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Fostering A Sustainable Future Through Inclusive Design

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FOSTERING A SUSTAINABLE FUTURE THROUGH INCLUSIVE DESIGN

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ABSTRACT

Fostering a sustainable future requires a balance between human necessities, societal institutions, and environmental systems; and this delicate equilibrium is best attained through strategic and innovative design. With this, and the growing diversity of our communities, it is imperative to equip engineering students with inclusive perspectives that allow them to critically assess the socio-technical elements of sustainable design. Recent research within engineering education has elevated the importance of empathy as a design practice and inclusivity as a design principle; exploring topics of bias and exclusion are essential to this work. As part of a first-year design course, we introduced these topics in a five-part instructional series, called Leading through Inclusive Design.

This series first focused on identifying exclusions in our designed world and exploring the intentionality of design. Second, students reflected on their identities and considered how biases might influence design work. Next, in the context of a re-design project, students evaluated the

exclusivity of an object and implemented learned strategies toward an inclusive re-design. Finally, by applying inclusive design principles and leadership mindsets, students were asked to develop an 'ecology' of solutions for a Grand Challenge' as defined by the National Academy of Engineering. Solving these multiplex problems around themes of sustainability, health, security, and joy of living required cultural, ethical and economic awareness beyond traditional engineering proficiencies. We describe the implementation of this series and summarize the unique outcomes of our approach for a class of predominant white, male engineering students with diverse majors and passions.

1 INTRODUCTION AND MOTIVATION

Designing solutions for a sustainable socio-technical future will only increase in complexity as we trend toward a more connected and heterogeneous world. This evolution begs design professionals whose qualifications stretch beyond the traditional engineering skillsets (Galloway 2007). It drives a need for expertise in user-centered solutions grounded in principles of inclusive design (ID) and empathetic leadership.

The challenge to engineering educators however, exists in the development and implementation of ID lesson plans. Dong (2010) highlights three such concerns at the course-level. First, the ID lessons should be strategically blended into the curriculum to avoid it being stigmatized as a stand-alone topic. Otherwise, this inadvertently leads students into a skewed view of ID as 'designing for special needs'. This is the second challenge that must be overcome and requires molding ID lesson plans to meet students where they are at, and in real-time if needed. Finally, although the value of real-world, problem-based activities in ID education is evident (Altay et al. 2016, Caswell et al. 2010, Prince 2004), implementation is often limited within a single semester-long course.

To address these needs and challenges, a five-part ID instructional series, referred to as Leading through Inclusive Design (LTID), was implemented inside a year-long design course for first year honors students with interdisciplinary interests. This course, titled Leadership by Design (LbD), hosted projects of varied scales which provided a unique opportunity to overcome some of the aforementioned logistical concerns in ID education. The five-part series was delivered over the progression of one semester of the LbD course.

The LbD course included two sections of 40 students engaged in 75-minute class sections. To encourage active participation in the LTID series, students were broken up into smaller groups depending on the activity. ID education and discourse necessitates a group which is small enough to facilitate all voices being heard but large enough to have the diverse perspectives crucial for the desirable depth of dialogue.

1.2 Our Philosophy and Approach to Designing this Series

We had two distinct goals for this series. As innovators, the learning objective was recognizing that ID practices are critical strategies in creating successful designs. As leaders, the objective was evolving beyond a passive tolerance of diversity education toward active appreciation and productive engagement with a wide variety of perspectives and stakeholders. To facilitate these learning outcomes, we took a distinctive approach to ID education – we shifted the focus from intentionally creating inclusive designs to intentionally avoiding exclusive designs. The former

mindset can encourage early-stage students to adopt a ‘check the box’ approach to engineering design practices which often manifest as superficial remedies to accessibility. In the case of teaching first-year students, we focused on avoiding intentional, exclusive design to introduce the topic without having to delve into the complexities of systemic inequities and social constructs surrounding diversity and inclusion. For an upper division course, this tactic could be broadened toward gaining a deeper understanding of unintentional exclusionary practices.

The overall teaching approach was to motivate students to take a critical lens to their current perspectives on inclusivity, and identify how and why it might be relevant to their design work. A combination of active and reflective pedagogies were implemented to achieve this. Reflective pedagogies are critical in strengthening empathic design education to account for inclusivity (Prince 2004). The reflection activities adopted for this series strategically varied in scale of collaboration and degree of guidance. Coupled with these reflective exercises were self-driven learning opportunities rooted in active learning pedagogies. These types of activities were mainly discovery- and problem-based exercises as elucidated by Cattaneo (2017).

