



Kendell Miller-Roberts MDES '22

MAKING JUSTICE

Designing for Diversity, Equity, and Inclusion in Engineering Curricula

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Candidates, MDes
University of Michigan
Spring 2022



UNIVERSITY OF MICHIGAN

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Abstract

The recent revived focus on Diversity, Equity, and Inclusion (DEI) education has prompted universities to reconsider how their undergraduate curriculum integrates DEI topics as a critical component of civic education and social engagement. This focus is significant within engineering education because it is becoming increasingly pressing for Science, Technology, Engineering, and Math (STEM) fields to recognize how the socio-technical aspects of their work are tied together. Recent engineering education literature has highlighted faculty's important role in incorporating DEI content into the engineering curriculum (Garibay et al. 2020, Jiménez et al., 2019, Jiménez et al. 2020, Killpack and Melón 2016, Secules and Masta 2020). However, this problem has not been approached through a design research methodology. My research utilizes an integrative design methodology to understand how DEI education is created within undergraduate engineering classes at the University of Michigan-Ann Arbor. My research presents a card deck based on the Significant Learning Taxonomy (Fink, 2013) as a potential avenue for increasing the integration of DEI content into undergraduate engineering curricula.

Keywords

Diversity, Equity, and Inclusion (DEI), integrative design, engineering education, card deck, curriculum design

Glossary

Throughout this paper, I will refer to Diversity, Equity, and Inclusion (DEI) in four avenues. I am specifying these terms to clarify how I used them throughout my research and will use them throughout this paper. I came up with these terms to better delineate between various ideas within Diversity, Equity, and Inclusion. The first way is what my research is focused on: DEI topics and content, and how we integrate those into undergraduate engineering education. This means that I am talking about the topics or content that make up a DEI education, such as identity, power, privilege, accessibility, et cetera. The second avenue is DEI education. This refers to an educational curriculum that integrates DEI topics into and across its curriculum. The third way I will refer to DEI is training. This is what many people consider when they think of DEI. A training that aims to educate its participants around areas of bias, and prejudice, often in the context of work and business. The last way that DEI is used in my paper is through DEI values. This is when DEI functions as a set of values that an organization, business or any other entity holds.

Though my research is focused on DEI content and DEI education, dominant narratives of DEI training and DEI values are inherently intertwined in the ongoing conversation surrounding DEI, and some attention in my work to DEI training and DEI values are needed. As such, I do my best to draw the distinctions between what dimension of DEI (content, education, training, and values) I am talking about and how it relates to my work.

DEI Content and DEI Topics - This focuses on the actual topics that are discussed within DEI education. Including but not limited to power, privilege, identity, accessibility, et cetera.

DEI Education- This refers to an education that incorporates DEI topics/content into and across its curriculum. In the context of my work, it refers to the context of higher education.

DEI Training - This refers to what many people consider when they think of DEI. A training that aims to educate its participants around areas of bias, and prejudice, often in the content of work and business.

DEI Values - This is when DEI functions as a set of values that an organization, business, or any other entity holds.

Preface

Personal Background and Motivations

I was adopted from China when I was an infant and raised by two moms. When I first started learning how to type on a computer, I noticed that anytime I wrote “moms” or “mothers,” the word document would tell me I had the incorrect spelling. As I reflect, I recognize that the spelling algorithm was only programmed to recognize “mom” or “mother” as a singular noun, without the possibility of having two. This daily experience was my first encounter with how principles of DEI and engineering could interact.

I spent most of my life training in dance (ballet, modern, and jazz). The world of science, math, and engineering always seemed foreign to me. It wasn't until I went to college that I found a passion for all things related to social justice and human rights—including the advocacy and dissemination of diversity, equity, and inclusion education. Though I am not formally educated within an engineering discipline, I was trained to believe that the bounds of human rights education are not constrained to any one specific subject. When I entered graduate school, I was looking for a way to strategically think about how we begin to tackle our time's complex human rights issues. In the summer of 2021, during my graduate cohort's fieldwork in Boston, one of the designers I was able to speak with said something that stuck with me. He said, “There are a lot of important issues in this world. What may be even more important than the issues themselves, is how we solve them.” My thesis project is my attempt to join the ongoing conversation around the integration of DEI education within higher education and to dive into that “how,” the continued process and challenge of fully integrating DEI content into higher education by drawing from design methodologies and methods.

My first motivation for this project is my involvement with the Center

for Socially Engaged Design (C-SED) at the College of Engineering at the University of Michigan (U-M). When I began working with C-SED in the summer of 2021, I began engaging with stakeholders and educators actively working in this space and thinking deeply about issues of representation, power, and inclusive practices in classrooms and within learning content. Given the dominant narrative of engineering in society, these conversations were refreshing and empowering. I chose to focus my research on engineering because I wanted to use my design research as a vehicle to aid the process of integrating DEI content into the undergraduate curriculum at the College of Engineering.

My second motivation for this project is my deeply held belief that DEI education should be fully integrated into higher education. I should state upfront that I do not believe that a DEI education and DEI training will solve every social justice issue. No social justice framework is perfect. DEI as a framework for values has its own issues and considerations worth investigating. However, the increased focus on DEI values and training within the United States during this time calls us to consider why DEI is the framework organizations, institutions, and businesses gravitate towards when attempting to address broader social inequalities and inequities.

DEI is not really about “diversity, equity, and inclusion,” though. It's about representation, power, and belonging. DEI as a framework for values forces us to confront issues that we would rather not discuss. It is uncomfortable topics packaged in a digressive three-word framework. DEI education is an entry point for which we can gather and dive into these conversations with deep reflection. It is a framework that can call in those who have been working in social justice spaces their entire lives and those who have never thought about social issues once. The integration of this framework into education, particularly higher education, has never been more important.

While I will not be able to cover the depth and breadth of all the topics

relevant to the integration of DEI content into higher education in my work, I hope that my work can contribute to this ongoing and nuanced conversation. I believe that learning spaces can function as a site of transformative change for all those open to discovery within the self and with others. I believe that the integration of DEI content within higher education challenges all educators to become better by calling us into a necessary and frequently uncomfortable conversation about belonging and power. Any solutions to 21st-century problems that are not diverse in community, inclusive by practice, and equity-centered at every stage of the process have a high chance of yielding results that fail to redistribute power. So, as educators, it is our responsibility to meet this call of the integration of DEI content and help prepare all learners to the best of our ability.

Assumptions and Positionality

While conducting this research project, I was a graduate student at the Stamps School of Art and Design at the University of Michigan-Ann Arbor. I identify as an Asian-American, cisgender female. Other identities I have are being able-bodied, and being a United States citizen. My positionality as a graduate student at the university where my research took place was my most salient identity while conducting my research. I readily acknowledge that I am an outsider to the engineering discipline both by formal training and culture. I reflect continuously on this point in my project and have done my best throughout the research process to remain reflexive about my positionality and how it influences my work.

One of the first assumptions I would like to point out about my project is that DEI content should be integrated within higher education. I do not question whether or not this is true. As such, I write to my audience with the intention that they share this belief. My second assumption is that educators are willing and ready to wrestle with the tough conversations when it comes to integrating DEI content

and actually teaching these topics to students. While I acknowledge that not all educators feel this way, I do not attempt to convince educators otherwise. Just as those who research and write about intimate partner violence do not attempt to convince their readers why violence and abuse is wrong, I do not try to persuade educators on the “why” and the “if” of integrating DEI content. If DEI content is to truly be integrated as a learning topic for all higher education courses, then we must shift our mindset from questioning “if” to “how.”

While I recognize that not all educators share my beliefs, I have made the intentional decision to approach my work with the mindset that my design research should aim to challenge dominant power structures and beliefs, including those that only regard formal research literature as valid forms of knowledge. As such, I may draw from my own experiences and other sources of knowledge in writing and contextualizing my work. Throughout the various human rights, social justice, and design spaces I have been a part of, I have heard over and over again that we must acknowledge the lived and tacit expertise of those around us, especially those who are closest to the problems we seek to address. If that is true, then research must also leave room for acknowledging how the researcher’s lived experiences and identities actively shapes their work, and not always in a “biased” or negative way.

I did my best to reflect on how any assumptions related to my work revealed themselves and caused my project to move in certain directions based on assumptions I might be making. There are limitations to my research, which will be discussed later on. In the spirit of transparency, I wanted to leave room for reflecting on my background, motivations, positionality, and assumptions of this project before discussing the work. I hope that this helps the readers of my work better understand the origins of my project and the active role I play in engaging with my research topic and the ongoing movement towards social change.



INTRODUCTION

The Problem

From the roads we drive on and to the facial recognition software in our phones, we are deeply affected by the decisions that designers make to shape the world around us. Engineers, in their own right, are designers, and the designs they create can have a profound impact on the world we live in. For example, facial recognition software can be used to help find missing people, increase security, as well as complete more menial

tasks such as identifying photos of certain people on our phones. However, facial recognition software has been used in ways to violate people's privacy rights as well as perpetuate racial discrimination. In 2014, a research study at Duke University collected facial recognition data of students on campus without the consent of all students whose faces were captured (Satsky, 2019). The public data set went on to be downloaded by other academics and others around the globe via a public website (Satsky, 2019). Research also continues to demonstrate that facial recognition technology has a higher inaccuracy rate for darker-skinned people, specifically for darker-skinned females (Buolamwini and Gebru, 2018). Efforts to stall or completely stop facial recognition software—especially by agencies such as the police or government—continue. In 2019, San Francisco banned the use of facial recognition software by police and other agencies (Conger et al., 2019). Though there are many subfields within engineering, the societal implications of the development and dissemination of facial recognition highlight a few important points about engineering in the 21st century.

The first point highlights how the designs we create can have inequitable and disparate effects. Twenty-first-century issues such as climate change, water access, and healthcare continue to be some of the most pressing problems facing even the most wealthy countries in the world. Tackling these issues will require engineers to acknowledge how dominant systems of oppression such as white supremacy, capitalism, and patriarchy are actively working against efforts to meet even the most basic needs and rights of humans and the planet. Given the complexity of these challenges and the essential need for collaboration in creating potential solutions, the engineers of tomorrow must be able to radically reimagine and implement futures that are more diverse, inclusive, and equity-driven.

The second point is that for future engineers to create more socially just futures, education on topics of Diversity, Equity, and Inclusion (DEI) must be fully embedded into their undergraduate education. A

tremendous amount of research has been analyzed on the relationship between undergraduate education, identity formation, and cognitive development (Pascarella et al., 2016). However, this integration effort comes with a significant challenge. Engineering education has faced popular criticism over its lack of ability to educate engineers around complex social contexts and instead focus heavily on developing technical skills and knowledge. Despite these criticisms, there is a growing body of support for integrating DEI topics into the curriculum. On March 31, 2021, the Big 10+ Universities Deans of Engineering (including the College of Engineering at the University of Michigan-Ann Arbor) wrote to the Accreditation Board for Engineering and Technology (ABET) in support of its incorporation of DEI into ABET's General Criteria for Accrediting Engineering Programs (ABET, 2022). The letter reads:

“...We believe that diversity, equity, and inclusion (DEI) are core values for all engineers, and are essential considerations for generating creative and effective solutions to the most important challenges facing our society and our planet. By creating a culture within our engineering programs where diversity, equity, and inclusion are considered to be a prerequisite to excellence and impact, our students will be prepared to develop technological solutions to society's most pressing problems and to combat prejudice, racism, and discrimination during their careers...”

The Big 10+ Universities Deans of Engineering continue to write,

“...It is also important to note that many engineering students do not interact with other diverse groups of students until they attend college and begin their undergraduate studies. Such opportunities to personally experience and learn from and about other diverse perspectives are often limited during high school. So the undergraduate curricu-

la becomes the ideal venue to inform students about DEI concepts and the importance of listening and learning about diverse opinions, perspectives and point of views...”

This call to incorporate DEI into undergraduate education leaves educators with the task of integrating DEI into curricula in addition to meeting the field’s educational standards of skills and knowledge. Previous literature from engineering education continues to highlight the various barriers and challenges to integrating DEI content into engineering education and the resistance from faculty (Armanios et al. 2021, Garibay et al. 2020, Leydens 2013, Rogers and Valdez 2021). However, I have yet to come across the problem being researched through design methods and methodologies. As such, I propose that creating a design intervention through integrative design research will ultimately help engineering educators integrate DEI content into their classes.

The Design Intervention

My project topic focuses on integrating DEI content within undergraduate engineering education at the University of Michigan-Ann Arbor. To address this challenge, I utilized design research and design methods to uncover insights and potential intervention points to increase DEI content integration into engineering education. Thus, I chose to utilize qualitative design research to better understand how current engineering faculty develop DEI content within their curriculum and what challenges they face. From this research, I prototyped a card deck for engineering educators that will help them strategically link learning objectives, DEI content, and learning activities.

The card deck is divided into different sections, with each section having its own objective. The three sections are Learning Dimensions, DEI

Topics, and Learning Methods. The first section of the cards, Learning Dimensions, is based on the Significant Learning Taxonomy (Fink, 2013). This section of the cards aims to help educators identify which learning dimension they are most focused on when teaching DEI topics in their class. The second section, DEI Topics, is comprised of various DEI topics that educators may incorporate into their classes based on their field. The last section of the cards, Learning Methods, functions to help educators consider which teaching tools they may use in the classroom for the DEI topics. The goal of the card deck is to help engineering educators strategically link learning objectives, class methods and activities, and DEI topics in their course design.

