

Capturing Existing Design Experiences

Prompt

For each dept: answer the set of questions that help us understand what design means to your dept/discipline and how your dept integrates design into the experience of your students. This is written from the perspective of just a single course but if you have multiple courses/experiences, please include those in the responses in a way that makes sense and provide enough context that everyone else can follow your response.

Shared Questions and Explanations

(Don't answer here... put answers in the respective section after the shared questions)

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

Provide a high level description of what design means to your dept and, if relevant, your discipline. It may be helpful to provide some rationale for this, as well. What is the "output" of your design experience? (physical artifact, software system, plans, specifications, etc.) What approach or process do you use for your design process? What are the specific steps or milestones of your process? Do you use a common model or something specific to your experience? How do you evaluate the quality of your design experience (not the student output, the process itself)? What has informed the creation of your design process/experience? How do you monitor and change the course over time?

Learning objectives and prioritization

What do you expect students to get out of the process? Please prioritize the learning objectives of the experience(s) - high / medium / low (or some other scheme with a similar number of levels). Another option might be to note how much time you expect students to spend developing each objective - lots / some / little.

Roles of those involved: Fac, Students, Staff, Client, others?

Who is involved and how do they connect with the experience? Please be specific on the type of support that they are providing and not providing, if that is relevant. An initial list is noted, but please add more people if needed.

Resources: Space, funding, technology, tools/equipment, time

What resources are available to students? Time has been included here, as well.

Teams: Create, maintain, support, and evaluate

This is a popular topic of conversation in this space but please don't get carried away. Focus on the major aspects and we can discuss details later on, if desired. Are there things that you consciously _don't_ do with regard to teams? How do you evaluate individual and team performance? How does accountability work? Provide rationale for any / all parts of your response.

Curricular integration

How does design connect with the program experience? Is it a course, multiple courses, aspects of multiple courses? If “design” spans more than one course, how connected are the experiences and how do you maintain those connections? Briefly describe how these things connect and how they are maintained.

Context of experience: Problem-based, project, client, etc.

What is the context of the experiences? What agency do the students have or not have in these experiences?

Current challenges and pains

What are your current challenges? How have these been going? What is your current understanding of them?

Desires and future plans and things to explore

What’s on your mind for the future? What do you want to try (at some point)? Specifics and a plan are not required.

Additional thoughts or context

What else would you like us to know about with regard to design in your dept? What else would help us understand what design means to you and why you do what you do?

Some ways to compare us to others:

- Howe, Suzanne -
<https://peer.asee.org/the-2015-capstone-design-survey-observations-from-the-front-lines.pdf>

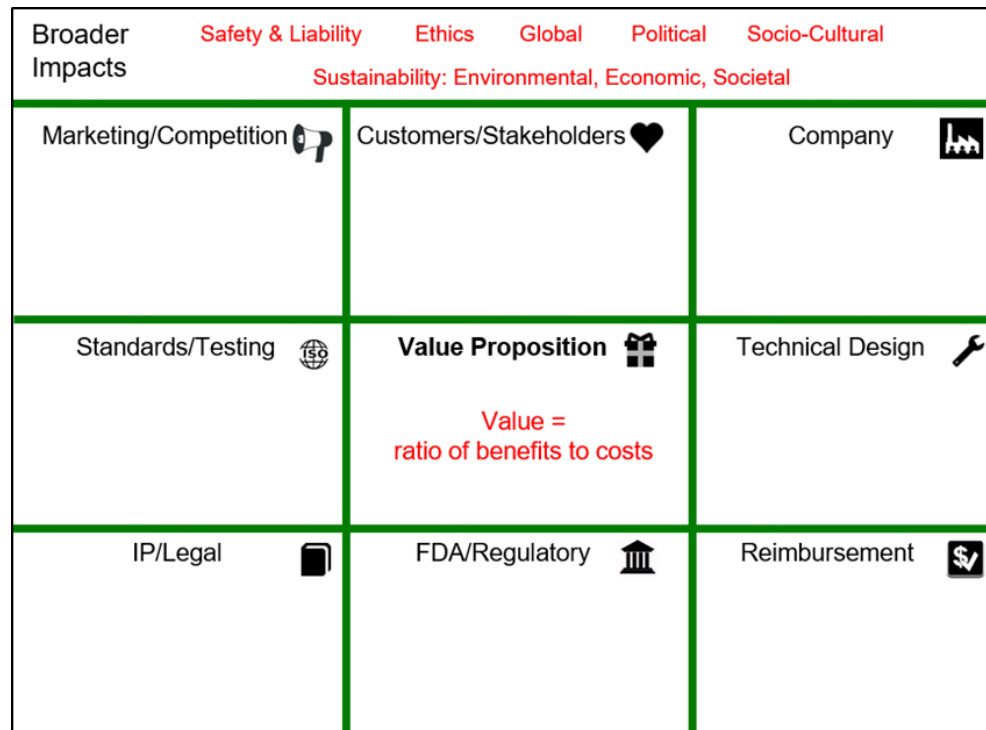
Please work with those in the group from your dept to fill out the following information. If this crosses multiple courses, please adjust the questions and responses as needed.

Biomedical

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

- We have a four course design sequence in our department.
 - In fall of sophomore year, students take a half-credit fabrication (and cell culture) course (BMEG 409) that teaches them a cad program and rapid prototyping techniques (laser cutting, 3D printing). They learn to create parts, assemblies, and drawings in the CAD program.
 - In spring of the junior year, students take a half-credit medical device development and assessment course (BMEG 408) that teaches them the “soft skills” of medical device design. They study an existing medical device, and how it got to market, considering aspects such as IP, FDA approval, reimbursement, standards and testing, and marketing. Then they make suggestions for improvements to the device with consideration for

safety (FMEA analysis), sustainability, and user needs, with the goal of creating value for the user (customer) and the company. This class also focuses on teamwork, with time spent creating team contracts. We introduce the canvas below (which Joe Tranquillo developed, and we reference in the senior capstone course) in BMEG 408, with value at the center.



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- In senior year, the students take a 2-course sequence capstone course(BMEG 401-402, both courses full credit) where they work in teams of 3-4 students, one faculty member advisor, and one clinical mentor to design a prototype device that meets a need of the clinical mentor. In fall semester, they focus on needs identification through research, meetings with their clinical mentor, and observations in the clinic. After identifying 20+ problems, they narrow down to 3-4 projects to do thorough research into, then pick one to pursue. Next, they brainstorm possible solutions, and by the end of the first semester they pick a solution path to pursue. In the spring, they do feasibility testing, build and test prototypes, and ultimately present their final proof-of-concept prototype at the design expo. There are two reports each semester, and one mid-semester presentation in the spring about a month before the final expo.
- When meeting with prospective students, we frame our curriculum as preparing students to work in medical device design, so this design thread is central to our curriculum. We also have student-driven design experiences in other courses throughout the curriculum, including our intro course in spring of the first year, biomechanics in fall of the sophomore year, and signals and systems in fall of the junior year (which also introduces systems thinking). We expect students to carry through what they have learned in earlier design courses and experiences to the senior capstone.
- Steps of design in senior capstone:

- Problem Identification & Scoping
 - Problem Statement
 - Supporting Technical Information (research)
 - Design Functions and Specifications
 - Potential Solutions & Evaluations
 - Brainstorm Potential Solutions
 - Feasibility Testing & Decision-Making
 - Prototype Development & Testing (Iterative)
 - Report Writing and Presentation
 - Project Planning
- We do not evaluate the quality of your design experience, aside from comparing to what other schools are doing
- The senior capstone design experience has not changed significantly since the first offering in 2007. We have varied what is taught in lectures, and the timeline of different steps in the process, but the general structure of the projects has not changed.