2 IMPLEMENTATION

The themes of each of the five lessons of the LTID instructional series are described in **Table 1**.

	Session Topic	Description	Reading or Supporting Literature
Part 1	Brave Space Setting	Setting norms/expectations for engaging in this work and motivating the importance of ID in successful design	Brave Space (Brown, 2008)
Part 2	What is Inclusive Design?	Identify exclusions in our designed world and considering the intentionality of design.	Mismatch – Chapters 1 and 8
Part 3	Who is the designer?	Reflect on individual identities and consider how ones biases might influence ones design work.	Mismatch – Chapters 1 and 8
Part 4	Who is advantaged/ disadvantaged?	Evaluate the exclusivity of a chosen object and identify/ employ design strategies toward and inclusive re-design.	Mismatch – Chapter 7
Part 5	Who is the design for/with?	Assess the socio-technical elements of an engineering grand challenge and derive solutions using the learned inclusive design principles and leadership mindsets.	Mismatch – Chapter 5 and 6

Table 1: Structure of the Leading through Inclusive Design instructional series which is anchored by readings from Mismatch: How Inclusion Shapes Design (Holmes 2020)

Mismatch: How inclusion shapes design by Kat Holmes (2020) served as a foundation for structuring reflections and preparing students for the in class discussions. The pivotal concepts from each reading are summarize below.

- Parts 2 and 3 – Chapter 1 introduced the concept of mismatches in design and the idea that inclusion should be an ‘intentional choice rather than an accidental harm’. Chapter 8 provided real examples of how ID motivates innovative design.

- Part 4 – Chapter 7 introduced the human spectrum which spurred reflection on how human beings differ and how biases might impact design
- Part 5 – Chapters 5 and 6 motivate the ID mindset of ‘designing with not for’ and provides tangible strategies toward ID.

In addition to these preparatory readings which stimulated curiosity, we attribute the successful depth of dialogue attained in this series to instructors’ facilitation/engagement as equally curious students of ID. We pushed ourselves to be vulnerable in sharing our experiences and participated in group dialogue by both provoking ideas and allowing our ideas to be challenged. While some discussions were guided, many were impromptu and propelled by student-to-student dialogue.

2.1 Part 1- Brave Space Setting

Part 1 was hosted within a subdivided class session of 20 students. We first provided context for the instructional series with respect to the general LbD coursework/projects and then proceeded to introduce the concept of a ‘brave space’ in which the lessons would be facilitated.

Brave Space Contracts

To lay the groundwork for a critical exploration into ID, our first exercise was to establish the classroom as a ‘brave space’ (Brown 2010). As opposed to a ‘safe space’ where the area is intentionally free of judgement and contention, a ‘brave space’ is one in which we accept that the necessary conversations might be difficult for some, yet we engage with the dialogue in the interest of education and innovation (Brown 2010). Brave spaces encourage civil discourse on challenging topics with respect and intentionality as drivers beyond empathy and compassion. Both types of spaces offer key educational benefits. Here, we chose to focus on brave spaces to allow students to challenge one another, and their own preconceptions about inclusivity with an eye on critical analysis and depth over comfort.

We established ‘rules’ of our brave space by having students create social contracts at their shared tables. We encouraged them to sit with their closest peers at the start of this series. In these agreements, we asked them to share how they intend to abide by the expectations of their brave space and get specific about the practices they will implement. Throughout the series we would remind students of these agreements.

2.2 Part 2: What is Inclusive Design?

Coupled with a Socratic discussion on the assigned Mismatch reading, a discovery-based activity of common-place objects successfully introduced the idea of ID and motivated its relevance at depth.

Object Exploration: The World Around Us

The intended goal of this activity was to motivate ID principles as critical tools toward successful design. Allowing students to sit with their peer groups, we placed one of 6 objects on each table: an Xbox controller, an Amazon Echo, a pack of Band-Aids, an automatic soap dispenser, a computer mouse, and an Apple watch. On butcher paper, students were asked to sketch out the matrix shown in **Figure 1** and fill out the quadrants based on the object at their table. Following

this, they would rank the object on the inclusivity scale below the matrix. Finally, in silence and individually, students walked around to the different tables, reflected on the groups' assessment, and marked their own ranking on the inclusivity scale for each object. In the initial groups, students then reflected on the assessments thinking about how their evaluations may have differed from the random individual perspectives. We also introduced and discussed popular examples such as the male-biased seatbelt design, and the exclusive nature of facial recognition software toward persons with Asian features.