Given the flexibility of card decks in general, the deck I have created could be used in a few different ways. The first is to use each section of the cards along with the visual maps I used in my research stage (bullseye targets, grids, etc). The second way is to simply lay them out to prompt conversation. The last is a workshop that would be run by course design facilitators and experts. The advantage of this card deck is that it can be used in a myriad of ways and adapted for each specific context. This card deck aims to help engineering educators begin the process of revising, adding, or further integrating DEI topics into their courses.

Research Topic and Objectives

My research topic focuses on the integration of DEI content within undergraduate engineering education at the University of Michigan-Ann Arbor, one of the top engineering colleges in the United States. My research question is, “How do engineering faculty design DEI content for their undergraduate classes?” As a graduate student in the MDes in Integrative Design Program (Stamps School of Art and Design), I sought to understand the range of responses to this question and

more sub-questions through my qualitative integrative design research project. Through a case study methodology, my thesis analyzes the design of DEI content and how U-M engineering educators approach DEI content creation, and the pedagogical decisions they make given the learning context of their discipline.

My research objective was to gain a better understanding of how current engineering faculty develop DEI content within their curriculum, what topics they choose, and why they choose those topics. By researching this process, I hope to show that in order to more fully integrate DEI content within the engineering education curriculum, there needs to be a greater emphasis on strategically linking learning objectives, DEI content, and learning activities when teaching DEI content within classrooms.

Contribution to Integrative Design

My research and design work presents a challenge inherently grounded in integrative design. The struggle of how to link DEI learning objectives, content, and the appropriate activities is challenging—especially in a field that has long viewed itself as apolitical. To adequately address the challenge of integrating DEI content as a fundamental component of engineering education, it will require merging interdisciplinary perspectives, theories, and stakeholders. By combining traditional qualitative methods, design methods, and educational theory, my work is grounded in the interdisciplinary nature of integrative design. My research moves from the standpoint that integrative design is a process, not a subject on which the research is focused.

While my thesis is set within undergraduate engineering education, I aim to demonstrate through my research the importance of integrating DEI content across all disciplines within higher education. When I

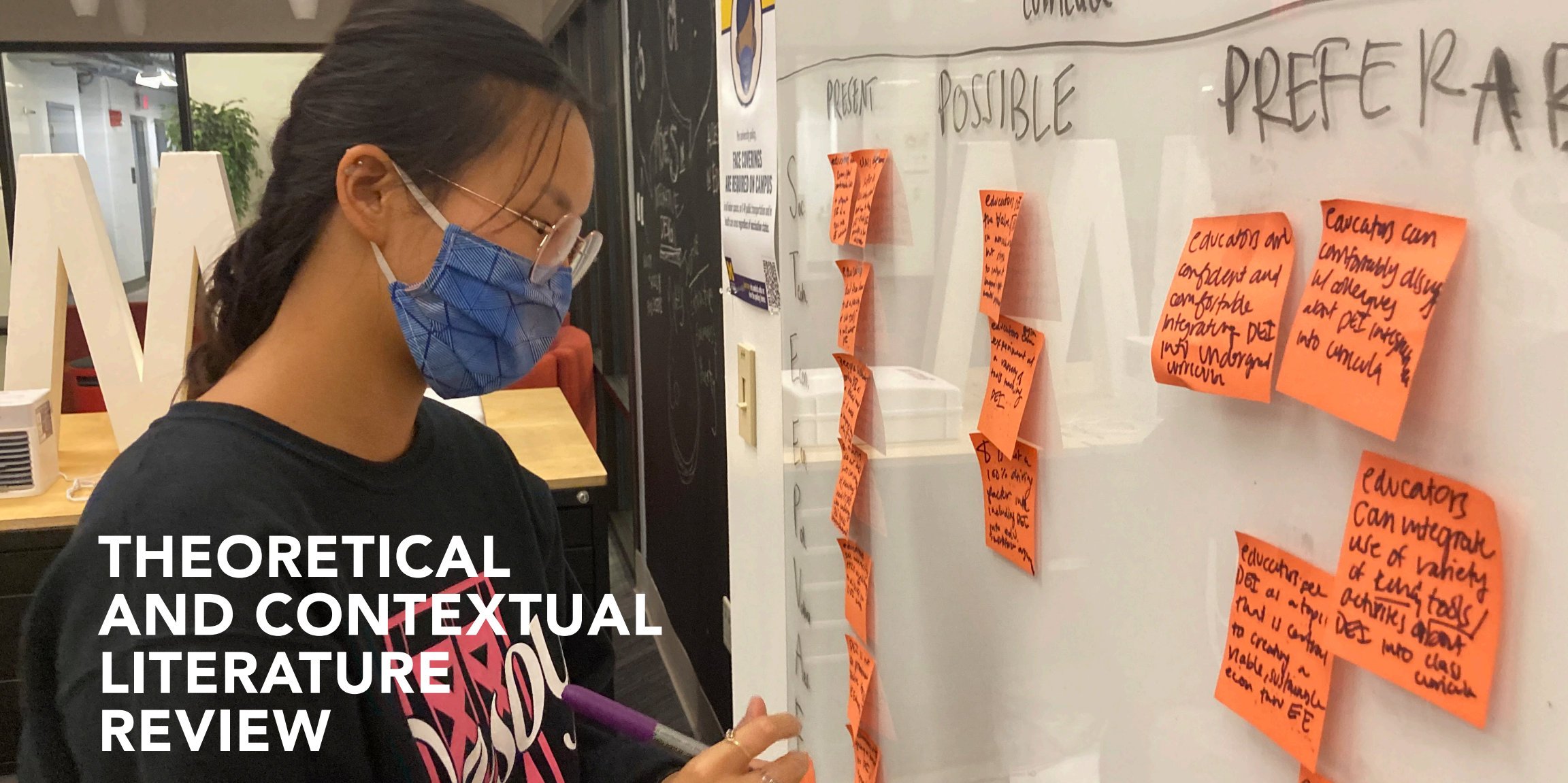
tell people about my work, most people immediately assume that I am working on upholding or increasing DEI itself in engineering education. My work is not focused on assessing how well the College of Engineering is upholding DEI as a value of practice or action. Rather, my work focuses on how we teach DEI topics to students in the first place.

I consider the practice of teaching and learning to be a sacred relationship and force within this world. As the challenges of the 21st century become more complex and nuanced each day, educators' pedagogical and course design practice must become more reflexive, critical, and thoughtful. Our ability to create socially just futures will be shaped mainly by how well we can educate and train future generations on the importance of upholding the dignity of those around us. Crafting engineering courses where DEI education is fully embedded necessitates a process that is inherently integrative in its design.

Relation to Program Theme and Cohort

Topic

As a member of the sixth cohort of the MDes in Integrative Design Program, my cohort has been working under the specific topic of “Making Justice” under the larger umbrella theme of “Equity and Access.” My research addresses the cohort topic by examining the integration of DEI education as a legitimate and necessary topic of justice to be integrated within engineering education. It falls under the umbrella theme by exploring how an integrative design process can address helping educators craft more thoughtful course design when teaching DEI topics in their courses.



THEORETICAL AND CONTEXTUAL LITERATURE REVIEW

I will begin this theoretical and contextual literature review by first defining diversity, equity, and inclusion, and discussing the context of the University of Michigan-Ann Arbor and the culture of engineering. I will then review the relevant literature regarding DEI content in engineering education, design, and the Significant Learning Taxonomy. Lastly, I will review previous card decks from the fields of design and education that

precede my work.

Defining Diversity, Equity, and Inclusion

Despite fairly visible and widespread public declarations, there is no one singular definition of Diversity, Equity, and Inclusion. Nor is there one singular agreed-upon framework of what topics are included in DEI education. I believe this presents both a challenge and opportunity for the emergence and incorporation of DEI education into higher education. In order to define DEI within my research, I will examine how DEI has been defined within my research setting (Michigan Engineering), the Association of American Colleges and Universities (AAC&U), the Accreditation Board for Engineering and Technology (ABET), and within the literature.

Definition	University of Michigan - College of Engineering (Michigan Engineering, 2016)
Diversity	We recognize that many dimensions exist that describe human beings and speak to the human experience, such as race and ethnicity, gender and gender identity, sexual orientation, socio-economic status, language, culture, national origin, religious commitments, age, (dis)ability status and political perspective. We commit to work assiduously to broaden the diversity of our community, to promote and extend opportunities and outcomes for all members of our community, and to develop a campus environment in which each individual can realize his or her full potential.

Equity	We commit to working actively to challenge and respond to bias, harassment, and discrimination. We are committed to provide equal opportunity for all persons and do not discriminate on the basis of race, color, national origin, age, marital status, sex, sexual orientation, gender identity, gender expression, disability, religion, height, weight or veteran status as
Inclusion	We commit to pursuing deliberate efforts to ensure that our college is a place where differences are welcomed, different perspectives are respectfully heard and where every individual feels a sense of belonging. We know that by building a critical mass of diverse groups and creating a vibrant climate of inclusiveness, we can more effectively leverage the resources of diversity to advance our collective capabilities.

Figure 2.1 University of Michigan DEI Definition

Definition	Association of American Colleges and Universities (AAC&U, 2022)
Diversity	Individual differences (e.g., personality, prior knowledge, and life experiences) and group/social differences (e.g., race/ethnicity, class, gender, sexual orientation, country of origin, and ability as well as cultural, political, religious, or other affiliations).
Equity	The creation of opportunities for historically underserved populations to have equal access to and participate in educational programs that are capable of closing the achievement gaps in student success and completion.

Inclusion	The active, intentional, and ongoing engagement with diversity—in the curriculum, in the co-curriculum, and in communities (intellectual, social, cultural, geographical) with which individuals might connect—in ways that increase awareness, content knowledge, cognitive sophistication, and empathic understanding of the complex ways individuals interact within systems and institutions.
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Figure 2.2 AAC&U DEI Definition

Definition	ABET (ABET, 2022)
Diversity	Diversity is the range of human differences, encompassing the characteristics that make one individual or group different from another. Diversity includes, but is not limited to, the following characteristics: race, ethnicity, culture, gender identity and expression, age, national origin, religious beliefs, work sector, physical ability, sexual orientation, socioeconomic status, education, marital status, language, physical appearance, and cognitive differences.
Equity	Equity is the fair treatment, access, opportunity and advancement for all people, achieved by intentional focus on their disparate needs, conditions and abilities. Achieving equity requires understanding of historical and systemic patterns of disparity to address and eliminate barriers, and remove participation gaps as part of a comprehensive strategy to achieve equitable outcomes and social justice.

Inclusion	Inclusion is the intentional, proactive, and continuing efforts and practices in which all members respect, support, and value others. An inclusive environment provides equitable access to opportunities and resources, empowers everyone to participate equally,
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Figure 2.3 ABET DEI Definition

The above definitions share similarities and differences between the organizations. The definitions for “diversity” are similar in content, with a focus on the diversity of identities. However, the definitions for “equity” and “inclusion” are defined slightly differently. Michigan Engineering’s definition of “equity” focuses on challenging bias and harassment and uplifting equal opportunity but fails to address any actions towards access given the historical underinvestment in marginalized communities. AAC&U and ABET’s definitions of “equity” both touch on systemic disparities in some way and mention closing the achievement or participation gaps. For the definitions of “inclusion,” one similarity across all organizations is that they all mention the concept of being “intentional” or “deliberate.” The AAC&U and ABET go a step further with their definitions of “inclusion,” with the addition that inclusion is an ongoing or continuing process that needs attention and effort. These definitions, despite the differences in their specific diction, demonstrate a common thread of understanding between the concepts. I will define DEI as the following throughout my paper.

Diversity	Diversity is the range of human differences, encompassing the characteristics that make one individual or group different from another. Diversity includes, but is not limited to, the following characteristics: race, ethnicity, culture, gender identity and expression, age, national origin, religious beliefs, work sector, physical ability, sexual orientation, socioeconomic status, education, marital status, language, physical appearance, and cognitive differences.
Equity	Equity is the fair treatment, access, opportunity and advancement for all people, achieved by intentional focus on their disparate needs, conditions and abilities. Achieving equity requires understanding of historical and systemic patterns of disparity to address and eliminate barriers, and remove participation gaps as part of a comprehensive strategy to achieve equitable outcomes and social justice. (ABET, 2022)
Inclusion	The active, intentional, and ongoing engagement with diversity—in the curriculum, in the co-curriculum, and in communities (intellectual, social, cultural, geographical) with which individuals might connect—in ways that increase awareness, content knowledge, cognitive sophistication, and empathic understanding of the complex ways individuals interact within systems and institutions. (AAC&U, 2022)

Figure 2.4 DEI Definition

Structure and Culture of Engineering

Before moving into the theoretical framework of my research, I want to spend time understanding the culture and context that my work is situated within. Dominant narratives in society about engineering paint the discipline as mostly White and male. Statistics on racial diversity in engineering confirm that the discipline is still relatively homogenous in terms of representation. In 2015, white professionals made up approximately 67% percent of all scientists and engineers, Asians make up 21%, Hispanic professionals at 6%, and Black professionals at 5% (NSF, 2017). When looking at the educational statistics of engineering education, there is a similar trend in racial representation. In 2019, white students accounted for 60.7% of all Bachelor's degrees awarded, while Asian students accounted for 14.7%, Hispanic students at 12.1%, and Black students at 4.4% (ASEE, 2020).