Learning objectives and prioritization (**bolded are most important of learning objectives from syllabi**)

- Senior capstone 1 (BMEG 401)
- 1) **Utilize project management tools to manage a semester-long team project.** (throughout courses)
- 2) **Identify current challenges in the biomedical field through interactions with biomedical experts.** (~1 month, problem identification stage)
- 3) Work on a team consisting of students, faculty and an external mentor to determine the focus and objectives of a senior design project. (~1 month, problem identification stage)
- 4) **Identify, analyze and synthesize relevant supporting technical information in support of the senior design project.** (~2 weeks, problem identification stage)
- 5) Demonstrate the ability to function as a member of a team. (throughout courses)
- 6) Demonstrate multiple levels of communication of technical ideas: verbal, written, and graphical. (four written reports, one oral presentation, one pitch video, elevator pitches, final expo)
- 7) Incorporate creative thinking techniques in the design of a product. (~4 months, from solution identification to final prototype)
- 8) Participate in discussions on professional ethics. (~1-2 lectures)
- 9) Incorporate concepts of human factors in the design of a product. (~4 months, from solution identification to final prototype)
- 10) **Demonstrate consideration of engineering economics by creating and managing a budget.** (throughout courses, but documented in four reports)
- 11) Present the design rationale among a selection of alternatives. (~1 month, solution identification phase)
- 12) Write effective project update memos. (throughout courses students write weekly or biweekly update memos to faculty advisor and clinical mentor)
- 13) Prepare a design proposal. (four times throughout the courses, 2 reports per course)

- 14) Specify components from catalogs and prepare purchase orders. (~4 months, from solution identification to final prototype)
- 15) **Demonstrate the ability to learn new information independently.** (throughout courses)
- Senior capstone 2 (BMEG 402)
- 1) **Demonstrate an ability to function on, and manage, a multidisciplinary team including students, faculty members, and a medical professional from outside the university.** (throughout courses)
- 2) **Demonstrate multiple levels of written communication of technical ideas, including effective project update memos and a comprehensive Final Design Report.** (throughout courses)
- 3) Incorporate concepts of design-for-manufacture during the fabrication of a prototype and in a proposal of a final manufactured product. (~3 months, during prototyping and testing phase)
- 4) **Demonstrate an awareness of the environmental impact and sustainability issues associated with production of a prototype and/or new device.** (~1 week, for final report)
- 5) **Demonstrate an awareness of the implications of professional ethics and social/political regulatory systems on the design of a new medical or biological device.** (~1 week, for final report)
- 6) **Demonstrate an awareness of and application of safety, health, and liability concerns while developing a new device.** (~2 weeks, for problem identification report and final report)
- 7) **Apply analytical or computational tools for a theoretical analysis of their design problem.** (~2 months, during feasibility testing and validation testing)
- 8) **Use CAD software, as appropriate, for design and communication of designs.** (~4 months, from solution identification through prototyping)
- 9) **Demonstrate drafting and revisions of report sections during the design process, and will document their revisions and the rest of their design process in a design history file or similar electronic format.** (throughout courses)
- 10) **Demonstrate a working prototype or proof-of-concept of a design of a new biomedically-relevant device.** (~2 weeks, prep for final design expo)

Roles of those involved: Fac, Students, Staff, Client, others?

- Project is mostly student-driven, with each team attached to a clinical mentor from Geisinger. The students work in teams of 3-4 that are built by the students ranking their interest in the different clinical departments represented by that year's mentors (e.g. pediatric orthopedics, radiology, ...). They are assigned a clinical mentor from their department, usually a doctor or a team of clinicians. The clinician shares some initial ideas with students, helps them visit the clinic / OR as relevant to observe their work, provides feedback on their solution ideas, and continues to serve as a resource for students throughout the design process. The teams are assigned a faculty advisor based on the clinical department, before the project topic is known (since the students identify the problem they will focus on in consultation with their clinical mentor in the first 2 months of the fall semester). Hence, the faculty advisor serves more as a person to guide the process, bounce ideas off, and direct students to useful resources. The faculty advisor meets weekly with the student teams. Other faculty members are also consulted by students, as needed.

Resources: Space, funding, technology, tools/equipment, time

- Each team gets a \$1000 budget (in recent years, funded by HTIP)
- The course has 3 hours of a lecture and a 2 hour lab scheduled each week. The two hour lab is always for student work time and meeting with faculty advisors. Often, one or more lectures are also allocated to work time.
- Each team is assigned a table in our senior design classroom, and has access to all department tools and fabrication resources (3D printers, drill press, etc) and maker spaces
- Jacob Nickle, our lab director, serves as a resource for equipment training and purchasing

Teams: Create, maintain, support, and evaluate

- Teams are built blindly based on student interest in clinical departments.
- Students are encouraged to make team contracts (but I do not think it is required).
- When planning their project, students are required to assign individual students to specific tasks.
- Peer evaluations are used at the end of each semester to evaluate individual contributions.
- If faculty advisors note issues, or students bring up issues, the faculty may intervene to help mediate issues.
- There is not a lot of individual accountability.

Curricular integration

- As mentioned above, the senior capstone courses are the culmination of a 4 course design sequence, and we also have other design experiences sprinkled throughout our curriculum. The four course sequence is well-integrated, with the clear expectation that students will carry skills, knowledge and competencies from the first two courses (e.g., CAD design, engineering drawings, BME canvas topics) to senior design. The other design experiences are not as intentionally integrated, but do give students more confidence in their design skills before tackling senior design.

Driver/Context of experience: Problem-based, project, client, etc.

- Although the clinical department is assigned, the specific project is selected by the students. The clinical mentor and students' clinical observations when meeting with the mentor inform the project that the students choose to tackle. They are allowed to include student interest as one of the criteria by which they evaluate what project to focus on after brainstorming and researching many ideas. So students have a high level of agency in defining their projects.

Current challenges and pains

- Our current challenges include inclusive teamwork (best strategies for team creation, how to ensure all students feel valued and welcome and mechanisms for individual accountability), getting students to include analytical calculations or modeling in the design process, and quality of the final report (now that there is no senior week, and students are distracted during finals week when the report was typically revised). We are actively working on the teamwork issue,

and we would love to hear what other departments are doing. We are considering changing the timeline or expectations for the final report, but don't have a firm plan yet.

Desires and future plans and things to explore

- This year we may try teams of 5 (instead of 3-4) and focus all projects on simulators / training devices rather than keeping options completely open.
- In the future, we would like to consider the possibility of mentors/clients from outside Geisinger, including QL+ (a group that connects veterans with student groups to create a device for them), or veterinary or dental options.

Additional thoughts or context

- Nothing at this time

Civil and Environmental:

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research
We have a two-semester senior design capstone course, with a half credit course each semester. In addition the first half of the first semester is dedicated to students learning about ethics and licensure (and other stuff), and conducting a feasibility study. During the second half of the first semester, students start working in their capstone projects. We also have a Sustainable Design course (CEEG 443) that is required for environmental majors and can be taken as an upper level elective by civil majors. In this course students read and learn about social implications of design and tools that can be used for community engagement. Over the last two years, students have created conceptual designs for the Bucknell Farm and engaged with their client to "get to know them", and quantified environmental impacts and costs with uncertainty.

Other courses may include elements of design, but these are not standardized.

A high-level definition of design might be, from one person's perspective, using knowledge, principles, techniques, tools, and teamwork to create a solution to a problem/situation that has no singular solution. (In this way, it should be very unlike a homework problem with a 'right answer,' for example.) Students should participate in defining the problem and considering a broad range of stakeholders, constraints, and criteria. Iteration is/should be inherent.