Key closing conversations of this part were motivated by the following four questions: "Were the designers intentionally, or unintentionally being exclusive?", "Is it possible to have a design that is 100% inclusive?" and "How might we attempt to avoid being unintentionally exclusive?" Some students made an immediate connection to questioning their implicit biases which motivated Part 3's lesson plan.

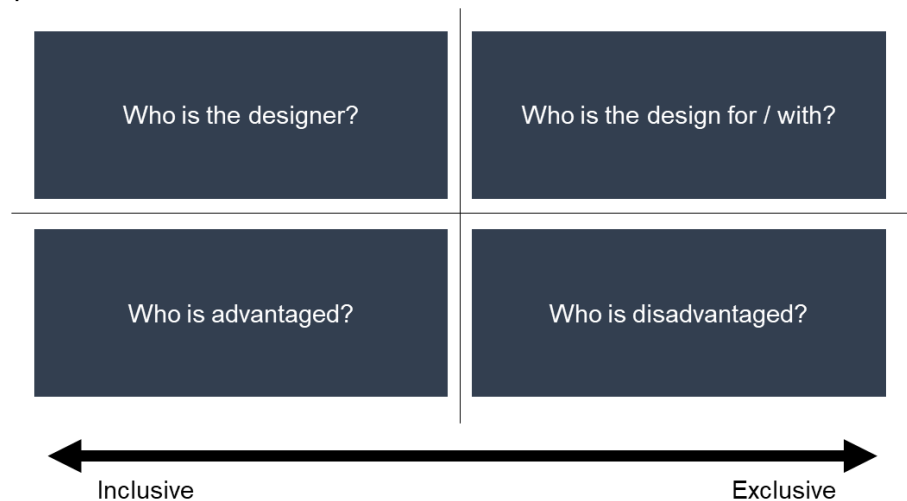


Figure 1: Rubric for Object Exploration Activity and key communication tool for topics to be explored in the LTID series

2.3 Part 3: Who is the Designer?

Using the rubric in **Figure 1** as a communication tool with students, Part 3 of the series concentrated on the upper left quadrant – exploring the identity of the designer and how/why they might influence the success of ID.

Implicit Bias Test

The implicit bias test was assigned as a preparatory class activity. Students were tasked with exploring Harvard's Implicit Association Tests (IAT) (Greenwald, 1998) and completing any two of their choice. We asked that they reflect on the results and contemplate on whether they learned something new about themselves. At the beginning of the lesson, we invited students to share their learnings and perspectives with the greater class.

Biased by Association

Following this, we introduced the notion of human identities and led a guided exploration into understanding biases as implicit products of our experiences and associations. We reflected on

whether the biases are inherently good or bad, and whether our biases align with our values. The intended learning outcome was that while we might want our design work to be steered by our values, our implicit biases can unconsciously affect the process and result. Such introspection and personal reflection were critical pre-cursors for the design sprints and discussions that followed in Parts 4 and 5.

2.4 Part 4: Who is Advantaged/Disadvantaged?

Part 4 dug deeper into the lower quadrants of **Figure 1**. Activities in this portion were intentionally aligned with helping students implement ID principles in an object re-design project that was an assignment of the LbD course. As an introductory exercise to this part (taught almost a month after Part 3), students were asked to recall the discussions on bias, imagine who might have designed their object and speculate on the designer's motivations. They were then asked to reflect on how their biases might influence their redesign work for the project before diving into the following active learning exercises.

Cards for Humanity

Cards for Humanity is an online card game by Eva Tkautz, a member of the frog design team within the creative consultancy Capgemini Invent (Eva 2012) that challenges designers to consider a diverse range of perspectives and user scenarios. Two decks of cards each describe a user and a diverse need. Examples include a person who: is confident and has an essential tremor, is impatient and anxious, is impulsive and listening to loud music, and is very caring and partially sighted. The students utilized these cards to help them imagine how inclusive their objects might be for various people. Students were challenged to explore the following questions for each scenario:

1. In what scenario is this user interacting with the object?
2. What is the user's goal with this object?
3. Is this object a match or mismatch for this user?
4. If a mismatch, what might an inclusive re-design look like for them?