In addition to the field's racial imbalance, there are also major gaps in terms of gender diversity. Women make up 29% of all working engineers and scientists (NSF, 2017). In 2015, white women make up the majority of working professionals at 18%, Asian women at 7%, Hispanic women at 2% and Black women at 2% (NSF, 2017). In 2019, 77.5% of all Bachelor's degrees were awarded to male-identifying students, and only 22.5% were awarded to female-identifying students (ASEE, 2020).

While the statistics of representation of the field can provide us a snapshot of the field, we need to understand the relationship between engineering education's culture and the implicit values it holds.

Two ingrained, unconscious values that dominate engineering culture are depoliticization and meritocracy (Cech, 2013). Depoliticization in this context refers to the belief that engineering is apolitical and technical, and that all matters regarding human and political dimensions are distant from engineering and not necessary to integrate. Meritoc-

racy refers to the belief that individual talent, knowledge, and ability are the basis for achievement and justifies systems of inequality and oppression. These ideologies not only reinforce each other, they also inhibit engineering students from being able to consider social justice issues (Cech, 2013). Furthermore, Cech (2013) argues that it is not enough for social justice topics to merely be introduced to engineering students, but that depoliticization and meritocracy must be confronted when teaching social justice topics to students.

Additional research shows that an engineering student's interest in their responsibility to the public welfare actually decreases over their undergraduate engineering education (Cech, 2014). Cech (2014) further defines engineering culture by calling it a culture of disengagement which includes depoliticization, meritocracy, and technical/social dualism. (The technical/social dualism allows for a cognitive separation between technical competencies and social competencies as it relates to public welfare or interest.) A culture of disengagement promotes public welfare concerns to the margins of engineering practice. Furthermore, in order to change a culture of disengagement, engineering must confront its ideological pillars (Cech 2013, Cech 2014).

The structure of engineering education also recognizes the need for students to be able to take into consideration the broader social and environmental contexts. Two notable student outcomes as outlined in ABET's "Criteria for Accrediting Engineering Programs" are as follows (ABET, 2020):

2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering

solutions in global, economic, environmental, and societal contexts.

The structure of engineering education shows us that future engineers must be able to consider context when conducting an engineering practice and that this should be an expected outcome for students in an engineering program. The culture of engineering as defined by Cech (2013, 2014) demonstrates that the cultural pillars of engineering must be confronted when attempting to embed DEI content within the curriculum.

DEI Education in Engineering Curricula

Previous literature from engineering education continue to highlight the various barriers and challenges to integrating DEI content into engineering education (Armanios et al. 2021, Garibay et al. 2020, Rogers and Valdez 2021). One recent qualitative study identified three broad categories that influence the integration of DEI into systems engineering education: curriculum development (DEI content), educators development (DEI education of colleagues), and course design (pedagogy) (Rogers and Valdez, 2021). The differentiation between content and pedagogy is important in both the literature as well as my research because the two topics are intertwined and influential in creating an inclusive classroom experience for students. The three dimensions identified (Rogers and Valdez, 2021) mirror a previous study done that utilized four dimensions (course content, teaching methods, faculty, and students) for an analysis of integrating DEI content into courses (Sciame-Giesecke et al., 2009). But what about students? In a large quantitative study within software engineering, students were asked to read papers on diversity within the tech industry, and the challenges that various marginalized communities face within the industry (Murphy et al., 2021). While there was some feedback given regarding the

inclusion of the content in the curriculum, results from this study were encouraging; most students did engage with at least one of the papers and provided positive feedback on the integration of the readings into class (Murphy et al., 2021).

However, Integrating DEI content into engineering education continues to be a challenge. Previous studies have identified that the role of faculty in incorporating and teaching this content in classrooms is extremely important (Garibay et al. 2020, Jiménez et al., 2019, Jiménez et al. 2020, Killpack and Melón 2016, Secules and Masta 2020). Three factors that have been identified for faculty are that they are key players in influencing undergraduate education to begin with, addressing faculty and student identities and positionalities are important, and that acknowledging the class content and institutional barriers should be considered when trying to achieve equity in classrooms (Secules and Masta, 2020). In addition to the large influence that engineering instructors have on the inclusion of DEI content, educators must continue to make sure that the curricular materials themselves are equitable and inclusive, in order to help broaden STEM participation (Fujii et al., 2020).

Engineering instructors are major players in promoting equity within the classrooms through pedagogy and curriculum development (Killpack and Melón, 2016, Secules and Masta, 2020). One study that focused on the relationship between faculty values and the inclusion of diversity content within environment and sustainability programs found that inclusion of DEI content (specifically environmental justice in this study) within courses is largely tied to faculty subject values (Garibay et al., 2020). Furthermore, the authors also found that even if instructors hold values toward DEI itself, it is less likely to actually translate into the inclusion of DEI content into the course curriculum (Garibay et al., 2020). Other barriers that have been identified are that engineering faculty place more value on ethical and environmental responsibility over issues of peace, and gender equity (Jiménez et al.,

2019). Additionally, engineering faculty have been found to place a lesser value on the humanities and non-technical subjects within the curriculum (Jiménez et al., 2020). In order to address resistance by faculty to integrate social justice education, the following guidelines have been suggested: Enact Humility, Identify Accreditation Constraints and Opportunities, Know Your Institutional Context, Discuss Definitions of Social Justice, Unveil the Apolitical Myth, Address Engineering Ethos Perceptions, Acknowledge the Need for Pedagogical Innovation (Leydens, 2013).

DEI at the University of Michigan-Ann Arbor and College of Engineering (CoE)

Given that Michigan Engineering produces copious amounts of graduates each year, I would like to give attention to the context in which my research will be taking place. The College of Engineering at the University of Michigan (Michigan Engineering) is in the top ten undergraduate engineering schools in the nation (U.S. News and World Report, 2022). Michigan Engineering is also among the top ten institutions awarding the highest number of engineering bachelor's degrees in the United States, ranked at number eight (ASEE, 2020). Michigan Engineering also falls in the top twenty colleges when looking at undergraduate engineering enrollment numbers. In 2019, Michigan Engineering enrolled 7,334 undergraduate engineering students (ASEE, 2020). These statistics highlight both the national reputation Michigan Engineering has attained and the impact the education engineering students receive given the copious amount of engineers that graduate from Michigan Engineering.

In 2016, the College of Engineering released its five-year Diversity, Equity, and Inclusion Strategic Plan outlining the College's five-year

objectives, measures, and actions regarding DEI initiatives (Michigan Engineering, 2016). The CoE conducted qualitative and quantitative research with the community that lead to key insights and recommendations for both the CoE and the university at large. This plan also includes DEI goal-related metrics and plans for supporting the strategic plan in the then, coming years.

Within this report, the first significant finding and recommendation for the CoE is to “increase the understanding and application of diversity, equity, and inclusion concepts to build skills and provide learning experiences to effectively and constructively engage in dialogue on DEI-related topics across our community” (Michigan Engineering, 2016). This finding demonstrates there is a clear need to increase the DEI content in the engineering curriculum. This finding also acknowledges that there are many within the CoE community that lack the understanding of key DEI topics and that there is a need to increase skills and experience regarding “intercultural engagement” (Michigan Engineering, 2016).

In September of 2020, the College of Engineering at U-M released their four-year update on how they are meeting their DEI objectives outlined in the 2016 report. The CoE wrote the following as an update to the first strategic finding in the 2016 report (Michigan Engineering, 2020).

“Plans are to continue DEI training for students, faculty and staff. At the directive of the Dean, plans are being developed for new CoE Race/Equity Education and Training Initiatives. The objective of these initiatives is the systematic education of all CoE constituencies (faculty, students and staff) to promote informed and conscious engagement on DEI for the College, the University and Society.

Meanwhile we will continue our general training efforts... Efforts will also continue to review the undergraduate

curriculum, modifying existing courses and creating new curriculum to replicate best practices identified through our Inclusive Teaching initiative.”

In addition to the four-year update on the DEI strategic plan, recent public statements from the college highlight the growing attention for engineering to increase its focus on the intersection between engineering and social change. Within the past year, CoE President Alec Gallimore released a statement calling for Equity Centered-Engineering to be embedded into engineering education in addition to the hire of Michigan Engineering’s first Executive Director for Culture, Community, and Equity (Gallimore, 2021, Hensel, 2021). The continued efforts and focus on DEI as it relates to culture, education, and skills within the CoE point to a desire for long-term change.

Making as a Design Inquiry

Within my work, I primarily focused on making and prototyping as a means of design inquiry. Prototyping is a “means by which designers organically and evolutionarily learn, discover, generate, and refine designs” (Lim et al., 2008). The specific act of prototyping to test ideas and initial concepts can fall under the broader category of making. Making is “a creative act which involves construction and transformation of meaning” (Sanders and Stappers, 2014). Utilizing making in a design process can help designers make sense of the future (Sanders and Stappers, 2014). While there are many ways to understand prototyping, for the context of my work, I am categorizing prototyping into production-driven prototypes, experimental prototypes, and provocative prototypes (provotypes) (Ruecker, 2015). My prototyping of the card deck would be categorized as a production-driven prototype that goes through stages of refinement from a rough version to a finished product with a specific purpose. While the physical card deck proto-

type can be categorized as a production-driven prototype, the process of designing the prototype can be understood as an iterative design process. An iterative design prototyping process can be defined as “...growing early conceptual designs through prototypes into mature products (or services, environments, experiences, etc.)” (Sanders and Stappers, 2014).

Another important way that my prototype functions within my research is as a boundary object between stakeholders. Boundary objects were originally defined as

“...objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites...They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds.” (Star and Griesemer, 1989)

The card deck functions as a boundary object for engineering educators from different disciplines. By acting as a boundary object, the card deck becomes an anchor for engineering educators from diverse backgrounds to gather and be prompted. When prototypes function as boundary objects within design, they can serve as a way for user feedback, as a tool to improve the team experience, and as a way to help converge thinking during a design process (Rhinow et al., 2012). For my thesis, the prototype serves as a way to gain user feedback for further iteration and testing. Utilizing prototyping and making as a method within my project allowed for further generative and evaluative discovery.

Card Deck Precedents

Card decks have been widely used in the human-centered design field to aid more active participation and spark creativity and innovation within the design process itself. A meta-analysis of 155 card decks in the design field categorized them into three design categories: systematic design methods and procedures, human-centered design, and domain-specific design (Roy and Warren, 2019). Other card categories identified outside of the design discipline included card decks that focused on creative thinking and problem solving, team building and working, and future thinking (Roy and Warren, 2019). In addition to the various focus areas that card decks can take, they are also shown to help with specific learning aspects such as motivation, social behavior, and play dynamics (Turkay et al., 2012).

Previous card decks created within the learning design space have focused on lesson planning, learning assessment, and learning objectives. One card deck, Learning Design Tools, uses a collaborative approach to curriculum design (Recke and Perna, 2021), and is based on the revised Bloom’s Taxonomy (Krathwohl, 2002). Another card deck that aims to help facilitate lesson planning, in addition to taking into consideration things like learning environments and processes is the MethodKit for Lesson Planning (Möller, 2022). Another card deck, Learning Design, focuses on developing learning events (Gruber, 2019). The Key Competencies: A Curriculum Design Deck, focuses on helping the curriculum be built with key competencies in mind, such as thinking and relating to others (Hipkins and Bolstad, 2017). All of these card decks are aimed at helping educators with their curriculum design in some form or another. However, I have not been able to find a curriculum design deck that focuses explicitly on integrating DEI topics into the course curriculum. Nor have I found a card deck that uses the Significant Learning Taxonomy.

Significant Learning Taxonomy and Theory

The theoretical underpinning of my prototype card deck is the Significant Learning Taxonomy and Theory developed by Dr. Lee Fink. Fink outlines the six learning dimensions he believes will prompt a significant learning experience (Fink, 2013). I chose this taxonomy to base the cards on because the Significant Learning Taxonomy considers the humanitarian aspects of learning, such as the “Caring” dimension and the “Learning How to Learn” dimension, whereas Bloom’s taxonomy does not. I saw these added dimensions as essential to the teaching of DEI topics. Another reason I chose this specific taxonomy is because Fink (2013) believes that for significant learning to occur, there needs to be a change in the learner, and for significant learning to occur, the change has to be life-lasting. I believe that in order for any learning to happen regarding DEI topics, there also has to be a change in the learner. Another reason I chose this taxonomy is that Fink saw these dimensions not as hierarchical but as interrelational and reactive to one another. Lastly, Fink’s argument that educators must teach their students with the view that learning is a lifelong process aligns well with the necessary, lifelong process of understanding DEI topics.