I think the products from design work in our department primarily include reports, presentations, and posters, usually supported by calculations and computational models. Physical manifestations are occasionally created, such as in design competitions (shake table structures and mechanically-stabilized earth system contests). Traditional CEEG contract documents (drawings and written specifications) are becoming more rare as design products in our department.

Learning objectives and prioritization:

These are the course objectives associated with the 492 course (first of two-course sequence in senior year):

By the end of the term, students should be able to demonstrate an ability to:

1. *Analyze fundamental concepts relating to engineering planning, sustainability, ethics, public policy, and licensure, and apply them to civil and environmental engineering applications;*
2. *Collaborate on a real-world civil/environmental engineering design project, culminating in successful completion of a design report at a conceptual level of detail.*
3. *Communicate effectively, both orally and in writing.*

For the second of the two courses, a six-page document goes into more detail. While it does not explicitly list the objectives, there are some additional objectives inherent in the process and deliverables, such as:

4. Students should gain some experience in managing a project, by rotating through roles of Project Manager and “Recorder” (recording notes and minutes of meetings).
5. Managing effort across an extended time period, including budgeting and tracking of hours in a manner similar to what would be expected in a consulting/design engineering role.
6. Considering environmental, economic, and social/societal factors associated with their design.

These are the course objectives associated with the 443 course (Sustainable Design):

1. In team, design engineered technologies with poorly defined objectives under a diverse set of constraints.
2. Apply quantitative sustainable design tools—life cycle assessment and technoeconomic analysis to an engineering case study.
3. Describe socio-political challenges associated with engineering designs and how these relate to environmental justice.

Roles of those involved: Fac, Students, Staff, Client, others?

Some of the projects in our courses have clients, either internal to Bucknell or external. Others do not, consisting instead of hypothetical situations that are created to be similar to real projects. In Senior Design faculty provide a problem statement or design goal. Students are responsible for managing a project, by rotating through roles of Project Manager and “Recorder” (recording notes and minutes of meetings). Jim Gutelius and Monica Hoover may help as needed. In 443 and senior design the clients may help define the project scope, explain their needs, constraints, and provide input.

Resources: Space, funding, technology, tools/equipment:

The technologies to support design work are, I think, relatively available to us. This includes quantitative software and modeling packages like R, Python, MATLAB, Excel, BioWin, SimaPro, MASTAN2, and others. Because the design output products are often not physical manifestations, I have not found space or (physical) tools to be a limitation. Time spent with students in teams or in an individual setting is more difficult to come by.

Teams: Create, maintain, support, and evaluate:

For the capstone design sequence, mid-semester peer evaluations are conducted. Digesting those into anonymous feedback and getting it out to the students can be challenging, often arriving only a few weeks before the end of a semester. End-of semester evaluations are also conducted. These evaluations are used semi-quantitatively in student grading.

Curricular integration:

Currently the formal design experiences are bookended in the curriculum, ENGR 100 and CEEG 492/493. Any other design experiences are course-specific. Inclusion of any design activity and its nature is up to the instructor.

Driver/Context of experience: Problem-based, project, client, etc.

My (KRG) take on this is that the context of design projects in our curriculum depend on (a) the interests and network/contacts of the faculty member, (b) the projects or problems faced by those contacts, and (c) past experience of the faculty member in their area. I think the vast majority of the design work in our department is problem- or project-based in some form, whether that project is an active, real project or not.

Current challenges and pains:

One challenge I (KRG) have observed is the way in which students approach research into a design problem. Internet searching is the first step they take, and the results they get from those searches are all over the place in terms of quality, bias, etc. Having reliable, accessible sources and guiding students to use those is an ongoing effort for me.

Desires and future plans and things to explore:

Create more of a sequence with design experience in the junior year on which to build.

Be more thoughtful and explicit about learning objectives associated with design

Do a more thorough inventory of the various other design activities across all our courses.

Additional thoughts or context:

Possibly create a "D" course designation internally to identify courses with design components to them.

Have a requirement related to that designation.

Chemical

Consider incorporating more summative reflection after P3.

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

CHEG 400 is the first of the Department of Chemical Engineering's two capstone design courses, focused on *process (or plant) engineering*. This course is focused on designing a Chemical Process to meet a desired need. The main tool the students use in this class is process simulator software used in the petrochemical community, and fundamental engineering economics.

CHEG 410 is the second of the Department of Chemical Engineering's two capstone design courses. This course focuses on a range of learning experiences in *project engineering* and provides an opportunity for students to gain experience with topics that can be difficult to incorporate into the core curriculum courses at Bucknell.

This course deals with real engineering problems—real clients with real needs, real timelines, real constraints, and real uncertainties. You will work as a member of a team on an open-ended design project. The course setting is what you might encounter in your initial experience as a professional.

Phase 1 – Project Setup

Based on the initial information provided to you, discussions with your client, team brainstorming, and literature search, your team will provide a *problem statement* (or a success statement) based on the resources available and constraints present. Your team will provide a set of **project goals** that are SMART (specific, measurable, achievable, realistic, and timely).

Based on the goals, your team will develop a *project plan*. This work plan will consist of a set of specific, assessable **activities** with clear timelines, resource requirements, difficulty assessment, and role assignments.

In terms of timeline, by February 06, 2024, your team should finish both aspects of this project setup. At 8:30 am on February 06, 2024, your team is asked to submit a progress memo summarizing your accomplishments up to that point.

On February 06, 2024, your team is asked to defend the problem statement and project plan in front of a panel of faculty (and clients, if available). Your team must pass this preliminary defense to move on. Specifically, any team that presents project goals or project activities that do not meet the panel's expectations based on the course objectives and supervisor and client feedback will not be permitted to continue on to Phase 2. In such cases, the team will be required to re-do the elements of Phase 1 to correct the deficiencies before continuing.

Phase 2 – Project Execution

In executing your project plan that was approved by the panel, we request that teams adopt the agile project management framework called SCRUM. A guide to SCRUM will be provided to you in a different handout. All the activities proposed in your project plan will be put into your

SCRUM product backlog. From the product backlog, your team is to develop specific **tasks** to be completed at certain time frames. The time frames are one, one week sprint and four predefined, 2 week periods from the start of the second phase, termed **sprints** (2/12 to 2/16, 2/19 to 3/01, 3/04 to 3/22, 3/25 to 4/05, 4/08 to 4/19). The specific tasks are to be stored in your sprint backlog of appropriate timeframes, again with clear timelines and role assignments.

An important aspect of project engineering is self-regulation. We ask that you watch the timing and reflect on your project status often. By April 24th, 2024, your team should finish your design. At 8:30 am on April 29th, 2024, your team is asked to submit a progress memo summarizing your accomplishments up to that point. We ask that your team provide an honest and useful review of the state of your project and its progress.

During the week of April 18th, the panel of supervisors will conduct a review of your final design data. Your team must pass this review to attain the privilege to participate in the College-wide Design Expo poster session on April 28th, 2023. Any team that does not meet the panel's expectations based on the quality of the design with respect to the originally defined problem will not be allowed to participate in the Design Expo session; instead, you are requested to continue working through the final weeks of the semester and sign up for a full-fledged oral defense during the CHEG 410 final exam slot.

Phase 3 – Project Delivery

Communicating your design to various audience levels via different modes is an important aspect of this course. We start earlier, during the Phase 2 period, with some drafting process. By 3 pm on April 12, 2024, your team is asked to submit a full first draft of the final project design report.

At 3 pm on April 29th, 2024, your team is asked to submit the final project design report. For teams presenting at the Final exam slot, your final report is due on the final exam presentation day.

