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GIFTS: Designing Five OER Lessons for Integrating Design Thinking into Introductory Engineering Design Courses

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Abstract: This Great Ideas for Teaching (and Talking with) Students paper overviews a project at Dartmouth College's Thayer School of Engineering to design, prototype, and publish five hands-on lessons that introduce design thinking to students in introductory engineering design courses. These lessons are published as Open Educational Resources OERs with CC BY 4.0 licenses, allowing any educator to freely use and adapt the materials (with attribution). The authors of the lessons (henceforth, "project team") *practiced what they preach*, prototyping and iterating each lesson with a recruited student audience before revising and publishing.

Background: Design Thinking (DT) is now a transdisciplinary field that has diverged in important ways from its origins in, among other disciplines, engineering design (ED) in the late 20th century [1]. Crucially, most DT practitioners today have adapted: ethnographic methods to understand stakeholder needs and anticipate unintended consequences of technologies; discoveries in the brain sciences to enhance creativity and team effectiveness; and techniques from across design disciplines to navigate ambiguity and complexity. Several other OERs exist that introduce design thinking, e.g. [2] and [3]. The published lessons introduced in this project and paper augment existing available resources in four key ways:

1. **Academic content**. Much like existing OERs on design thinking, these lessons rely predominantly on active, collaborative experiences. Unlike existing OERs, these lessons include short lecturettes that ground the activities in academic knowledge appropriate for an undergraduate audience for, by example, defining terms such as "design thinking," "abductive reasoning," and "ethnography."
2. **Integration with Engineering Design terminology**. These OERs also define terms students are likely to see later in their ED coursework, such as "problem frames," "specifications," "alternatives," and "looks-like/works-like prototypes."
3. **Ease of use and adaptation**. The materials are all published as Google Drive documents and slides, thus allowing instructors to easily adapt the lessons to fit their courses. Moreover, the teaching notes include suggestions for how to do so.
4. **Designed by faculty and undergraduate students**. The five lessons were collaboratively designed (and taught) by three undergraduate students and either one or two faculty members from the school's program in Human-Centered Design (HCD). The inclusion of undergraduates on the design team may have deepened the project's empathy for the student experience and enhanced creativity.

Published OERs: Table 1 contains an overview of the topics, learning objectives, hyperlinks/QR codes to the materials, and activities. Each published lesson includes: a **Teaching Note** with a proposed timeline of the lesson along with learning objectives, key concepts, suggestions for alterations, and suggested pre-reading; editable **Slides**; editable **Handouts**; and a recorded **Demo Video** of the project team piloting the lesson (for reference by the instructor only).

Table 1. Overview of the five lessons' topics, learning objectives and key activities

Lesson Topic	Main Learning Objectives	Key Activities
1. Design Thinking & Design Process  Hyperlink	Students will: **Experience** a miniaturized design process, preparing them to experience a similar process in longer project(s) in the course **Understand** that engineering design is one of many design disciplines, and how all design disciplines share common processes, tools, and ways of reasoning about the world in order to create value	A **miniaturized design sprint** in pairs: each student designs for the needs of a partner A **lecturette on design**, design thinking, and engineering design
2. Empathy & Needfinding  Hyperlink	Students will: **Experience** using ethnographic methods to build empathy for stakeholders' experiences **Understand** the importance of centering human needs & values in the design of technology	Practice **conducting observations and interviews**, followed by a debrief A **lecturette on design research**, needfinding, and ethnographic methods (including interviews and observations)
3. Abductive Reasoning & Problem Definition  Hyperlink	Students will: **Experience** abductive reasoning as both "inference to an explanation" and the core reasoning involved in articulating clear problem statements, stakeholder needs, and requirements/specifications. **Understand** how design process is well suited for hypothesizing, testing, and revising a thesis for how to create value for stakeholders.	A **sprint from synthesizing data to drafting problem statements** for a pre-prepared case. A **lecturette on problem definition**, needs, requirements/specs, and abductive reasoning.
4. Creativity & Lateral Thinking  Hyperlink	Students will: **Experience** lateral thinking in a collaborative setting, and how identifying self-imposed constraints can unlock new pathways for creativity **Understand** how to foster creativity in groups, and the importance of separating generative activities from evaluative activities	Practice two **brainstorming methods** that highlight how self-imposed constraints can hamper innovation A **lecturette on the science and practice of creativity** and lateral thinking
5. Prototyping & Feedback-Driven Iteration  Hyperlink	Students will: **Experience** making works-like and looks-like prototypes and receiving feedback that would lead to iteration **Understand** how prototypes serve to generate high quality feedback that helps test problem definitions and early solutions	Making **works-like and looks-like prototype**s for a given case study A **lecturette on prototyping** purpose and methods, as well as seeking feedback well