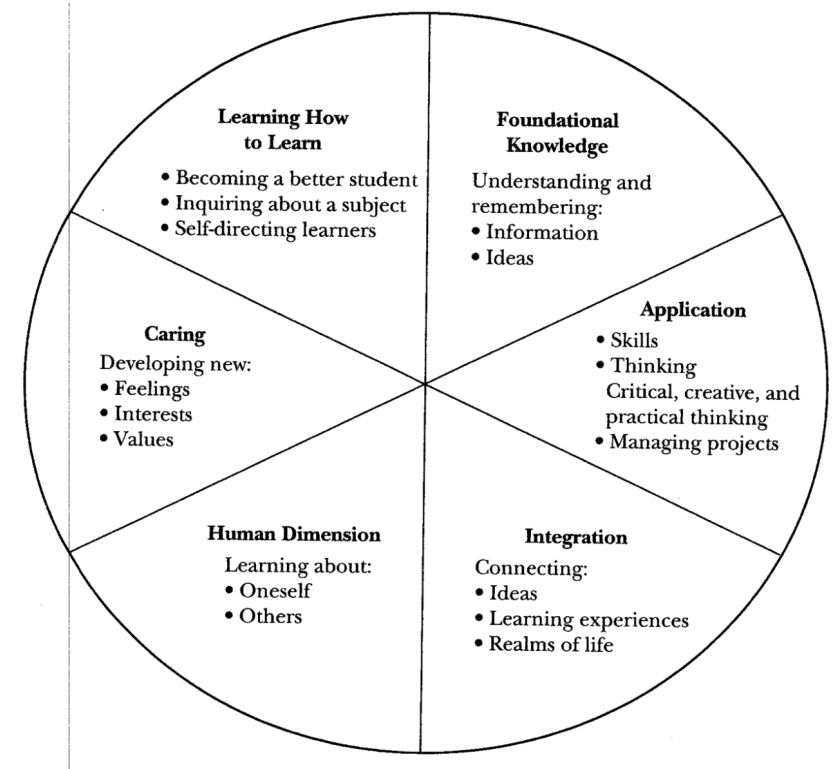


Figure 2.5 Significant Learning Taxonomy (Fink, 2013)

Though my research question is specifically focused on how engineering educators develop DEI content for their classrooms, it is important to be able to link DEI content with specific student learning objectives. I sought to understand how engineering educators would contextualize their DEI content within the Significant Learning Taxonomy. During the interview process, I focused on understanding the following in relation to the Significant Learning Taxonomy:

1. Which dimensions do faculty place the most importance on when teaching DEI topics

2. Which dimensions are the most challenging when teaching DEI topics
3. Which dimensions are the easiest to meet when teaching DEI topics

The goal of centering the card deck and my research in Fink's Significant Learning Taxonomy is to help engineering educators shift to a more learner-centered framework and to better articulate why they are asking students to critically reflect upon certain DEI topics rather than starting with the topics or content. Using the Significant Learning Taxonomy in my design research allowed me to anchor my prototype in this theory as well as use it as a point of measurement in the data collection process.



I conducted qualitative research on tenured/tenure-track and lecturer faculty in the College of Engineering (CoE) starting early November 2021 through early February 2022. Before beginning my data collection, I applied for IRB approval and was granted exemption. (For more information on my IRB exemption, please refer to the Appendix.) Then using purposive sampling, I recruited nine CoE faculty to participate in

my study. Once recruited, I began the first phase of my study, which involved a survey that contained demographic questions, CoE Position Questions, and DEI-related curriculum design questions. Nine participants took the questionnaire. After completing the questionnaire, participants partook in a one-hour, semi-structured interview to further discuss how DEI content and curriculum content are developed for their undergraduate classes. Eight participants consented to a semi-structured interview. The third phase of my research consisted of the analysis of the questionnaire and the interview transcripts. From this analysis, it will inform the prototyping and iteration of the card deck, the last stage of my project.

Before describing more about my design research process, I will discuss my integrative design approach.

Integrative Design Approach

Integrative Design is an approach to solving complex problems that utilizes interdisciplinary perspectives, theories, and methodologies. In integrative design, "...the challenges are not only complex, but in which the very complexity of the problems is complicated, and in which, from the outset, solutions are under increasing pressure to really make the world a better place" (Michel, 2019). I use an integrative design approach by grounding my research in a traditional qualitative methodology, the Significant Learning Taxonomy, and making as a form of inquiry. In addition to my integrative design approach in my research, I am also engaging in graphic/product design through the physical prototyping of a card deck for engineering educators. By prototyping the card deck, I am building on my integrative design research into a tangible artifact to function as a design intervention for the problem I am trying to disrupt and change.

As an emerging and dynamic field, there is no single approach to integrative design, I synthesized the most immediate and important approaches from different disciplines into my design research in order to address my wicked problem in the timeline of my research. Through my work, I utilize an integrative design approach to better practice leveraging interdisciplinary knowledge and design methods. I believe that by grounding my work in integrative design, I can better address complex issues—such as integrating DEI content into engineering education. Using an integrative design approach allows for the selection of unique methods (such as prototyping and making) that go beyond the traditional qualitative research methodologies and methods.

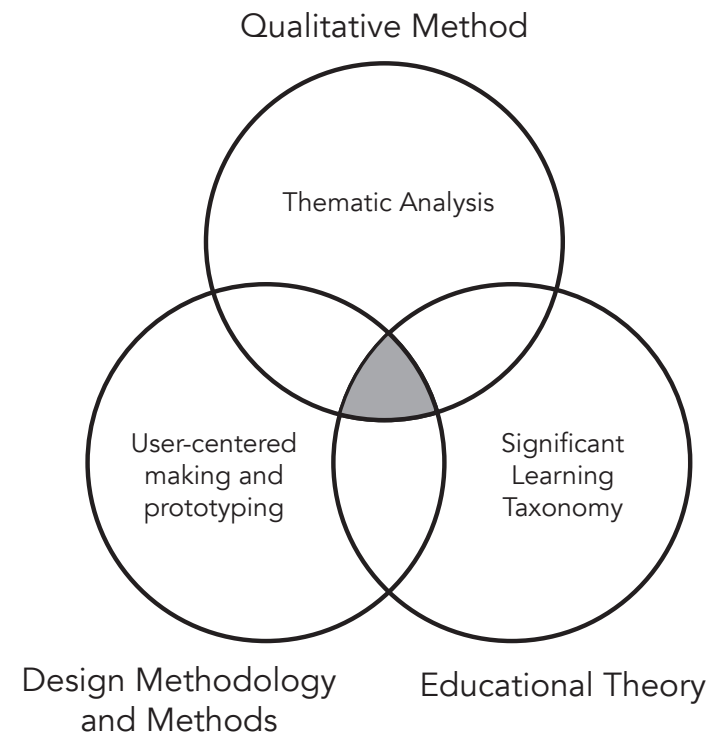


Figure 3.1 Integrative Design Approach

Sampling and Recruitment

After securing IRB exemption, I began recruiting for my research. I contacted potential participants through email with an attached information flyer about my research. In total, I recruited nine faculty members from the CoE to participate in my research using purposive sampling. Nine participants completed the survey, and eight participants completed interviews. Each faculty member recruited met the following parameters in order to participate in my study. The parameters of my research are as follows:

- Participants must be faculty members (tenure-track or lecturers) within the College of Engineering at the University of Michigan-Ann Arbor
- Participants need NOT be from any specific engineering discipline; all engineering fields welcome
- Participants must include one or more DEI topics (context, ethics, identity, accessibility, etc). in at least one of their undergraduate engineering classes (past or current). DEI topics can be explored through a wide range of learning activities that include but are not limited to reading assignments, class activities, guest lectures, videos, essays, group projects, service learning, community-engaged learning, et cetera.
- Participants should be available to take part in an asynchronous survey (approximately 15 minutes)
- Participants should be able to participate in a one-hour interview for the project

I collected some demographic information about my participants via the survey that was distributed in the first phase of my research. My sample spanned nine College of Engineering departments, with one

faculty member teaching in more than one department and the rest teaching in only one department. None of my participants had a joint appointment in another U-M school. All of my participants were with Full Professors or Lecturers. My sample spanned the following U-M CoE departments.

- Biomedical Engineering
- Chemical Engineering
- Climate and Space Sciences and Engineering
- Electrical and Computer Engineering
- Mechanical Engineering
- Naval Architecture and Marine Engineering
- Nuclear Engineering and Radiological Sciences
- Technical Communication
- Robotics
- Center for Entrepreneurship

Participants' experience teaching within the College of Engineering spanned from as little as three years to up to twenty-two years. Three participants have been teaching in the CoE for 1-5 years, two participants teaching for 6-10 years, two participants teaching for 11-15 years, and two participants teaching for 16+ years. 77% of my sample were lecturers, and 22% were full professors. In terms of the racial and gender breakdown, 77% of my sample identified as White, and 22% identified as a person of color. My sample was about evenly divided among gender lines, with 44% being male-identifying and 44% being female-identifying. One participant chose not to disclose their gender identity. Participants were compensated with a \$20 gift card to a local Ann Arbor coffee and tea shop for participating in my project.

Survey

This survey covers the following sections: Demographic Information (two questions), CoE Positions (four questions), Diversity, Equity, and Inclusion Questions (9 questions), and Choosing to Participate in an Interview. Demographic Information collected was race and gender identity. The next section asks participants to state their position within the CoE (assistant professor, associate professor, lecturer, etc), their respective engineering department(s), and whether they have a joint appointment in another U-M school on the Ann-Arbor campus. DEI-related questions are focused on what topics they include in their curriculum, their level of comfort, and/or expertise in DEI-related topics, whether they include a Diversity Statement and/or an Inclusive Teaching Statement, and their own understanding of DEI. Some example questions are “How important do you feel including DEI content is in your undergraduate engineering classes?” and “How would you rate your understanding of DEI together?” Participants rated their understanding of DEI as separate concepts and together on a likert scale of 1-9 (1 representing “Little to no knowledge and/or expertise, and 9 representing “Extensive knowledge and/or expertise”). Nine people completed the survey. For a more in-depth look at the survey, see the Appendix.

Interviews

Given the Covid-19 Pandemic, I chose to hold all interviews virtually for the health and safety of my participants as well as myself. After each person completed the survey, I conducted virtual semi-structured interviews over Zoom with each participant for an hour. I completed eight interviews with participants. To help increase reflexivity of this stage in the research, I completed a reflective memo after every inter-

view. The interviews conducted were both generative and evaluative. The generative focus of the interviews was focused on understanding barriers and experiences related to choosing DEI content for their classes, and the evaluative focus was on usability testing of the card deck prototype. For a complete look at my interview protocol, please see the Appendix.

The interview begins with questions related to courses they have taught at the CoE that incorporate DEI topics, what prompted them to include those topics, and if they have had any curriculum training for incorporating DEI topics into their classes. Some of the initial questions in this first section were “What prompted you to incorporate DEI content into your classes?” and “Can you tell me about any undergraduate engineering classes you have taught that incorporate DEI topics?” After this section, we move on to the interactive activities in MURAL. (See the appendix for the full MURAL template.)

MURAL is a virtual whiteboard tool used for visual collaboration. The activities in the MURAL board cover four topics: Importance and Integration of DEI topics, Fink’s Significant Learning Taxonomy, Learning Activities/Methods, and Prototype Feedback. In the first activity, participants are asked to move various DEI topics written on virtual sticky notes onto a bullseye target, denoting their importance to them and to their specific classes and field. DEI topics that are more important to teach are moved closer to the center, and ones that are less important to teach are moved towards the margins. Next, participants are asked to do the same bullseye activity except, rather than denoting the topics’ importance, they move them according to how easy or hard they are to integrate into the courses they teach. Questions around this activity involve asking them why they chose to move specific topics into the center in each bullseye target, to explain certain topics and their relation to the courses they teach, and the barriers to integrating the DEI topics that fell closer to the margins of the bullseye target.

DEI Topics

- Privilege
- Identity (Race, gender, etc..)
- Systems of Oppression (racism, etc..)
- Acts of oppression (violence, discrimination, etc...)
- Strategies of oppression (dehumanization, gaslighting etc...)
- Power and power dynamics
- Context (historical, current, future)
- Unconscious and Implicit Bias
- Ethics
- Equity and Equality
- Human Rights
- Justice (Social, cultural...)
- Intersectionality
- Zero-Sum Thinking
- Accessibility
- Allyship
- Frameworks of Resistance (anti-racism, feminism, etc..)
- Environment / Sustainability
- Community
- Prejudice and hatred
- Communication

- Positionality

Next, we move on to an activity exploring Fink's Significant Learning Dimensions (Fink, 2013). A circle with different sections is shown, with each section representing a different learning dimension of Fink's taxonomy: Foundational Knowledge, Application, Integration, Human Dimension, Caring, and Learning how to Learn. Participants are asked to place the checkmark icon on the dimension they feel is easiest to meet when teaching DEI topics in their class, a star icon on the dimension they feel is the most important to consider when teaching DEI topics, and the question mark icon on the dimension they feel is hardest to meet. Questions about this section revolve around why they chose which dimensions for which icons.

The next activity focuses on understanding the learning methods they use to teach DEI content, which is represented by a two-by-two grid. For this activity, participants move virtual sticky notes with various learning activities onto the grid, denoting how comfortable they are with the method and how often they use that method when teaching DEI topics in their class. Participants are asked to explain the methods they chose and why.