Learning objectives and prioritization

The specific goals of this course are that students will:

- develop teamwork and project management skills in the context of a realistic setting
- work with a client to develop suitable project goals that meet the client's needs
- provide tangible results associated with project goals within the constraints of time, space, and budget
- practice skills needed to understand a problem, develop a plan of work to address that problem, execute that plan, and finally communicate findings clearly in both written and oral forms
- demonstrate self-directed learning by working professionally, effectively, and proactively with teammates, supervisors, and clients to understand and solve problems associated with the project

Roles of those involved: Fac, Students, Staff, Client, others?

Faculty are mentors on projects. We provide a few lectures on defining problems, goal setting, and project management but the students are largely responsible for their project and the client interactions.

Resources: Space, funding, technology, tools/equipment

You are provided with various resources so that you can be successful with your project. For starters, please refer to the Team Roster document for the supervisor, laboratory space, and laptop assignment.

- One of the instructors will be your direct supervisor to provide you with the necessary resources, direction, and advice as s/he sees fit. S/he is your main contact for everything related to this course. You are expected to keep your supervisor abreast of your work progress at all times.
- The clients have also committed to being a valuable resource for your team. You are advised to update your client with an appropriate frequency.
- Your team and your supervisor are responsible for setting up a safe and appropriate lab setting to carry out its work. Be aware that other teams may be using the same physical resources, so be prepared to cooperate.
- Some of the administrative assistance may come from Logan Osgood-Zimmerman (College of Engineering Industrial Liaison) and the SBDC Engineering Project Manager, who provided the clients' projects to us.
- College facilities, such as the Materials Laboratory, Project Development Laboratory, Makerspace Environmental Engineering, and Science Laboratory, are available for testing and fabrication of prototypes or specialty items for experiments. Be sure to plan well ahead of time and work with your supervisor if your project needs these specialized facilities.
- Your team is provided with secure and unlimited space within the Course Google Drive. Please make sure that the links and privacy settings are working. You are expected to use this space to keep everything, including drafts of written documents, presentation files, literature, and test results. Please also remember that the client will be given access to a subfolder within your workspace.
- Each team is given a budget to spend on materials, supplies, and travel. Each team should plan to spend no more than \$500. Please work with your supervisor to make the most effective use of this funding. In exceptional circumstances, with prior approval, this budget may be exceeded.
 - We provide a list of preferred vendors, and Diane Hall can help you identify additional vendors if needed and help with ordering supplies. However, she is not responsible for your needs in this course. Your team is responsible for getting what you need in a timely fashion.
 - Orders for any materials or equipment for projects in this course should be approved **in writing** by your project supervisor before being given to Diane Hall or Megan Leavy. Diane and Megan will help us place orders, but they will not approve orders. Please download a "Purchase Order Form" for the course and use it to organize and make purchases.
 - You do not have to purchase something that the department already owns. However, do not take any equipment or glassware from laboratories unless you have been given permission to do so by Diane Hall. Plan ahead and work with your supervisor to ensure that you have sufficient equipment and materials for your project.

Time

- The course meeting MWF for 1 hour and T for a 2 h recitation

Teams: Create, maintain, support, and evaluate

Creation:

We use a Google form to create teams. We provide a general description of the project without the client name or company and ask the students to rank the projects. We ask for one person they want to work with and one they do not want to work with. We also ask them which is the most important to them project, person or non-person.

Evaluate:

- CATME
Each team member will take the CATME Teamwork peer evaluation. CATME is an assessment of teamwork skills developed as part of a National Science Foundation-funded research project. CATME assesses the following skills

Skill 1: Team Members Are Contributing to the Team's Work

Skill 2: Positive Interactions Among Team Members

Skill 3: Team Members Are Keeping the Team on Track

Skill 4: Quality of the Team Member's Work and the Exception Quality

Skill 5: Team Members Have Relevant Knowledge, Skills, and Abilities

- Team Firing
Teams where the peer assessments (CATME) indicate a problem are asked to meet with the instructor and to identify specific changes that would improve whatever problem is occurring. All students have to agree that the suggested actions are doable for everyone, and all members should sign off on the new agreement.

If the problem persists at the next regularly scheduled peer assessment, the rest of the team unanimously sends a memo to the underperforming student saying that they are in danger of being fired if the behavior does not change, as agreed in the previous document.

If all the other team members report that the problem persists at the next peer evaluation, the student is fired, with the consequences outlined above.

If a student is fired, they are required to complete the same project by themselves moving forward without teammates.

- Work Product
Only students who contribute to completing the work and writing the memo for a particular assignment should have their names put on the memo when it is handed in. Students whose names are not on the assignment receive a grade of 0 for that memo.

Curricular integration

We used to have a CHEG 410 manage a group of junior chemEs to accomplish an additional part of the project they defined, but we stopped that practice because it was difficult to coordinate, and some of the experiences for the juniors were not worthwhile.

Driver/Context of experience: Problem-based, project, client, etc.

Our course is structured around problems. We seek to have every project come from an external client, but after COVID, that has been nearly impossible. So we supplement with local projects either other faculty in or out of the department.

Current challenges and pains

Finding projects that fit the course. Student work quality and applying engineering principles from other courses. Writing is poor.

Desires and future plans and things to explore

Based on our challenges in finding a good project and the ambiguity of the external projects coordinator position, we may look to find an internal project that would work.

Additional thoughts or context

Grading:

We use a non-linear grading strategy so that teams that take some time to figure out how to complete the project are not penalized.

The grading is also based on technical, professional, and goal completion. For instance, only completing your base goals results in a maximum grade of a B from P3. You need to complete some of your stretch goals to get an A.

Project Management:

We teach them and use Scrum for the course. Every two weeks during the second phase there is a sprint retrospective with the faculty and the client.

Sprints will be 2 weeks long

Each Sprint will have a scrum master

Use Google sheet template for backlog, sprints, and tasks

ExampleTies to Grading:

Conceptual modeling:

We have spent a considerable amount of time trying to help students infuse more technical engineering into their projects. We have developed a conceptual modeling framework and worksheets for the students to practice and see examples.

Computer Science

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

Learning objectives and prioritization

Roles of those involved: Fac, Students, Staff, Client, others?

Resources: Space, funding, technology, tools/equipment

Teams: Create, maintain, support, and evaluate

Curricular integration

Driver/Context of experience: Problem-based, project, client, etc.