Purpose & Audience: The purpose of this project was to develop five adaptable lesson plans that introduce key learning objectives from design thinking in the context of engineering design. The primary intended audience is faculty who teach ED (especially in mechanical or interdisciplinary introductory ED courses) but who may not have much experience with DT or Human-Centered Design. The five lessons can be used as a cohesive sequence, or any one lesson can be adapted and used independently. The lessons all use the same example product design

challenge, but this too might be changed to meet the needs of the instructor, course, or discipline. Each lesson plan is written for 60 minutes, with suggestions for greater depth if time allows.

Motivation: The project's PI (this paper's author) has a Bachelor of Science and Engineering, yet much of his career (and graduate studies) has been in design thinking, entrepreneurship, business, and education (without specific emphasis on engineering education). After joining the faculty at a school of engineering and ASEE, the PI received requests to help Engineering faculty at multiple institutions consider how to better incorporate DT in ED courses. While published OERs cannot replace rich dialog and co-design, these lessons might serve as useful artifacts to scaffold and scale.

Design process: The project team roughly followed Stanford's design thinking process [4]—Figure 1—for the design of these lessons, thus practicing what they preach.

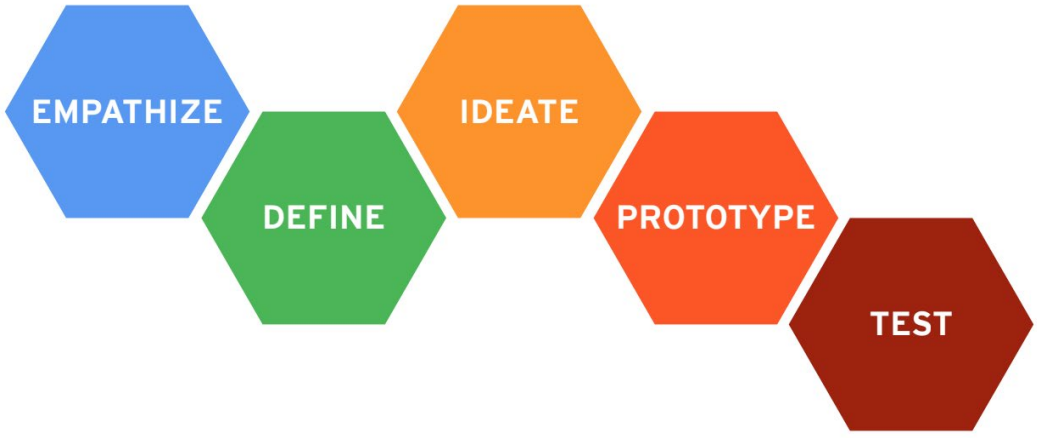

Figure 1: Design Thinking Process [4]

The project team recruited six first- and second-year students from Dartmouth and interviewed three faculty—one from Dartmouth and two from another institution. This helped the team craft learning objectives and articulate key requirements for the lessons. Next, for each lesson, the team brainstormed activities drafted lesson plans and materials. Crucially, they prototyped (and recorded) each lesson with the six recruited students and conducted follow-up interviews to assess the experience and learning. The team then iterated on the lesson plans before publication. For example, the second lesson was substantially revised after feedback. Initially, project team delivered a single lecture on ethnographic observations and interviews, then had students practice in the atrium. Follow-up interviews revealed students found the experience confusing and intimidating. In the next iteration, the introduction of the two methods was separated, and students were tasked with practicing interviews with one another instead of with strangers.

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[1] J. Auernhammer and B. Roth, "What Is Design Thinking?," *Underst. Innov.*, pp. 169–196, 2023.

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[4] Hasso Plattner Institute of Design at Stanford University, "An Introduction to Design Thinking PROCESS GUIDE." 2012. [Online]. Available: https://web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf

[1] Only included are references in this paper about the overall project. References used in each lesson are included in the published Teaching Note for each lesson.