Learning Methods

- Readings
- Small group dialogue
- Interactive Activities
- Videos
- Performing Arts based activities
- Guest speakers
- Group Projects

- Service Learning or Community-Engaged Learning
- Lectures
- Social Identity Wheels/Mapping
- Reflective Writing
- Case studies
- Making
- Large group dialogue
- Essays
- Visual Art Activities
- Podcasts audio (listening)
- Podcast-making
- Research-based projects
- Film-making
- Prototyping

The last activity in MURAL is to look at the first prototype of the card deck and to provide feedback on the tool and how it could be helpful, and how it could be used. If there is remaining time in the interview, participants are asked to discuss barriers and challenges to including DEI topics into their classes, and what other kinds of support might be helpful in integrating DEI topics into their curriculum.

Data Analysis and Synthesis

After all of the surveys and interviews were completed, I conducted a

thematic analysis of the interview transcripts and searched for key insights from the survey. The goal with my analysis and synthesis of the data was to better understand the first-hand experience of engineering educators in choosing and teaching DEI content and how this might inform the next iteration of the card deck.

Beginning with the survey, I first looked at the demographic section of the survey to understand the backgrounds and experiences of my participants. The results are described in the Sampling and Recruitment section of this paper. Next I moved on to looking at the DEI Curriculum questions. The first set of questions in this section focused on each participants' understanding of Diversity, Equity, and Inclusion together as well as each subject separately. These questions were able to show me the level of background knowledge that participants felt they had in DEI before the interviews. The next questions focused on the level of importance that participants placed on integrating DEI content and how often they actually feel like they integrated these topics into their classes. The answers to these questions were compared with the interview data which supported a difference in the placement of importance on DEI content and the actual integration of these topics into classes. Another question in this section of this survey asked about their level of comfortability including DEI topics in their classes, which I was able to look at in comparison to the barriers or challenges that participants faced when trying to include DEI content into their classes and any fears they held that were mentioned in their interviews. The last questions in the survey ask if participants include a Diversity Statement and an Inclusive Teaching Statement in their syllabi to better understand how their values toward DEI content and DEI values translate over to pedagogy.

After analyzing the survey data, I transcribed and cleaned the interview transcripts. I coded each interview transcript using a mix of in-vivo and descriptive coding. Because I was the only researcher analyzing the data, I tried to stay close to the data through in-vivo coding but found

myself alternating between that method and descriptive coding. Once I analyzed and coded the transcripts, I moved all of the coded data points onto a large virtual whiteboard to begin the synthesis process. I moved what I saw as similar themes into small groups and began to label each group with a theme. The groupings with the most data points became the themes I highlighted in this paper. This process was iterative in that I would revisit interview transcripts when I was unsure of where to move certain data points. To help increase reflexivity in the research process, I kept an analysis memo where I recorded my thoughts and reasons for analyzing the data in specific ways. I analyzed and synthesized all of the generative data points based on participants' direct experience integrating and teaching DEI content in their classes.

I also analyzed the interactive activities that were done in MURAL for trends and any other key themes and compared these back to the other data in the interview and survey. For the bullseye target activities, I analyzed them by noting which topics were placed in each layer by each participant and then counting which topics were most often represented in the center and which ones were most often represented in the margins across my sample. When participants spoke about certain topics and why they put them in the specific layer, I took those quotes and placed them onto their respective layer on the target. For the analysis of the Taxonomy Dimensions activity, I compiled every icon placed by participants onto the circle to see which dimensions were rated the easiest, hardest, and most important. I also placed answers given by participants onto the circle that corresponded with their icon placements. For the learning methods grid, I did the same thing as I did with the bullseye targets and the taxonomy activity, by placing important quotes onto a replica grid. In contrast to the generative data on first-hand experiences, I also looked at the feedback given about the card deck that could inform the next iteration of prototyping.

Prototyping

In order to maximize the efficiency of the timeline of my project, I used my design research as a way to produce generative and evaluative data in order to inform the development of the card deck. Much like the Analysis and Synthesis stage of my work, the prototyping was an iterative process that evolved as my research did. In the last section of my thesis, I will discuss the future work and possibilities that could be done with the card deck that could take them to the next level. Because these cards did not exist before my research began, the prototyping and development of the card deck in my work was very much the foundational work that could be built upon. Due to the limited timeline of my project, I focused on developing two prototypes. One was created before the Survey and Interview stages and the latter developed after the Analysis and Synthesis stage to reflect the data and create a more enhanced visual communication of the cards.

The first prototype was developed while also creating the interview and survey materials. This prototype was created as a way to initially move a potential idea into physical form to spark questions and to begin the process of creating my design intervention. The initial prototype was put onto 3X5 lined note cards and with all of the text handwritten on the cards. This initial card deck served an important purpose during the interviews to garner initial feedback, impressions, and a better understanding of the usability of the cards. I knew from the creation of the initial prototype that the aesthetic and visual communication of the cards would need to be enhanced in the second prototype. Thus, I looked for a graphic designer while in my Analysis and Synthesis stage to help me with this portion of creating my design intervention. The graphic designer and I worked on developing the second prototype for three weeks. We worked on incorporating the feedback from the interviews and giving the cards a distinct look through color, typography, and visual communication. This second prototype is the one

that I would recommend doing further testing on with small groups of engineering educators.



RESULTS AND DISCUSSION

Survey Results

The following results are from the Diversity, Equity, and Inclusion (DEI) Curriculum Questions. While no one chose 9 for any of the questions, no one chose anything below a 5 for any of the questions either. The topic that was rated with the highest level of understanding was diversity, with four people selecting an 8 out of 9. The topic that was rated the lowest level of understanding was inclusion, with four people

choosing a 6 out of 9.

For the question regarding their understanding of diversity, almost half of the participants who took the survey (four people), rated themselves at an 8 out of 9 for an understanding of “Diversity.” Three people rated themselves at a 7, and two people rated themselves at a 6. The topic of equity was evenly divided by the nine participants who took the survey. Three people rated themselves at an 8, three people rated themselves at a 7, and three people rated themselves at a 6. The topic of inclusion was one of the least understood topics for my participants. Four people rated themselves at a 6, two people rated themselves at a 7, and three people rated themselves at an 8. For the question regarding DEI together, the majority of respondents (five people) chose a 7 out of 9. One person chose a 5, another chose 6 and two people chose 8.

After rating their understanding of DEI, participants were asked about their perceived level of importance placed on DEI content, their level of comfort including DEI content, and how often they felt like they actually included DEI content in their course. The table below represents the responses to the question of the importance of including DEI content in their classes. A majority of respondents (62.5%) feel that DEI content is always or regularly needed in their classes.

Answer Choice	Percentage of Sample that Identified with this Choice
I feel that DEI content is always needed my undergraduate engineering classes.	50%
I feel that DEI content is regularly needed in my undergraduate engineering classes.	12.5%
I feel that DEI content is sometimes needed in my undergraduate engineering classes.	12.5%

I feel that DEI content is occasionally needed in my undergraduate engineering classes.	0%
I feel that DEI content is never or almost never needed in my undergraduate engineering classes.	0%

Figure 4.1 Survey Results - Level of Importance

The next chart depicts the level of comfort including DEI content in participants’ classes. Just over half of respondents (57.1%) feel comfortable including DEI content in their classes.

Answer Choice	Percentage of Sample that Identified with this Choice
I am extremely comfortable including DEI content in my undergraduate engineering classes.	28.6%
I am comfortable including DEI content in my undergraduate engineering classes.	57.1%
I feel neutral about including DEI content in my undergraduate engineering classes.	0%
I am uncomfortable including DEI content in my undergraduate engineering classes.	0%
I am extremely uncomfortable including DEI content in my undergraduate engineering classes.	0%

Figure 4.2 Survey Results - Level of Comfort

The next chart shows how often participants actually feel like they actually include DEI content in their classes. Only 37.5% of participants always or regularly include DEI content into their classes.

Answer Choice	Percentage of Sample that Identified with this Choice
I always include DEI content in my undergraduate engineering classes.	25%
I regularly include DEI content in my undergraduate engineering classes.	12.5%
I sometimes include DEI content in my undergraduate engineering classes.	37.5%
I occasionally include DEI content in my undergraduate engineering classes.	12.5%
I almost never or never include DEI content in my undergraduate engineering classes.	0%

Figure 4.3 Survey Results - Level of Integration

For the last questions in the survey, most participants include a Diversity Statement (66.7%) and an Inclusive Teaching Statement (77.8%) in their class syllabi. Though the majority of respondents include a Diversity Statement in their class syllabi, 22.2% of respondents do not, and 11.1% of participants are currently working on a Diversity Statement. More participants include an Inclusive Teaching Statement in their course syllabi (77.8%), while 11.1% does not, and another 11.1% is unsure about what an Inclusive Teaching Statement is.

Discussion of Survey Results

The results of the survey align with previous literature regarding the difference between the value faculty place on DEI or DEI topics and the actual integration of these topics into the courses (Garibay et al., 2020). 50% percent of participants said that they felt like DEI content was always needed in their classes, whereas only 25% said they always include DEI content, and 12.5% said they regularly include DEI content in their classes. The results of the survey highlight the gap between values and practice. (This gap was also reflected in the bullseye target activity during the interview.) Another result that came up in the survey that can be further contextualized in the findings from the interviews was that 28.6% of participants stated they felt extremely comfortable including DEI content, and 57.1% of participants felt comfortable including DEI content in their courses. However, in the interviews, one of the barriers identified by participants to more fully integrating DEI topics into courses was uncomfortability on the part of the professor as well as the student.

Interview Results

For the interview results, I will first discuss the themes that emerged from the interviews across the eight participants that were interviewed. Then I will move on to the insights and themes that came from the interactive activities done in MURAL.

Theme 1: Using One Topic to Cover a Variety of

Topics

The first theme that I interpreted in my data is that many participants expressed feeling like one DEI topic could encapsulate many. This

theme arose from doing the first bullseye target activity after participants placed their DEI Topics sticky notes on to the target. One participant stated,

“A lot of these things overlap. Ethics could be even almost considered an umbrella term. Ethics and human rights could be an umbrella term to encompass DEI stuff.”

Another participant felt like some topics could be “implicitly addressed” through other topics. Whether it was seeing the relationship between topics under an “umbrella” as a “subset” or that the topics could “grow” from each other, most participants saw the DEI topics listed as being in some way linked together. Some participants felt that in addition to the topics being linked to each other, by discussing or teaching on the one topic in class, you could actually teach about the other topics as well. For example, some participants felt that ethics could encapsulate other topics such as justice, context, or accessibility, and by talking about ethics in class, you could cover other DEI topics without explicitly naming them. There were 13 data points supporting this theme across 6 participants.

Theme 2: Avoid Harm in the Design Process

The second theme I identified in my data is that when participants spoke of teaching DEI topics to their students, they often spoke about it in a way that was about getting their students to ultimately avoid harm. When participants spoke about the relationship between DEI topics and the design process, they spoke about wanting their students to better understand the diversity of stakeholders or end-users they are designing for as a way to avoid creating harm through their design. One participant responded,

“I don’t necessarily need them to feel a type of way. I just need them to make the thing in a way that isn’t harmful.”

Discussing DEI topics only in the context of implications, mistakes, or harm feeds another micro-theme found in my data that some DEI topics are “harder,” “bigger” and could make people feel more “uncomfortable.” There were 15 data points supporting this theme across 6 people.

Theme 3: Humanities Can Contextualize Harder Topics Better

This theme is very connected to the second theme and often grew out of discussions surrounding barriers to integrating DEI topics into the course. The mention of humanities as being able to better “teach” or “contextualize” DEI topics also arose during the Bullseye target activities in MURAL. One participant stated,

“I think that any discussion of sensitive topics can be difficult in a classroom. I think that probably for engineering faculty, it’s more difficult than for humanities faculty while they may or may not have been prepared to talk about this particular topic.”

Within the context of my work, I interpreted this theme as a genuine belief that some participants held, even though I felt that this theme was partly based on assumptions. For example, another participant said,

“We have been more focused on, ‘Can we get things to work?’ really focused on the technology. It’s not like we are, you know, it’s not like in the humanities where they are so centered on, you know, the, so the other side, the emotional, the emotions and the feelings and the empathy.”

However, this same participant also mentioned earlier in their interview about one of their classes,

“...also talking about how to design for our stakeholders

and particular users, right? So different patient populations, trying to get them [students] to think in the shoes of the user to be, to have a sense of empathy about what's going on with those users.”

This is particularly interesting as there seems to be a disconnect. There were 8 data points across 5 participants for this theme.

Theme 4: Attention to Pedagogy is Needed

The fourth theme identified in my data was that participants recognized that the discussion of certain DEI topics, or ones that were rated as harder to integrate into engineering classes, necessitated an emphasis on intentional pedagogy and community classroom building.

One participant stated,

“So we had an anti-racism talk that was kind of, I think, designed for engineering 100 courses. And, you know, we had one African American student in the room and I was concerned that, you know, that student might have been uncomfortable.”

Most participants recognized that a shift or change in pedagogical style was needed when discussing harder DEI topics within an engineering classroom. There were 8 data points from 7 participants that supported this theme.