Object Exploration: Our Object Redesign

Like the activity in Part 2, students used the rubric in **Figure 1** to explore the inclusivity of the object they had selected to re-design. At this point in the LbD course, students were familiar with thinking of successful design in terms of form, function, the systems it interacts with (political, social, environmental, etc.), and its life cycle. With this activity, students further developed this definition of successful design to include inclusive principles. They were able to incorporate issues of accessibility, identity, and diversity into their redesign concepts.

2.5 Part 5: Who is the Design For/With?

Part 5 of the LTID series explored the final, upper right quadrant of the inclusivity rubric in **Figure 1**. The problem-based activities in this section were facilitated by the Global Challenges final group project of the LbD course. The National Academy of Engineering identified 14 engineering Grand Challenges within themes of sustainability, health, security, and joy of living. These complex, real-world design problems with real stakeholders, provided a landscape for us to explore strategies of empathetic design. Leaning on the perspective taking skillsets that were

developed to this point in the series, students derived research questions and identified practical tools toward ID.

Identifying Empathetic Tools toward ID

We introduced the idea of empathetic design through design failures, citing published examples of visually impaired and handicapped design (Thomas and McDonagh 2013). Connecting these failures to assumptions made in the design process motivated the need for empathy in design. We used Brené Brown's RSA (The Royal Society for the Encouragement of Arts, Manufactures and Commerce) short video on empathy (Brown 2021) to introduce and define the term. From these discussions, we established that there was a third element of successful design beyond form and function and that is, feeling. The emotional connection that a user makes with the product is the root of empathetic design principles. We briefly reintroduce in discussion, the products of Part 2 such as the Band-Aid. Although successful in terms of form and function, the mismatched 'feeling', driven by the lack of skin color representation, makes it a controversial design.

Reflecting on these stimulated concepts, the question was then posed: "How could the designers of these products introduce empathy into the design process?" Students generated ideas such as having a diverse group of designers, interviewing end users, engaging with the extreme ends of the persona spectrum, and conducting research beyond the technical elements of the solution. As we progressed through this activity, students were challenged to consider how empathetic design shifts the mindset of ID from designing 'for' some user to designing 'with' a stakeholder.

Identifying Research Questions toward ID

Provided the time constraint of their Global Challenges final project, we focused on introducing research techniques as an empathetic tool toward ID. Within their project groups, they were first asked to frame a research question using the format: "How might we [tackle this problem] with [these stakeholders] to achieve [this solution]".

Next, as a group, they were tasked with mapping out three socio-technical elements of their global challenge: the system it is a part of (considering institutions such as social, political, environmental etc.), the stakeholders involved and its historical evolution.

To facilitate this, as a class, students generated a list of actionable research questions to stimulate a deeper level of investigation. A few of these crowd-sourced questions included:

- Where does the challenge exist? (country, specific area, environment)
- What makes it bearable or worse?
- What is the history of the grand challenge? Who has worked on it previously?
- Who are the stakeholders and what is the demographic/identity distribution?
- Why do we personally care? How has it been broadcasted societally/culturally?
- Who continues to benefit/suffer if we do nothing?

These questions were documented and left visible on the board for project groups to reference as they proceeded to complete the three socio-technical maps.

3 RESULTS AND FEEDBACK

Throughout the series, student written reflections (submitted as pre- and post-class assignments) provided real-time feedback. We also formally collected commentary at two instances. Prior to starting Part 3, we provided three prompts for students to quickly answer on index cards: What were their key takeaways thus far? Did they have any habits or pre-conceived ideas that were challenged by the discussions? What might they change as we move forward in the series? At the end of the course, students were asked to voluntarily complete a survey in which they ranked the success of various activities and left comments as they saw fit.

3.1 Regarding Open Discussions

There was overwhelming positive feedback on the open discussions throughout the series which we attribute to three main factors: the setting of the 'brave spaces' before each lesson, the pre-class reading assignments from Mismatch which aroused curiosity and prodded contemplation, and the vulnerable participation in discussions by the instructors. Reflections such as *"I loved the quote in which it states "Always remember that you are unique, just like everyone else." ... How can design be centred around "normal"... how is that possible when we are all different. Normal is a fantasy thus it shouldn't be the baseline for design."* and *"The class discussions were a little tense and uncomfortable (but this doesn't necessarily mean they should be removed)"* are great indicators of the depth of introspection we were able to achieve and the effectiveness of the brave space model for engaging students. The second student quoted above ranked these discussions at the highest level of success on the feedback survey.