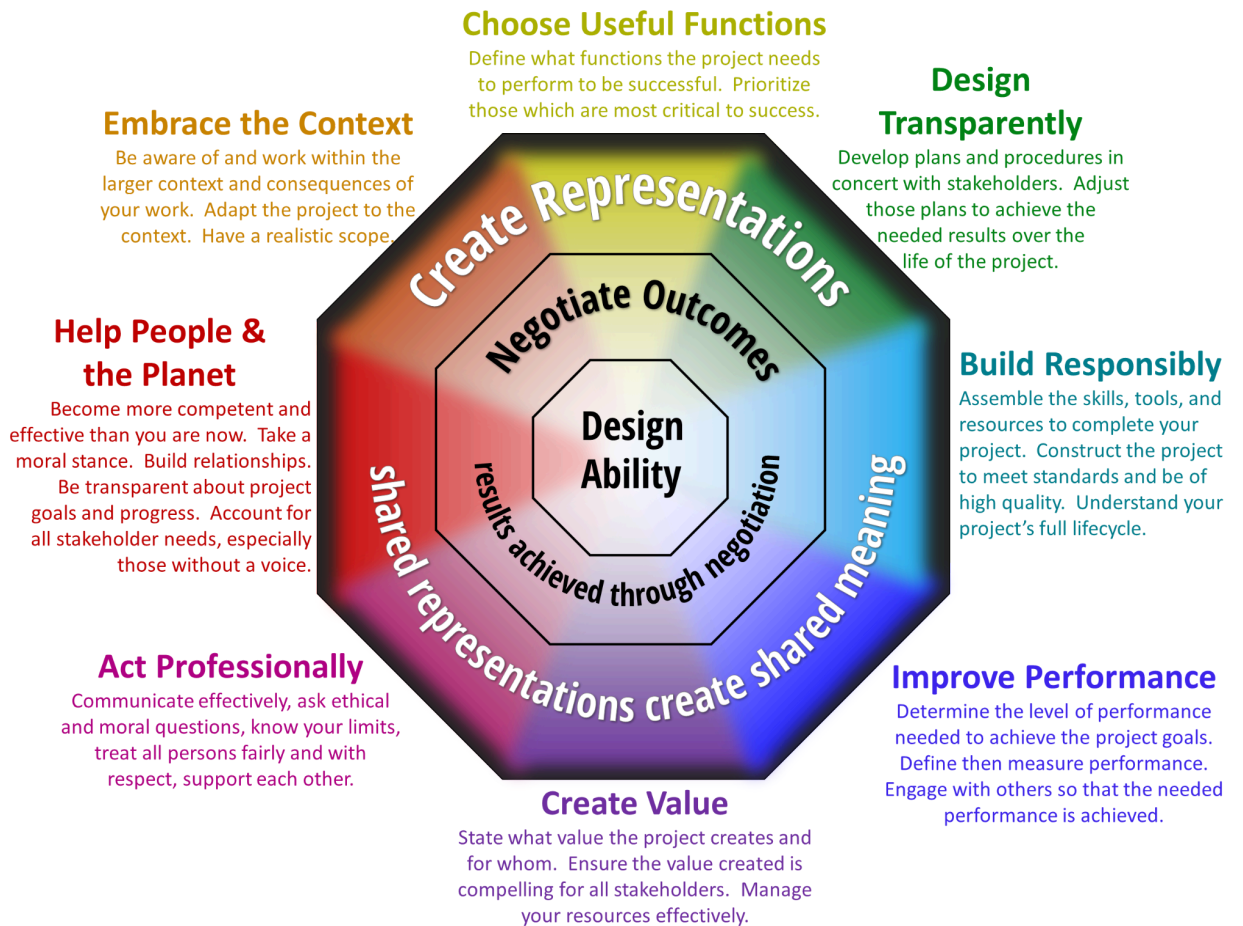
Current challenges and pains

Desires and future plans and things to explore

Additional thoughts or context

Electrical and Computer

- Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research



We use the above diagram across the five-course sequence in our curriculum. We could go into more detail, but this really captures that we want students to look at design through these eight lenses.

We use a combination of a test-vee model (<https://www.professionalqa.com/v-model>), which we need to be able to schedule activities and structure the course, with elements of a lean start-up methodology to focus on the context of the problem, discovery, and understanding value creation. Even in their fourth year students are not expert designers so all the work we do is pretty heavily structured and scaffolded.

Multicourse sequence - 100 (first year - some basic ideas of design), 201 (sophomore year - test, measurement, and fabrication), 301 (junior year - student chosen projects that connect to the UN SDGs, lots of scaled down aspects of senior design), 400-401 (senior year - full-year experience, client connected projects). The earlier courses were created to support what happens in senior design.

Research - 2 types: exploration and finding the things you don't know you don't know and the second is learning more about what you know you don't know. We leverage interviews a lot, where the students connect with anyone they think might have useful information for the project.

Evaluation - almost everything is rubric based using self-developed rubrics. In capstone we bring in other faculty at multiple points during the year to provide additional feedback.

Outputs - the students create a lot of different "representations" of their design. These are the primary outputs. A physical instantiation is one of the types of representation.

- Learning objectives and prioritization
See above. The diagram captures the lenses we look at design through. The goals in all the design courses is to have students develop skills and knowledge in all eight areas to become a better designer.

To provide an example and some context, below are the seven phases of the capstone course. The earlier courses only cover parts of these and capstone is where they skills learned earlier are integrated. The objectives tend to be different in each phase and together address the overall goal of having student go through an in-depth design process:

Outline of Phase Guiding Questions

Phase 1: The goal is to explore the context of your project, how it affects different groups of people, and your client's business space and their interests. You should try to develop a thorough understanding of the issue you are trying to address. At this point in your project the team should be asking lots of questions to learn about the larger space in which the project

exists, potential stakeholders, and what other products or players are in this space. Your research should be broad and exploratory.

Questions:

- What is the issue this project is addressing?
- Who is potentially impacted by your project and how are they impacted?
- Are there any potential negative outcomes that could arise from developing this project?
- What other entities (people, companies, government organizations, etc.) are working in this space? What roles do they play?
- What other products or solutions exist in this space you need to be aware of?

Representations:

- system map
- interviews
- research.

Phase 2: The goal is to define your project in a broad sense and set the general direction for the rest of the year. By the end of this phase you should be able to pitch the idea of your method to address the issue(s) you identified in Phase 1 in a way that guides future actions. At this point in your project you are still exploring many options but beginning to get a sense of the most appropriate direction for your project of the many options you have explored. Your research should be narrowing down into more details of a few possible paths.

Questions:

- What is the core idea that underlies what you plan to create and why is this important?
- How does this idea create value, and for whom?
- How does your idea differ from other products or solutions that already exist in this space?
- What are the most challenging aspects of implementing this idea?
- What organizations or individuals do you need to coordinate with in bringing your idea to life?

Representations:

- All of the above and
- GMA
- NABC
- System map
- Interviews
- Research
- Design abstraction stack
- Chose Project Manager

Phase 3: The goal for phase 3 is to have moved from an idea to detailed development plans that will allow the team to move into project development; ideally without a lot of mistakes, having to backtrack, or hitting dead ends. By the end of this phase you'll present detailed, but still fluid,

plans for your project that you will test through experiments in the next phase. At this point in your project you'll begin to converge to a solution, making choices that determine the form of your project. The decisions you make now will matter in the long run. It is time to get down into the details, for example by assigning design engineers to be responsible for specific functions. Your research should be getting more technical, weighing options for how to implement the functions your project needs to perform.

Questions

- What is your solution? Explain it in a way it can be broadly understood.
- What functions does your project need to perform in order to call this project a success?
- How will it perform these functions?
- In what order do functions need to be performed, how are different functions depending on each other, and what events trigger functions?
- Which of the functions are the easiest to implement, and which are the most challenging?
- Which functions are most critical, and which are of the least importance?

Representations

- All of the above and
- Flow diagram
- Block diagram
- Use cases
- Engineering standards

Choose System and Performance Engineer. Design Engineers vote on the person to take this role and negotiate for which of the functions they will be responsible for.

Phase 4: The goal for phase 4 is to build and test a prototype of your project to understand where it needs to be improved or modified. In the early part of Phase 4 DEs build prototype subsystems that demonstrate ways to achieve the functions they are responsible for. In the later part the DEs and the SPE combine the most viable versions into a complete and working early-stage prototype. Aesthetic and other aspects of the project are considered to inform the next version. At this point in your project the team should stop pushing the boundaries and exploring new ideas unless there is a real need to. Try to converge to workable solutions that enable the functions to be implemented. Your research should be far down into the details, with each DE focused on the function they are implemented.

Questions:

- What options are there to implement the needed functions?
- Which of these options is most appropriate given the project context and constraints?
- What are the various trade-offs that are important for this particular project given the context and stakeholders?
- How well does our initial prototype meet the goals we set for our project?
- How can we improve it, remove unneeded functions, or add features to create more value?
- If we redesigned the project based on what we know now, what would change?