Barriers to Integrating DEI Topics

In addition to the four themes discussed above, participants also discussed barriers to integrating DEI topics into their courses. While a majority of participants did not necessarily converge around one or two specific barriers, I felt that the reasons mentioned during the interviews were worth noting about the practicality and reality of integrating DEI topics into courses. One of the first barriers identified was how DEI

topics could make students feel uncomfortable as well as teaching the topics could be uncomfortable. Some of the barriers mentioned were realities such as a lack of time within the curriculum or feeling limited by the number of course credits.

One participant was hesitant to add more content and projects centered on DEI on top of what is already being taught in the classroom. Another barrier identified by one participant was their fear and concern over teaching DEI topics in a class of 100+ students. Other barriers that participants identified revolved around pedagogy. Half of my participants expressed serious concern about the lack of racial diversity among their students. The concern over the lack of racial diversity among the students was often followed by a statement of fear about tokenizing students of color in a class filled with predominantly White students. Other barriers identified were acknowledging the impact of the Covid-19 pandemic on teaching, as well as recognizing the generational differences of values placed on DEI by the faculty.

Discussion of Interview Results

The first two themes point to an underlying amount of fear and hesitation about DEI topics within the engineering classroom. In addition to participants feeling like certain DEI topics such as ethics could cover a wide range of topics, a few participants were hesitant to directly name topics in the classroom for fear of making students uncomfortable and assuming the students were not in the headspace to discuss topics such as racial justice. The second theme points to a mindset of seeing knowledge of DEI topics not as a positive asset but as a necessary step or checkbox to mark off within the design process. Participants named wanting their students to be able to strongly empathize with their end-users but expressed fear about naming things like identity in the classroom setting. Yet, at the same time, participants wanted their

students to avoid harm in their designs and would often only discuss diversity in the context of avoiding mistakes. My interpretation is that if my sample of engineering educators only discusses DEI topics in the context of potentially making mistakes, then it would bolster the idea that DEI topics are “harder” and “bigger.”

In regard to the third theme, previous literature has identified the distinction that engineering educators see and the lesser value they place on humanities subjects within the curriculum (Jiménez et al., 2020). In addition to the distinction participants saw between the humanities and engineering, my research findings also show that there is a belief that the humanities can teach DEI topics and in some cases, participants believed they should take the lead in educating students on DEI topics, especially topics participants saw as “harder.” Another theme that is connected to previous literature is the fourth. This theme addresses the recognition for a more intentional pedagogy when teaching DEI topics. Other literature notes the importance of pedagogy when placing an emphasis on DEI or DEI topics within a class (Killpack and Melón, 2016, Leydens 2013, Rogers and Valdez, 2021).

One of the barriers identified in my interviews was a level of discomfortability on the part of the instructor teaching about these topics. However, in my survey, a majority of respondents report feeling either extremely comfortable or comfortable including DEI topics in their course. It is possible the disconnect here is because of the phrasing of the question in both settings. In the survey, the focus was on “including DEI content” in their courses whereas in the interview, participants often spoke about discomfortability when teaching on the topics or trying to take into account the level of comfortability of the students in the classroom. Another barrier identified was teachers feeling limited by time and the number of course credits a class possesses. In response to the argument that there is not enough room in the undergraduate engineering curricula to teach students all of the technical and theoretical knowledge and skills engineers will need, Dr. Erin Cech offers

what she knows is a radical suggestion: that in order to educate students about social justice issues within the engineering curriculum, we will have to cut out content (Cech, 2013).

Interactive Activities Results

Bullseye Target Activity

In the first bullseye target activity in the interview, participants are asked to move various DEI topics written on virtual sticky notes onto a bullseye target, denoting their importance to them and to their specific classes and field. DEI topics that are more important to teach are moved closer to the center, and ones that are less important to teach are moved towards the margins. The second bullseye target is similar to the first. However, instead of moving the topics based on level of importance, participants move them based on how easy or hard they

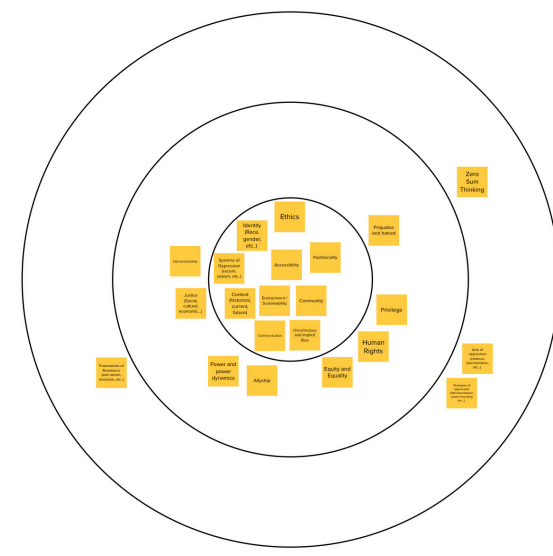


Figure 4.4 Bullseye Target 1

Most Common Topics Put in the Center	Number of Participants
Accessibility	8
Equity and Equality	7
Ethics	6
Communication	5
Context	5

Figure 4.5 Bullseye Target 1 Center Results

Most Common Topics Put Near the Margins	Number of Participants
Acts of Oppression (violence, discrimination, etc...)	8
Strategies of Oppression (dehumanization, gaslighting...)	7
Frameworks of Resistance (anti-racism, feminism)	7
Prejudice and Hatred	6
Positionality	6

Figure 4.6 Bullseye Target 1 Margins Results

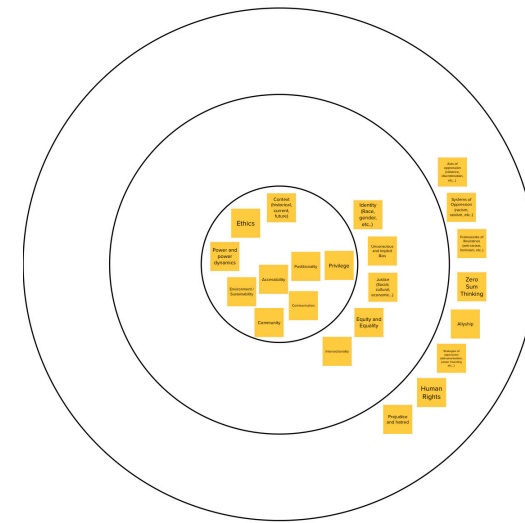


Figure 4.7 Bullseye Target 2

Most Common Topics Put in the Center	Number of Participants
Ethics	8
Environment	8
Communication	8
Context	6
Accessibility	6

Figure 4.8 Bullseye Target 2 Center Results

Most Common Topics Put Near the Margins	Number of Participants
Strategies of Oppression	6
Frameworks of Resistance	6
Prejudice and Hatred	6
Allyship	6
Systems of Oppression	5

Figure 4.9 Bullseye Target 2 Margins Results

Significant Learning Dimensions Activity

The next activity is exploring Fink's Significant Learning Dimensions (Fink, 2013). A circle with different sections is shown, with each section representing a different learning dimension of Fink's taxonomy: Foundational Knowledge, Application, Integration, Human Dimension, Caring, and Learning how to Learn. Participants are asked to place the checkmark icon on the dimension they feel is easiest to meet when teaching DEI topics in their class, a star icon on the dimension they feel is the most important to consider when teaching DEI topics, and the question mark icon on the dimension they feel is hardest to meet.

The dimension rated the easiest to teach was Integration with three participants choosing this dimension. The dimension rated the most important to teach students was split between Learning How to Learn, Caring, Integration, and Application with two participants each per dimension. The dimensions that were rated the hardest were Caring with four participants and Foundational Knowledge with three participants.

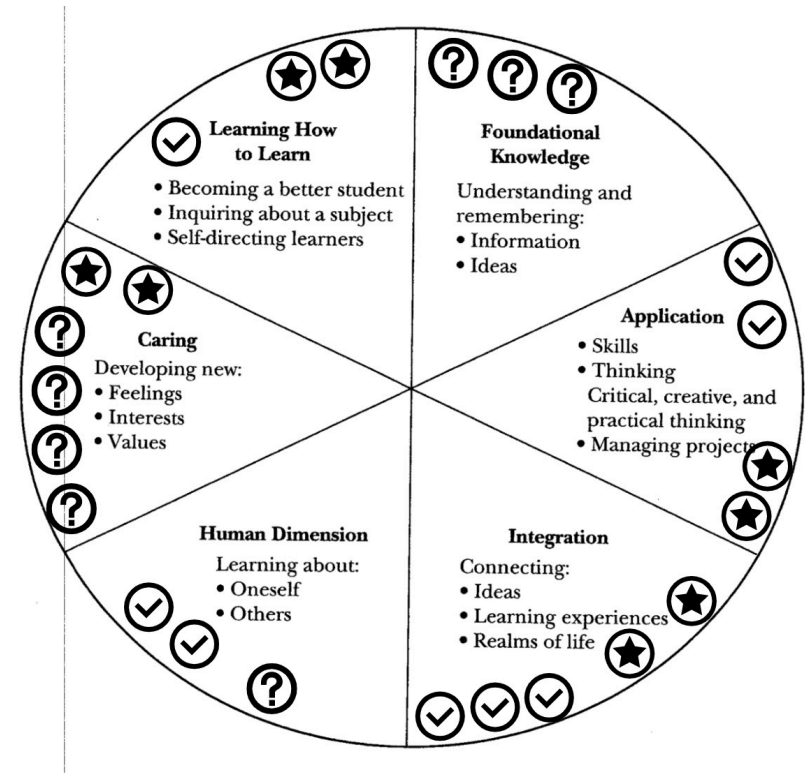


Figure 4.10 Learning Dimensions Results

Learning Methods Grid Activity

In the last interactive activity, participants work in a two-by-two grid. Participants move virtual sticky notes with various learning activities onto the grid, denoting how comfortable they are with the method and how often they use that method when teaching DEI topics in their class.

Quadrant	Most Common Topics in Each Quadrant
Upper Left - Extremely Comfortable and Used Almost Always or Often	<ol style="list-style-type: none"> 1. Small group dialogue - 8 people 2. Interactive Activities - 8 people 3. Guest speakers - 8 people
Upper Right - Extremely Comfortable and Rarely or Never Used	<ol style="list-style-type: none"> 1. Research-Based projects - 7 people 2. Service Learning/Community-Engaged Learning - 5.5 people 3. Podcasts Audio (Listening) - 5 people
Bottom Right - Little to No Comfort and Rarely or Never Used	<ol style="list-style-type: none"> 1. Visual Art Activities - 5.5 people 2. Film-making - 5 people 3. Making - 5 people
Bottom Left - Little to No Comfort and Used Almost Always or Often	No responses

Figure 4.11 Learning Methods Results A

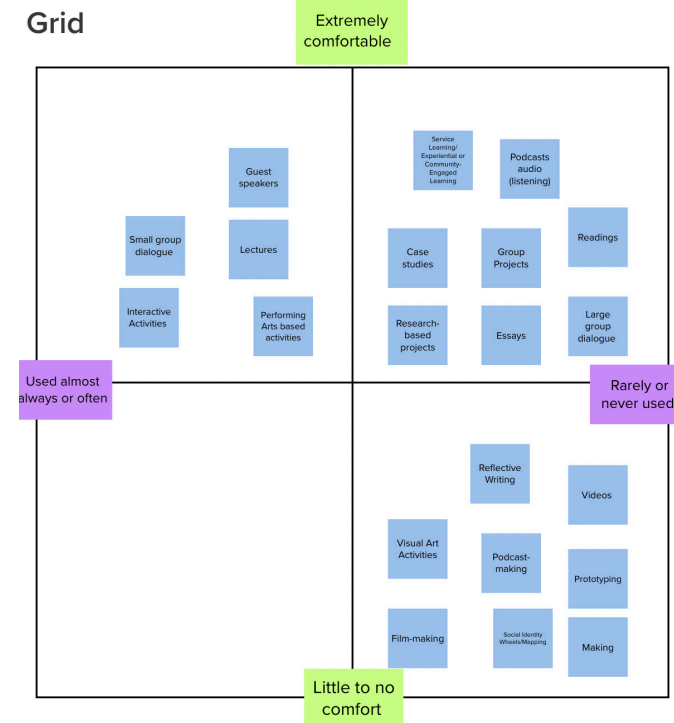


Figure 4.12 Learning Methods Results B

Discussion of Interactive Activities Results

The bullseye target activities further supported the finding that there is a gap between the values placed on DEI topics and the actual integration of DEI topics into a course. This gap first identified in the survey results was also reflected in the bullseye target activity in the interviews. While most participants placed importance on DEI topics and could place, on average, around 4-5 topics into the center of their first bullseye target, more topics fell to the second or outer layers of the second bullseye target, indicating the challenges of integrating these topics into the curriculum. When comparing the centers of both targets (importance versus integration), the only topic to not make it to the center in the second target was equality and equity.

The most common topic discussed during the activities was ethics and its importance in engineering. When looking at the outer margins of the targets, allyship, and systems of oppression were the two topics at the margins for the second target but not the first. The results from my second bullseye target activity align with previous research that shows engineering faculty place a higher value and emphasis on ethics and the environment over other issues (Jiménez et al., 2020).

In regards to the Learning Dimensions activity, participants had diverse reasoning for choosing the dimensions they did, and I did not identify any common themes for each of the icons placed on the learning dimensions circle. However, something interesting to note about the result from the hardest dimension rating is that this point of data was almost evenly divided between gender lines. Almost all male-identifying participants rated Foundational Knowledge as the hardest dimension to meet, and all almost female-identifying participants rated Caring as the hardest dimension to meet.