3.2 Regarding Exploration of Individual Biases

The IAT activity was less effective than we anticipated and could be replaced with a more in-depth exploration of individual identities and biases. After taking the IATs, student discussion focused on feeling 'tricked' by the questioning which generated a lot of doubt in the results and hindered genuine reflection on their biases. *"I would have greatly appreciated digging deeper into the implicit biases portion of the series."* While some students, were wanting to 'dig deeper', the large group of particularly early-stage students proved to be a challenge for brave space setting and was not conducive for vulnerable discourse. That said, self-reflections submitted after class revealed that students did connect with the material and the learning outcomes were achieved.

3.3 Regarding Active Learning Pedagogy

Object Exploration

The object exploration activities of Parts 2 and 4 were favourites based on the feedback survey. The use of common place objects in Part 2 had a particularly unique outcome in cultivating a deeper appreciation for diversity in a white, male dominated classroom. The Colorado School of Mines has a majority white (68.3%), male (68.3%) population (Diversity, Inclusion, and Access Committee 2022). The LbD course remained true to the gender distribution and had a significant number of white students (80%). For the following students, the activity challenged their perspectives and revealed the hidden 'mismatches' of the designed world.

"It was unexpected just how exclusive many designs are. From male crash test dummies only being used up until recently, or the soap dispenser's blindness towards dark skin, my perspective shifted due to these examples and made me really want to be intentional with inclusivity rather than leaving it up to chance."

“The perspective that challenged my views the most were from students of color who expressed that they did not really care about certain design choices [such as the Band-Aid color] as long as the object was functional.”

“I realized that I struggled to think far outside my background and this challenged my thinking about inclusivity”

Cards for Humanity

For the following students, the Cards For Humanity was a tangible tool that assisted them with perspective taking as they re-designed their objects. Many reflections mentioned realizing that accessibility and price were not the only barriers to inclusivity.

“I loved trying to find solutions for different people and recognizing that there are solutions that already exist for mismatches I had never considered.”

“The way some of the cards were not the obvious blind or deaf, but colorblind and stuff made it a lot more nuanced and opened my eyes to it.”

Identifying Empathetic Tools and Research Questions toward ID

As one student aptly reflects, *“Design is not always purely logical. People’s emotions and perceptions should be a huge consideration in the design process.”* The investigation of design failures was a successful, light-hearted approach to introducing a potentially triggering topic of empathetic design. It was well suited for the early-stage student demographic. The strategy of student-led questioning and brainstorming in these activities were also definite victories over lecture-style delivery. This is evidenced by the following student’s attestation.

“In the past, I felt like research on a problem could only get me so far in the design process, and I didn’t really value intensive research on problems. Through our inclusive design series, I saw how that research could be empathetic training on the subject rather than being limited to researching prior solutions. It helped me to see how spending time on design in that way was beneficial to my design.”

4 CONCLUSIONS AND SUMMARY

Introducing ID principles in engineering education is an imperative toward building a sustainably designed future (Holmes, 2020). The LTID instructional series approaches this challenge by empowering students, as leaders, to capitalize on the strengths of diversity in their design work. Noting the development and implementation challenges that many educators have faced in introducing ID principles in the classroom (Altay et al. 2016, Caswell 2010 and Dong 2010), we embedded this series within an established first-year engineering design course, LbD.

LTID was successfully structured such that the activities facilitated student process work as they tackled the major design projects of the LbD course. Integrating the ID lessons across active design projects helped students appreciate ID as an essential part of successful design. Students discovered that bringing in multiple perspectives in research and in the interventions that they designed, led to more sustainable and synergistic solutions to the grand challenges.

Our approach achieved successful outcomes in a class of 80 first-year, engineering students with little race and gender diversity but strongly varied societal interests and interdisciplinary degrees. As evidenced by student feedback, the instructional series not only motivated ID principles as tools toward successful design but did so by cultivating leadership mindsets which fundamentally celebrate diversity and equity.

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