- What will the final version of our project look like?

Representations:

- All of the above
- Form Evolution Plan
- Performance metrics, tests, and data

Phase 5: The goal of phase 5 is to do a rapid reiteration of your project addressing the most pressing issues from the last phase. You will eliminate parts of the project that are no longer needed, rapidly develop new approaches for functions that did not work well enough, and do a final check-in with the project stakeholders. At this point in your project you should be once again thinking broadly, but in a much smaller design space that is limited by what is possible to achieve with the time and resources that remain to you. If there are functions that have not been successfully implemented it is time to expand the scope of the research to explore other pathways.

Questions:

- What parts of the project need to be redesigned to be able to create value for our stakeholders?
- What parts of the project can be cut to free up time for more important work?
- Are there any key elements that we have failed to implement? How can we address these?
- Do the design representations still accurately reflect our work? If not, do we need to change the project or the representations?
- What do our stakeholders have to say about our choices in this phase?

Representations are all those created previously. Make sure they are updated.

Phase 6: The goal of phase 6 is to complete your project at the highest technology readiness level (TRL) possible, which will be different for each project. At this point in your project the team's thinking should shift to converging to a solution, building a robust and quality deliverable for your client, and testing and documenting the performance of what you have built. The research your team does is going to be driven by specific issues; the focus here is getting to the end so research may not be what is needed.

Questions:

- What critical path do we have to follow to complete this project?
- What distinguishes our design from other available solutions in our project space?
- How can we best present our work to demonstrate how it creates value for multiple stakeholders?
- What does 'quality' mean for our project and what TRL is realistically achievable?
- How can we best document how well our device performs? What performance metrics are most important for our application? Which metrics don't matter that much?

Representations are all those created previously. Make sure they are updated.

Phase 7: The goal of phase 7 is to wrap up the project and shut down your team and your space. Wrap-up includes getting your intellectual and physical work to your client in a way that is most useful for them. It also involves letting go of all the relationships built over this last year; this should not be left to chance. At this point in your project the team should be focused on making sure you do any finishing work and making sure everyone involved is clear on what value you created for the stakeholders. The research here is more retrospective, being reflective of your own work, looking back through the entire project.

Questions:

- What aspects of your work are most valuable to the different stakeholders involved?
- What relationships need to be brought to a close, what is the best way to do this in a way that leaves everyone feeling complete?
- How do we complete any needed documentation of our project?

Representations are all those created previously. Make sure they are updated.

- Roles of those involved: Fac, Students, Staff, Client, others?
 - 100 - not really relevant.
 - 201 - students work individually, course taught by Matt Lamparter.
 - 301 - students work in small teams; faculty mentor, no clients
 - 401 - The course instructors manage the course, faculty do not serve as advisors. Students have defined roles in capstone, not in other design courses. Client in capstone, not other courses.
- Resources: Space, funding, technology, tools/equipment
 - MakerE, teams in capstone get dedicated space, otherwise use available rooms. Budget annually so all courses have access to parts. SD teams typically get \$5k per team if we have an external project sponsor.
- Teams: Create, maintain, support, and evaluate.

We use a survey to look at team skills, available times, etc. and build teams based on the responses. There is no self-selection. In each of the courses, except for perhaps ECEG 100, we do not have students take on the same roles or do design in exactly the same way. In the design sequence we give increasing autonomy to students so by the end their experience in capstone and what they do might be radically different than that of another person on their team. We believe that being able to work on a team is an essential skill for an engineer. Students can fail design courses for poor performance on a team.

 - ECEG 100 - pairs or triples, peer evals are done multiple times per semester and feedback is given to individuals to drive improvement;
 - ECEG 201 - individual projects with weekly reporting. High scaffolded and structured. We want to be sure that every student gets the opportunity to develop relevant technical skills.
 - ECEG 301 - 3-4 per team, peer evals at the end of the project phases.
 - Capstone - 6-7 per team with defined roles of project manager (1), system engineer (1), design engineer (many). Teams are intentionally large to allow for communication and

collaboration issues to emerge that are typical of real world teams (and they typically do occur). Teams are created using a variety of information from students with a lot of focus on shared team (for meetings and work) and individual interest - no single approach has been that much better or worse than the others we have tried.

- Support - readings, team norms, peer evaluations, weekly PM discussions in capstone for JIT mentoring.
- Curricular integration
 - At least one design course every year of the curriculum, otherwise somewhat balkanized.
 - The design courses are a “thread” in the curriculum. The courses are maintained by a collaborative subset of the faculty in the dept (typically who teach them). They are the most well-coordinated part of the curriculum.
- Driver/Context of experience: Problem-based, project, client, etc.
 - ECEG 100 - build a simple IoT device
 - ECEG 201 - build IoT appliance to high TRL then make a custom application. No client.
 - ECEG 301 - address a UNSDG as a class, leverage ideas and parts from 201 if possible. Project at MVP level only since focus is on problem identification.
 - Capstone - client project
- Current challenges and pains
 - Capstone - Course is constantly making small iterations, this is time consuming.
 - Students can be highly technically focused, challenging to address context in sufficient depth.
 - Reports are time consuming to grade and there is not consistency across the department in what expectations are.
 - Student disengagement - some students are freeloaders.
 - Lots of shuffling of paper to capture and compile faculty feedback in capstone.
 - Not getting needed support from CoE to find projects now that Logan is gone. Year after year challenges of finding projects - need more focus on relationships that yield projects vs. just a single project.
 - Uncertainty of which students will go to IDSD and lack of integration. Getting ABET data from IDSD.
 - Coordinating across courses takes extra time and effort which is not accounted for in our current system.
 - Lack of integration in the first year between ENGR 100 and ECEG 100.
- Desires and future plans and things to explore
 - I would love to get away from assigning grades, it is counterproductive in a design course.
 - It would be nice to be able to continue projects in capstone past one semester.
 - Support for 2nd and 3rd year design courses - this is currently done from department funds. Students find clients to be motivating so finding ways to sponsor these projects would likely improve the course. Maybe connect with the service learning folks?
- Additional thoughts or context

- We have found it really beneficial to have ECEG 201 cover basic design and fabrication skills at almost a technician level. Since every student does their own project we know all students have some base level of fabrication skills after their second year.
- It has taken a long time to get the 3rd year design course operating well since doing project scoping and problem identification well was challenging to set up.
- The first year course is set up as partially design and partially an introduction to the rest of the program which has been quite successful.

Interdisciplinary senior design

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

Learning objectives and prioritization

Roles of those involved: Fac, Students, Staff, Client, others?

Resources: Space, funding, technology, tools/equipment

Teams: Create, maintain, support, and evaluate

Curricular integration

Driver/Context of experience: Problem-based, project, client, etc.

Current challenges and pains

Desires and future plans and things to explore

Additional thoughts or context

Mechanical

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

— students develop the following over the capstone course which is a two-course sequence: PRD (project requirement document with: project goals, value statement, statement of success, project requirements and specifications); CDR (concept design report with: concepts, virtual models with a theoretical development of the engineering science needed to apply to the particular project focus with performance predictions, develop various matrices i.e. go-no go and down selection to choose a final concept with explicit criteria defined with a rating process); FDR (final design report with: final design, build and test — must verify and validate through physical prototype and testing that the design meets ALL the specifications defined in the PRD, if not must engage in an iterative process to re-design solutions);

Learning objectives and prioritization

— take the client needs and develop a solution that adds value to the client goals; how to develop virtual models with performance prediction of particular theoretical (engineering science) relation needed to bridge the gap between the core-courses and the design solutions implemented — less emphasis on ‘teaching’ team dynamics

Roles of those involved: Fac, Students, Staff, Client, others?