For the Learning Grids activity, the topics that fell into the upper left quadrant, participants spoke about already using these methods quite often in classes. One common theme found when discussing topics in the upper right quadrant were some participants realized they weren't necessarily using all of the tools in their toolbox, specifically utilizing podcasts (listening) as a potential activity. Most of the methods that fell into the bottom right quadrant are methods based in the arts. Participants gave reasons such as uncomfortability or lack of knowledge about how to use them as the reasons they fell into this quadrant.

Prototype Results

During the interview process, participants were asked for feedback regarding the first prototype of the card deck. Most participants felt that a tool such as the card deck could be potentially helpful in thinking about how to incorporate DEI topics into their courses. One of the most common suggestions for the card deck was to incorporate actual examples of activities that engineering educators have used in the past or continue to use to teach DEI topics. Another common suggestion was to create examples of how to integrate these topics into assignments that professors are already doing. This suggestion was connected to some of the barriers that were mentioned by participants about integrating DEI topics into their courses such as a lack of time or hesitation to add more assignments given the certain number of course credits.

On the opposite end of the spectrum, some of the challenges that participants saw to the card deck were that they could be a conversation starter to integrating DEI topics but wouldn't necessarily tell the user how to actually do it. Another common challenge that participants saw was the barrier of uncomfortability on the part of the professor actually teaching these topics as well as for students in the classroom. This connects to the previous theme identified in my interviews about the recognition of the importance of pedagogy. Participants pointed out that students are not necessarily primed to talk about subjects such as identity or racial justice at 9 am. They mentioned that while the card deck could help educators think about how to theoretically do this, more resources and training would be needed.

Other feedback given was about the interaction and the visuals of the cards. Participants had differing views on the amount of sec-

tions the cards should have. For example, one participant felt that the cards could be consolidated into one section of DEI Topics and another section of Learning Methods and then incorporating the Significant Learning Taxonomy onto the back of the cards. However, another participant felt that the Learning Dimensions section of the cards was very useful as they had never heard of this specific learning taxonomy. All of this feedback was incredibly helpful and valuable to iterating on the card for the second prototype.

For the second prototype, I worked with a graphic designer to incorporate some of the feedback into the second iteration and give the cards a distinct color palette, typography, and aesthetic. One of the first major changes from the first iteration was that the section of cards that covered DEI was dropped and the topics of Diversity, Equity, and Inclusion, were incorporated into the DEI Topics section. Another change was adding verbs related to each of the dimensions of the Significant Learning Taxonomy to the front of each Learning Dimension card. One change that was incorporated based on feedback was to add some visuals to the cards. The graphic designer and I worked to create three visual icons for each of the sections (DEI Topics, Learning Dimensions, and Learning Methods). The addition of blank cards in the Learning Methods and DEI Topics were also added so those using the cards could add their own topics or learning methods.

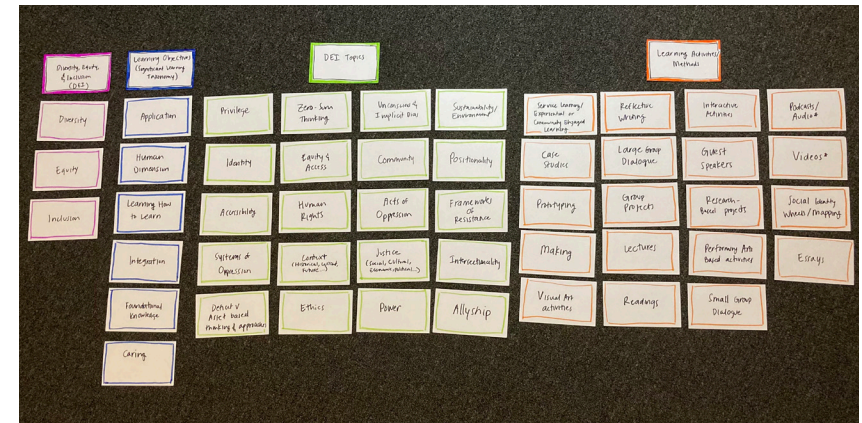


Figure 4.13 Prototype 1



Figure 4.14 Prototype 2



Figure 4.15 Learning Dimensions Card



Figure 4.16 Learning Methods Card



Figure 4.17 DEI Topics Card



Figure 4.18 DEI Topics Example Card - Front

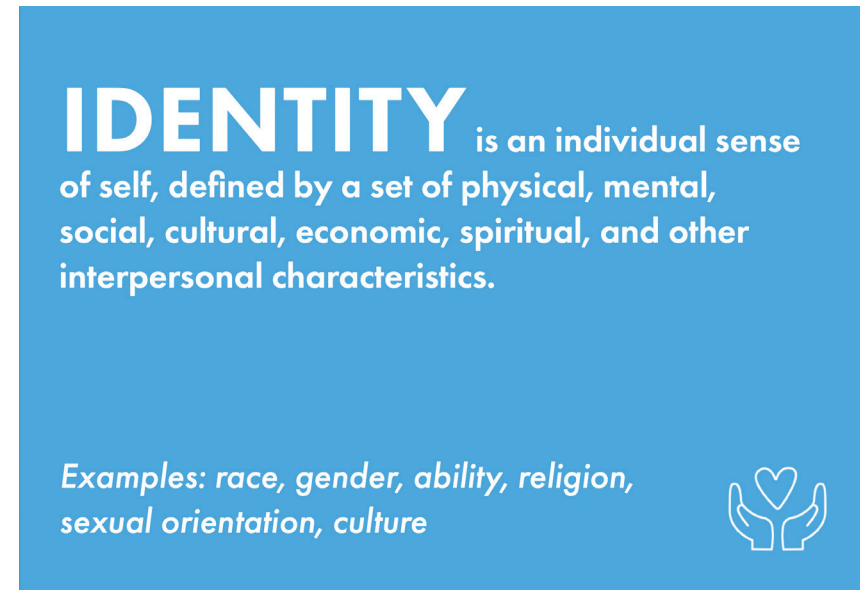


Figure 4.19 DEI Topics Example Card - Back

Discussion of Prototype Results

While I was able to integrate some of the suggestions from the interviews with stakeholders into the second prototype, there were two points of feedback that would ideally be included in the third prototype. For the Learning Methods cards, the incorporation of actual activities that professors have used before or are currently using on the back of the cards would be more ideal than randomly chosen examples. The second is to find a stronger connection between the Learning Methods cards and the DEI Topics cards that would allow educators to identify activities or assignments that they are already using in class and to incorporate DEI topics into those activities. More research would need to be done for both of these points to be integrated into the card deck.

Through my interviews with my participants, I identified the strength of centering the card decks within the Significant Learning Taxonomy. For some participants, the taxonomy was completely new to them and provided a different way of considering what the goals are of incorporating DEI content into the course curriculum. By utilizing the taxonomy as an anchor for the card deck, it creates both a shared language and a framework for educators to think about how to strategically link learning objectives, DEI content, and learning methods together.

Discussion of Final Results

All of the results from my research point to two important points. The first point is demonstrating the practical realities that act as barriers for faculty incorporating DEI content into their classes. The

second is the potential for a design intervention such as the card deck to help engineering educators reflect on how to better integrate DEI topics into their curriculum. By utilizing design methods, the findings from each source of data (survey, interviews, and MURAL interactive activities) were able to support each other. The results of the survey highlight the gap between values and practice which was further supported by the results from the bullseye target activities in MURAL. The themes from the interviews reveal more specific barriers that engineering educators face when incorporating DEI topics into their curriculum as well as some implicit attitudes that participants held about incorporating DEI topics. The MURAL activities built on the interview themes by revealing which topics were harder to integrate and how engineering educators from different disciplines have different considerations when deciding which learning objectives are most important and which learning methods would best suit their students. Lastly, the prototype results show the initial interest and possibilities of using a card deck and other game-based activities to help faculty think about how to incorporate DEI topics into their curriculum.

Limitations

Given the timeline of my project, each stage had its limitation. I will discuss the limitations present in each stage and how they affected the project.

Sampling and Recruitment

There are two factors within my sample that could limit the results of my research. The first is that my sample was predominantly lecturers and full professors in the CoE. I wasn't able to interview any assistant

or associate professors. The second is that while my sample did cover a range of CoE departments, I was not able to garner multiple perspectives from each field. Given how large the CoE is, the size of my sample is something to take into consideration when looking at my results. My results reflect the views of the participants in my project, not necessarily all engineering educators within the CoE. Future research could try to garner a slightly larger sample size to understand more perspectives and experiences on incorporating DEI content into the curriculum.

Research and Analysis Stage

One potential limitation in the research stage was that all of the interviews were conducted via Zoom because of the Covid-19 pandemic. This was a huge limitation for the usability testing of the first prototype card deck because participants were not able to hold the cards. Potential suggestions for the cards might have been missed given the online modality of my data gathering. I would have preferred to conduct the interviews in person, but the timeframe when I was able to conduct the interviews was during a period when Covid-19 cases were extremely high and winter was in full swing. For the health and safety of myself and my participants, I chose to hold the interviews on Zoom. Though some participants were open to being interviewed in person, I did not feel that holding some interviews in person and some through Zoom would create an equitable experience while in the research stage. Another limitation during the research stage was that because I knew I would be incorporating feedback from the research and analysis stages into prototyping the card deck, I had to stop after eight interviews in order to have enough time for analysis. For the analysis stage, I faced a similar challenge in that in order to be able to move on to working on the second prototype, I had to “finish” my analysis earlier than desired to keep the project moving. This was a limitation because there were

more ways I could have analyzed the data from the interactivities in MURAL. Potential insights or key trends might have been missed and are therefore left out of the presentation of my data.

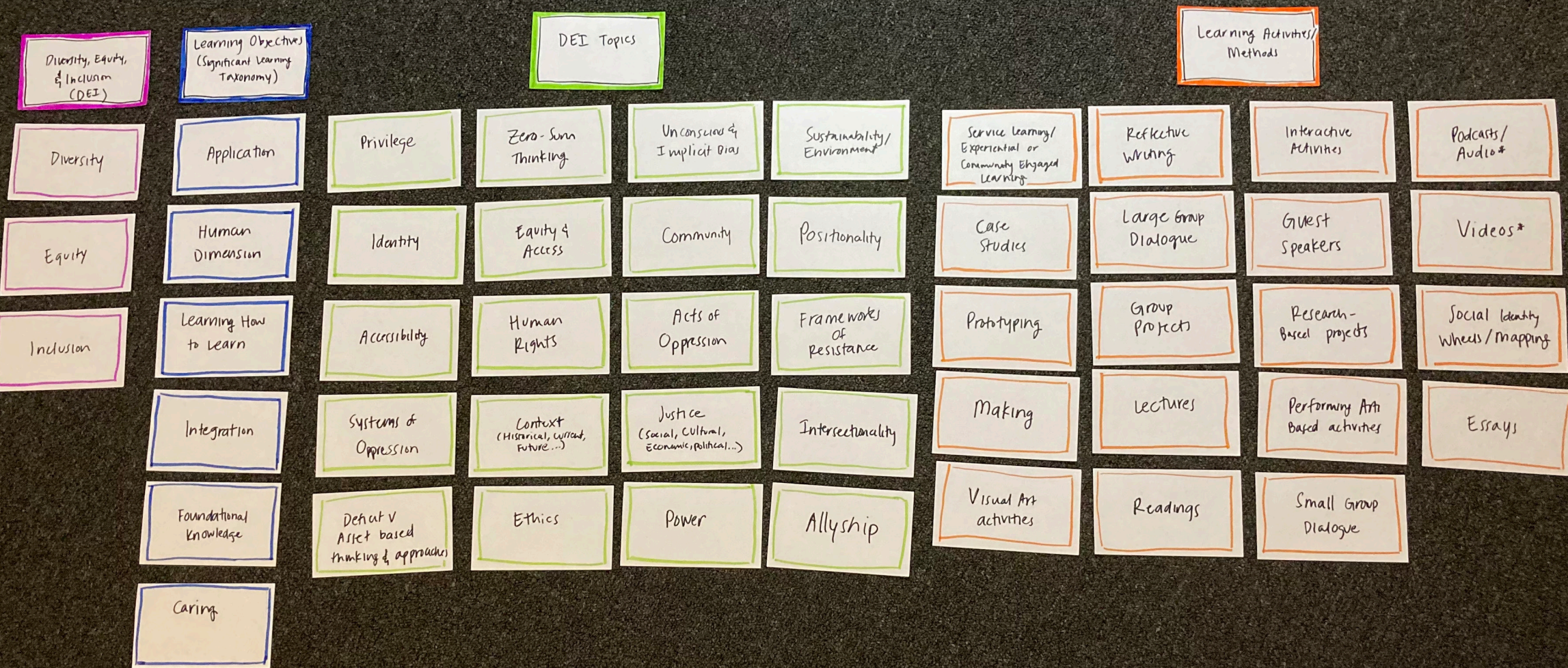
Positionality

Another limitation to my work is that I conducted this research being an outsider to the field of engineering. Some of the benefits of being an outsider by discipline were that I was able to approach this project with a more open mindset than I might have if I had been trained in engineering. However, there were some challenges to being an outsider to engineering. Some of the drawbacks to my positionality were that I did not have that first-hand knowledge of the discipline through my own education. Conducting this project without that experience might have led me to making certain analyses of my data that went in a different direction if I had come with that background. Another drawback was that I don't teach in the field of engineering and, therefore might not completely understand the challenges and barriers that educators face within the classroom when trying to integrate DEI content.

