make connections between courses, we have been more successful at getting them prepared to do the capstone project, as evidenced by improved projects.

**Future plans**

We expect to continue refining and updating our courses’ EM assignments, as well as to further fine tune EM’s integration beyond assignments into the design spine courses based on student, instructor, and industry partner feedback. As the BME Design Spine is included in Dr. Gary Lichtenstein’s overall evaluation of the initiative, we also expect to make changes based on formal research findings.

**Considerations**

This EM integration effort has benefitted from having EML experts on campus and available through KEEN. It would not have been possible without faculty training workshops and intensely collaborative curriculum development. To be most effective, faculty training should require multiple meetings to explain the 3Cs and adequately review the assignments instructors propose.

**KEEN Card**

This case study has a companion card on the KEEN Engineering Unleashed [website](#).

**Related Cases**

**Curriculum**
- Foundations 1: EGR 101 and FSE 100
- Foundations 2: EGR 102

**Engagement**
- Starting Strong: E2 Camp
- Extraordinary Customer Service: Entrepreneurial Catalysts
Change Makers: KEEN Professorships
Golden Opportunities: KEEN Student Mini-Grants
The Energy of Inquiry: Fulton Undergraduate Research Initiative (FURI)
The Weekender: Devils Invent Design Challenges
All In: Venture Devils

Workshops
Onboarding 1: EM Workshop for Faculty
Onboarding 2: EM Workshop for Staff
Onboarding 3: EM Workshop for Undergraduate Teaching Assistants

Life Cycle
Institutional Learning: Evaluating the Initiative
Dotting I’s and Crossing T’s: Administering the Initiative