— one faculty coordinator; 8 - 10 projects with technical advisors; ALL sponsored projects; weekly Zoom calls with the client, technical advisor

Resources: Space, funding, technology, tools/equipment

— project spaces across from the PDL - Dana 29-31 assigned for all projects; funding ranges from \$6000 to \$15000; tools are Mooney lab hand tools; sensors; LabVIEW, N/I instrumentation boards - PDL machining and purchases made at Lowe's or McMaster-Carr;

Teams: Create, maintain, support, and evaluate

— teams are 3-4 students; assigned mainly on interest in the project - students rate the projects from their top choice to third choice - we commit to attaining every student assigned either their top choice or second choice; technical advisor meets once a week - students use the SCRUM process to manage tasks with a dashboard - students self-assess progress and they rate each other through EnSight - technical advisor meets individually with student team to ameliorate any challenges;

Curricular integration

— MECH curriculum requires students to take a 400-level design course in BOTH thermo-fluids and mechanical systems (MECH 392 and 403 taken in the spring of their junior year and fall of their senior year); during the graphics course and the instrumentation course the students complete a design project within one semester;

Driver/Context of experience: Problem-based, project, client, etc.

—project-based with an externally-sponsored project;

Current challenges and pains

—young department - with a few folks who serve on the teaching team for senior design - some faculty advise more than one project; teamwork is hard

Desires and future plans and things to explore

—more design in the first two years to support student development in preparation for the capstone;
Additional thoughts or context

Engineering 100

Design Approach (high level): Definition of design, Outputs, Process/Steps, Evaluation, Research

Learning objectives and prioritization

Roles of those involved: Fac, Students, Staff, Client, others?

Resources: Space, funding, technology, tools/equipment

Teams: Create, maintain, support, and evaluate

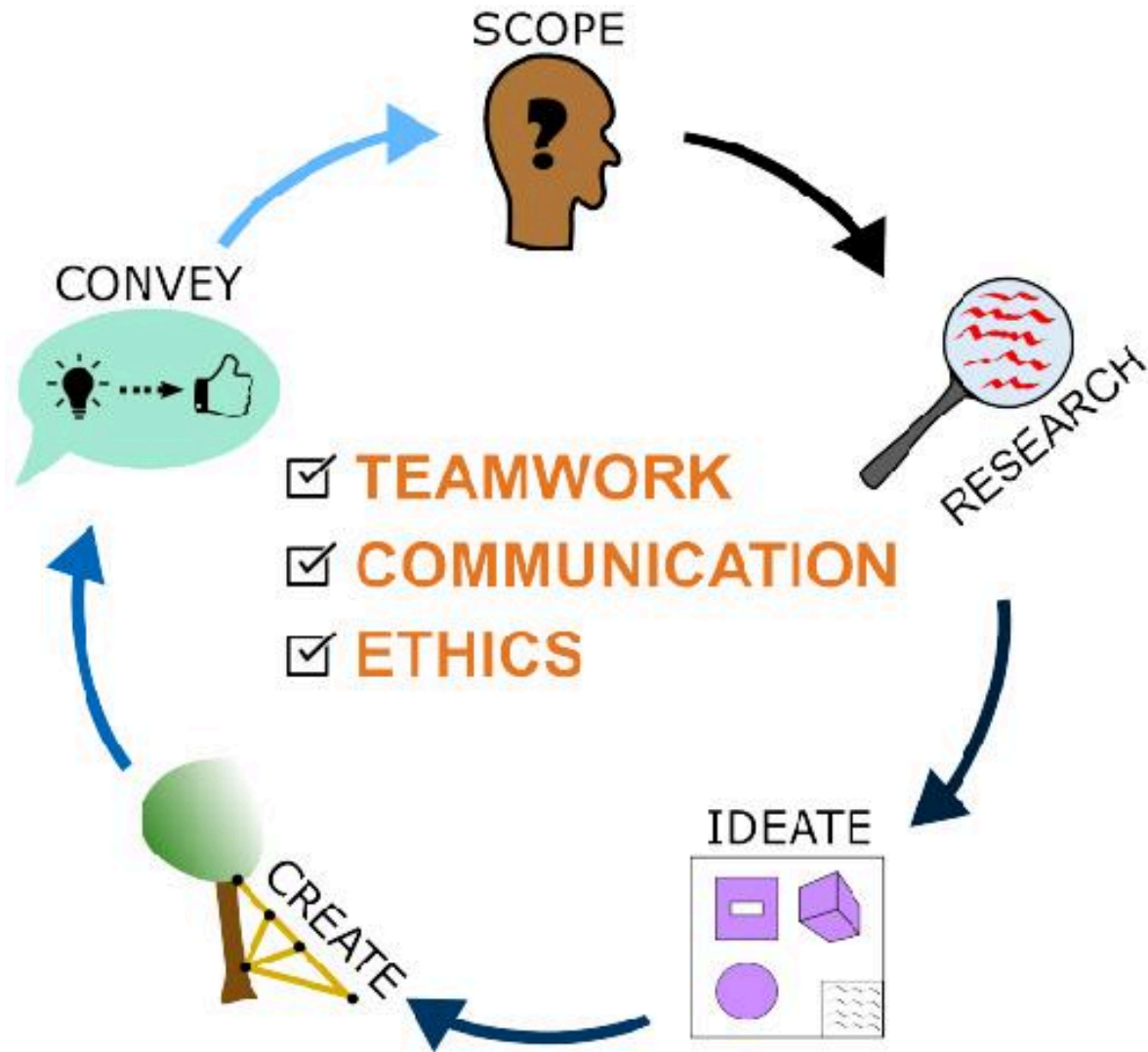
Curricular integration

Driver/Context of experience: Problem-based, project, client, etc.

Current challenges and pains

Desires and future plans and things to explore

Additional thoughts or context



ChatGPT's analysis of the responses (before cheme)

(prompt: I am leading a group that is reviewing and analyzing the engineering design experiences within a college of engineering in higher education. We have compiled a document that describes the experiences of each department (electrical and computer, civil and environmental, mechanical, computer science, biomedical, and chemical) using a set of categories: design approach, learning objectives, roles of those involved, resources, teams, curricular integration, driver and context of the experience, current challenges and pains, desires and future plans, and a category for additional thoughts. All of this is in the attached word document. for each category listed earlier, identify a list of common themes. Identify a separate list of unique themes, as well.)

Based on the provided document, here's an analysis of common and unique themes for each category across the different engineering departments:

Design Approach

Common Themes

1. **Iterative Process**: Many departments use an iterative design process involving steps like problem identification, brainstorming, prototyping, and testing.
2. **Project-Based Learning**: Design experiences are structured around real-world projects or problems.
3. **Use of CAD and Prototyping Tools**: CAD software and rapid prototyping techniques (e.g., 3D printing) are commonly used.
4. **Evaluation through Reports and Presentations**: Design outputs are typically evaluated through written reports and presentations.

Unique Themes

1. **Biomedical Engineering**: Emphasizes medical device design, including regulatory considerations like FDA approval.
2. **Civil and Environmental Engineering**: Focuses on sustainability and community engagement in design projects.
3. **Chemical Engineering**: Uses SCRUM for project management and emphasizes real clients and real-world problems.

Learning Objectives

Common Themes

1. **Teamwork and Collaboration**: Developing skills to function effectively in multidisciplinary teams.
2. **Communication Skills**: Emphasis on verbal, written, and graphical communication of technical ideas.
3. **Project Management**: Learning to manage long-term projects, including planning, budgeting, and reporting.
4. **Ethical Considerations**: Incorporating professional ethics and societal impact into design decisions.

Unique Themes

1. **Biomedical Engineering**: Specific focus on medical device development, including safety and human factors.
2. **Civil and Environmental Engineering**: Emphasis on sustainability and environmental justice.
3. **Electrical and Computer Engineering**: Strong focus on addressing UN Sustainable Development Goals (SDGs).

Roles of Those Involved

Common Themes

1. **Faculty Advisors**: Faculty provide guidance and feedback but allow students significant autonomy.

2. **Student Teams**: Students work in teams, often with assigned roles such as project manager or recorder.
3. **External Mentors/Clients**: Many projects involve external stakeholders who provide real-world context and feedback.

Unique Themes

1. **Biomedical Engineering**: Clinical mentors from medical fields play a significant role.
2. **Chemical Engineering**: Clients are heavily involved, with students working to meet real client needs.

Resources

Common Themes

1. **Access to Labs and Equipment**: Departments provide access to specialized labs, tools, and fabrication resources.
2. **Budget for Projects**: Teams often receive a budget for purchasing materials and components.
3. **Dedicated Workspace**: Students are typically assigned workspaces for their design projects.

Unique Themes

1. **Biomedical Engineering**: Specific mention of a lab director as a resource for equipment training and purchasing.
2. **Chemical Engineering**: Detailed list of resources, including specific labs and administrative support.

Teams

Common Themes

1. **Team Formation**: Teams are formed based on student interests, skills, and availability.
2. **Peer Evaluations**: Peer evaluations are commonly used to assess individual contributions.
3. **Team Contracts**: Encouraging or requiring team contracts to define roles and responsibilities.

Unique Themes

1. **Biomedical Engineering**: Teams are built blindly based on interest in clinical departments.
2. **Chemical Engineering**: Use of CATME for teamwork assessment and specific procedures for team firing.

Curricular Integration

Common Themes

1. **Design Courses Across Curriculum**: Design experiences are integrated throughout the curriculum, from introductory to capstone courses.
2. **Skill Building**: Early courses build foundational skills that are applied in senior design projects.

Unique Themes

1. **Biomedical Engineering**: A four-course design sequence with a clear progression of skills.

2. **Electrical and Computer Engineering**: Design courses are a well-coordinated "thread" throughout the curriculum.

Driver and Context of Experience

Common Themes

1. **Problem-Based Learning**: Projects are typically problem-based, with students identifying and addressing real-world issues.
2. **Student Agency**: Students often have significant input in defining their projects.

Unique Themes

1. **Biomedical Engineering**: Projects are driven by clinical needs and mentor observations.
2. **Chemical Engineering**: Structured around real clients, though local projects are used when external clients are unavailable.

Current Challenges and Pains

Common Themes

1. **Team Dynamics**: Issues with inclusive teamwork and individual accountability.
2. **Quality of Reports**: Challenges in maintaining the quality of final reports and documentation.

Unique Themes

1. **Biomedical Engineering**: Specific mention of challenges with analytical calculations and modeling.
2. **Chemical Engineering**: Finding projects that fit the course and ensuring quality work.

Desires and Future Plans

Common Themes

1. **Exploring New Project Types**: Interest in trying new project types or focus areas.
2. **Improving Teamwork**: Enhancing strategies for effective teamwork and collaboration.

Unique Themes

1. **Biomedical Engineering**: Exploring partnerships with external organizations like QL+.
2. **Electrical and Computer Engineering**: Desire to move away from traditional grading in design courses.

Additional Thoughts

Common Themes

1. **Continuous Improvement**: Departments are continuously seeking to improve their design experiences.

Unique Themes

1. **Biomedical Engineering**: Emphasis on the historical stability of their capstone design experience.
2. **Chemical Engineering**: Detailed grading strategy and project management framework (SCRUM).

These lists provide an overview of the shared and unique aspects of engineering design experiences across different departments, highlighting the diversity and commonalities in their approaches.

ChatGPT's suggestions on what categories we should add to the list.

(Prompt: What additional categories should we add to this list and why to capture the various aspects of design experiences for undergraduate engineering students?)

To capture a comprehensive picture of design experiences for undergraduate engineering students, the following additional categories could be included:

1. **Industry and Professional Involvement**

- **Rationale**: Understanding the extent and nature of industry involvement in design projects can provide insights into the practical relevance and application of student work.

- **Potential Questions**:

- What role do industry partners play in your design experiences?
- How are professional practices and standards incorporated into student projects?
- Are there opportunities for internships or co-ops related to design projects?

2. **Interdisciplinary Collaboration**

- **Rationale**: Design projects often benefit from interdisciplinary approaches. Capturing this aspect can highlight opportunities for cross-departmental learning and innovation.

- **Potential Questions**:

- Are there collaborative projects involving students from different engineering disciplines?
- How are interdisciplinary teams formed and managed?
- What benefits and challenges have you observed with interdisciplinary collaboration?

3. **Assessment and Feedback Mechanisms**

- **Rationale**: Understanding how student work is assessed and the types of feedback provided can offer insights into the learning process and areas for improvement.

- **Potential Questions**:

- What methods are used to assess student design projects?
- How is feedback provided to students throughout the design process?
- Are there opportunities for peer review or external evaluation?

4. **Sustainability and Ethical Considerations**

- **Rationale**: Increasingly, engineering projects must consider sustainability and ethics. This category ensures these critical aspects are addressed in student projects.

- **Potential Questions**:

- How are sustainability principles integrated into design projects?
- What ethical considerations are students required to address in their designs?
- Are there specific courses or modules focused on sustainability and ethics?

5. **Innovation and Creativity**

- **Rationale**: Encouraging innovation and creativity is crucial for engineering education. This category can capture how these aspects are fostered in the design process.

- **Potential Questions**:

- How are students encouraged to innovate and think creatively in their projects?
- Are there specific techniques or methodologies used to foster creativity?
- What examples of innovative student projects can you share?

6. **Global and Societal Impact**

- **Rationale**: Projects that address global challenges and societal needs can enhance the relevance and impact of student work.

- **Potential Questions**:

- How do design projects address global or societal challenges?
- Are there opportunities for students to work on projects with international partners or in diverse communities?
- What impact have student projects had on local or global communities?

7. **Alumni and Career Outcomes**

- **Rationale**: Tracking the career paths and successes of alumni who participated in design projects can provide valuable feedback on the effectiveness of the design experiences.

- **Potential Questions**:

- How have design experiences influenced the career paths of your alumni?
- Are there notable examples of alumni who have successfully applied their design skills in their careers?
- Do you have any feedback from alumni on how the design experiences prepared them for their careers?

8. **Technology and Tools**

- **Rationale**: With the rapid evolution of technology, it's important to understand the tools and technologies students are exposed to and how they enhance the learning experience.

- **Potential Questions**:

- What software and hardware tools are used in design projects?
- How do you ensure students are up-to-date with the latest technological advancements?
- Are there opportunities for students to learn about emerging technologies?

9. **Mentorship and Support Systems**

- **Rationale**: Effective mentorship and support are crucial for student success. Capturing this information can highlight strengths and areas for improvement in support structures.

- **Potential Questions**:

- What mentorship structures are in place for design projects?
- How do faculty and staff support students throughout the design process?
- Are there additional support systems, such as peer mentors or external advisors?

10. **Reflection and Continuous Improvement**

- **Rationale**: Encouraging students to reflect on their experiences can lead to continuous improvement in both their skills and the program itself.

- **Potential Questions**:

- How are students encouraged to reflect on their design experiences?
- What mechanisms are in place for continuous improvement of the design curriculum?
- Are there opportunities for students to provide feedback on their design experiences?

Adding these categories can provide a more holistic view of the design experiences, capturing various dimensions that contribute to the development of well-rounded engineering graduates.