Prototyping

The last area that limited my work was the prototyping stage and experience. Given the timeframe of my project, I was only able to create two prototypes and test one of them with stakeholders to gain feedback. Ideally, I would have liked to do another round of testing with smaller groups of engineering educators in a facilitated workshop to gain more insight into the interactivity of the cards. Another limitation to the prototyping stage was that participants

interacted with the first prototype only through Zoom because my interviews were conducted virtually. They weren't able to pick up and hold the cards.



CONCLUSION

Future Work

The first area that could continue to be developed is the research with engineering educators. More qualitative (or quantitative) research should be done to understand the barriers to integrating these topics as well as what topics engineering educators see as the hardest to integrate. I also think future research could look at faculty and student perspectives in the same study. Some participants

expressed hesitation about bringing up specific DEI topics for fear of making students uncomfortable. However, no participant could give an actual example of when they tried to teach a more complex DEI topic and what happened. In my study, professors were making assumptions about what could happen. Understanding the student perspective could bring valuable insight into how students could be better reached.

Another area that needs future work is the content and form of cards. My research was the first level of groundwork to help formulate the cards. One suggestion that should be integrated into the cards before any more testing occurs is to try to incorporate actual activities that engineering educators use onto the back of the Learning Methods cards. This was one of the recurring suggestions from participants about the cards. I wasn't able to incorporate this suggestion into the cards as well as a couple of other suggestions due to time constraints. After this incorporation, I believe the cards would be ready to test in small groups of engineering educators in a facilitated workshop. Testing the cards in a facilitated workshop would allow for more feedback not only on the visual communication of the cards but the function and usability of the cards. I would recommend doing 2-3 workshops with engineering educators from all disciplines. More research could also be specifically focused on how using a card deck or other prototype and game-like structures could be used to inform DEI education.

Conclusion

Engineering educators are still working to fully integrate DEI topics into the courses. The results from my research align with previous literature that while engineering educators may place significant value on DEI topics, the actual integration of these topics can be challenging. The

thought that engineering should prioritize technical training was evident in my findings, given participants' attitudes towards the humanities' ability to teach DEI topics better. More design research should be done to explore how to support engineering educators in incorporating these topics into their classes and to identify other barriers that may be prohibiting the process. This thesis focused on how using an integrative design approach could address the problem and reveal opportunities for intervention and begin the process of testing a possible intervention and tool in the form of a card deck for engineering educators. Through this process, key themes were identified through the interviews, and initial feedback on the card deck was incorporated into the second prototype. Integrating DEI topics into engineering education will continue to be a challenge but is a necessary step in working towards engineering a more just and equitable world.

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Appendix

IRB Exemption

Study eResearch ID:: HUM00205729

Date of IRB Exempt Determination: November 5, 2021

IRB Exemption Status: EXEMPTION 2(i) and/or 2(ii) at 45 CFR 46.104(d)

Recruitment Flyer

Study Title: Our Collective Future Depends on It: Integrating Learner-Centered Design for Diversity, Equity, and Inclusion in Engineering Curricula

Research Topic: DEI Content and Curriculum Design in Undergraduate Engineering Education

Primary Investigator: Kendell Miller-Roberts (kendell@umich.edu) (MDes in Integrative Design Student, Penny W. Stamps School of Art & Design)

Faculty Advisor: Nick Tobier (nicktob@umich.edu)

IRB Number: HUM00205729

Who are you?

Hello! My name is Kendell Miller-Roberts (she/her) and I am a second-year graduate student in the MDes in Integrative Design Program within the Stamps School of Art and Design at the University of Michigan-Ann Arbor.

What is the reason for this study?

I am conducting this research project as a part of my Thesis project for my program. In order to better understand how DEI education is created and chosen within an engineering context, my research explores how engineering educators create and choose DEI educational content for their undergraduate classes.

What are the qualifications for this study?

- Participants must be faculty members (tenure-track and/or tenured, OR lecturers) within the College of Engineering
- Participants need NOT be from any specific engineering discipline, all engineering fields welcome
- Participants must include DEI as a learning topic in at least **one** of their undergraduate engineering classes. DEI as a learning topic can be explored through a wide range of learning activities that include but are not limited to reading assignments, class activities, guest lectures, videos, essays, group projects, service learning, community-engaged learning, etc...
- Participants should be available to take part in an asynchronous survey (15 minutes)
- Participants should ideally be available to participate in a one-hour interview for the project (Option for virtual or in-person)

What will you be required to do and how long will it take?

Participants will ideally take part in an asynchronous survey (approximately 15 minutes) and will have the option to participate in a 1-hour semi-structured interview. The survey will precede the interview. Interviews will likely be scheduled for January 2022. After your interview, your participation is complete.

Survey

Will I be compensated to participate in the study?

You will be paid a \$20 gift card for participating in this study.

Who can I contact if I have more questions?

If you have any questions about the research project, you can contact Kendell Miller-Roberts at kendell@umich.edu

I would like to participate in your study. What are the next steps?

If you would like to participate in my study, please contact Kendell Miller-Roberts, kendell@umich.edu

I am not available to participate in your study but know someone who might be interested. Can I share this information sheet with them?

Yes! Please share this form with any College of Engineering faculty who might be interested in participating in this project.

Designing an Inclusive Curriculum: A Qualitative Study on Diversity, Equity, and Inclusion Content in Undergraduate Engineering Education

Hello!

This questionnaire is the first part of my Thesis Research Project, "Designing an Inclusive Curriculum: A Qualitative Study on Diversity, Equity, and Inclusion Content in Undergraduate Engineering Education." This survey should take approximately 15 minutes to complete.

You will be asked some demographic questions, teaching position questions, and DEI-related questions. All data collected through this survey will be de-identified.

Questions? Please email me, Kendell Miller-Roberts at kendell@umich.edu

[INCLUDE IRB NUMBER HERE]

The respondent's email (null) was recorded on submission of this form.

1. Email *

Demographic Questions

All demographic information will be de-identified and anonymized for this research project.

2. Select all racial and/or ethnic identities that apply. (Please use the last checkbox to self-identify in more detail if needed.) 1 point

Check all that apply.

- Black
- African-American
- African
- Afro-Caribbean
- Indigenous / Native American
- Hispanic
- Latinx
- Native Hawaiian / Pacific Islander
- Asian
- Asian-American
- East Asian
- South Asian
- Southeast Asian
- Arab / Middle Eastern
- White
- Western European
- Eastern European

Other: _____

3. What is your gender identity? (e.g. cis-woman, transperson, non binary, genderqueer, I prefer not to disclose, etc.)

College of Engineering Position Questions

4. What is your position title?

Mark only one oval.

- Assistant Professor (tenure-track)
- Associate Professor (tenure-track)
- Associate Professor (tenured)
- Full Professor (tenured)
- Lecturer
- Other: _____

5. What College of Engineering Departments do you teach in? Please select all that apply.

Check all that apply.

- Aerospace Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil and Environmental Engineering
- Climate and Space Sciences and Engineering
- Computer Science and Engineering
- Electrical and Computer Engineering
- Industrial Operations Engineering
- Integrative Systems & Design
- Materials Science and Engineering
- Mechanical Engineering
- Naval Architecture and Marine Engineering
- Nuclear Engineering and Radiological Science

Other: _____

6. How many years have you been teaching within the College of Engineering?

7. Do you have a joint appointment in another school within the University of Michigan-Ann Arbor?

Mark only one oval.

- Yes
- No

8. If you answered "yes," to the question above, what other School do you teach in?

Diversity, Equity, and Inclusion (DEI) Curriculum Questions

DEI is a dynamic, complex, and nuanced subject. Please note that there are no right or wrong answers. Choose the answer(s) that best fits.

9. How would you rate your understanding of diversity?

Mark only one oval.

1 2 3 4 5 6 7 8 9

Little to no knowledge and/or expertise Extensive knowledge and/or expertise

10. How would you rate your understanding of equity?

Mark only one oval.

1 2 3 4 5 6 7 8 9

Little to no knowledge and/or expertise Extensive knowledge and/or expertise

11. How would you rate your understanding of inclusion?

Mark only one oval.

1 2 3 4 5 6 7 8 9

Little to no knowledge and/or expertise Extensive knowledge and/or expertise

12. How would you rate your understanding of Diversity, Equity, and Inclusion (DEI) together?

Mark only one oval.

1 2 3 4 5 6 7 8 9

Little to no knowledge and/or expertise Extensive knowledge and/or expertise

13. How important do you feel including DEI content is in your undergraduate engineering classes? Please choose the answer that best fits.

Mark only one oval.

- I feel that DEI content is always needed in my undergraduate engineering classes.
- I feel that DEI content is regularly needed in my undergraduate engineering classes.
- I feel that DEI content is sometimes needed in my undergraduate engineering classes.
- I feel that DEI content is occasionally needed in my undergraduate engineering classes.
- I feel that DEI content is never or almost never needed in my undergraduate engineering classes.
- Other: _____

14. How would you rate your comfort level of including DEI content in your undergraduate engineering classes? Please choose the answer that best fits.

Check all that apply.

- I am extremely comfortable including DEI content in my undergraduate engineering classes.
- I am comfortable including DEI content in my undergraduate engineering classes.
- I feel neutral about including DEI content in my undergraduate engineering classes.
- I am uncomfortable including DEI content in my undergraduate engineering classes.
- I am extremely uncomfortable including DEI content in my undergraduate engineering classes.

Other: _____

15. How often do you actually include DEI content in your undergraduate engineering classes? (This could include a wide variety learning activities including reading assignments, class activities, guest lectures, videos, essays, group projects and any other class assignments that include DEI as a topic of learning.) Please choose the answer that best fits.

Mark only one oval.

- I always include DEI content in my undergraduate engineering classes.
- I regularly include DEI content in my undergraduate engineering classes.
- I sometimes include DEI content in my undergraduate engineering classes.
- I occasionally include DEI content in my undergraduate engineering classes.
- I almost never or never include DEI content in my undergraduate engineering classes.
- Other: _____

16. I include a Diversity Statement in my course syllabi.

Mark only one oval.

- Yes
- No
- Unsure about what a Diversity Statement is
- Currently working on developing a Diversity Statement

17. I include an Inclusive Teaching Statement in my course syllabi.

Mark only one oval.

- Yes
- No
- Unsure about what an Inclusive Teaching Statement is
- Currently working on developing an Inclusive Teaching Statement

Next
Steps:
Interview

I would love to talk about the above topics more in-depth with you in a one-hour interview. Should you decide to opt-out of the interview, there will be no penalty.

If you would like to be interviewed for my project, please indicate below which modality you would prefer your interview to take place. I recognize that the Covid-19 is a continuous challenge that we are facing. Please choose the interview modality that best fits your schedule, and the needs for your health and safety.

18. Would you like to participate in a one-hour interview to discuss DEI and curriculum development more in-depth?

Mark only one oval.

- Yes! I would like to participate in a one-hour interview for this project.
- No, but thank you for the offer.

19. If you would like to participate in an interview, please indicate which interview modality that best fits your needs. (Should you need to change your answer before the interview, please let me know.)

Mark only one oval.

- I would prefer an in-person interview located in a private, quiet space following U-M and state health and safety guidelines.
- I would prefer a video interview over Zoom.
- I am unsure right now, can you follow up with me closer to my interview date?
- Other: _____

Interview Protocol

20. Do you need any accommodations for your interview? If so, please list them below.

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Google Forms

Our Collective Future Depends on It: Integrating Learner-Centered Design for Diversity, Equity, and Inclusion in Engineering Curricula

Semi-Structured Interview Guide

Interviewer: Kendell Miller-Roberts

Interview Subject Number:

Interview Date:

Interview Conducted Via Zoom

Link to MURAL Board:

Introduction

Thank you so much for joining me and taking time out of your day to speak with me. I am a current graduate student in the MDes in Integrative Design Program within the Stamps School of Art and Design. I am here to learn more about how you develop DEI content within your undergraduate engineering classes. My goal with this research is to help design a card deck that can help educators more fully integrate DEI topics within their classes by understanding first-hand experiences in engineering curriculum design. As a reminder, I am not from the College of Engineering, and as such, I do not have your degree of familiarity with the content within the engineering field. You are the content expert, and I am here to learn from your experiences.

I want to remind you that your participation is entirely voluntary. Should you want to stop this interview at any time, please let me know.

During this interview, we will use a virtual tool called MURAL as some of the questions are more interactive. I will drop the link in the chat when we arrive at that section of the interview.

This interview should also take approximately 45 minutes to 1 hour. Does this timeframe still work for you? If possible, I would like to record our discussion today for reference later throughout my project. All data will be de-identified. Are you okay with that?

[wait for the participant's answer]

[BEGIN recording]

[If Zoom interview] Please feel free to turn off your camera should you need to, or if you need to pause to get up and use the restroom or get a glass of water, please do not hesitate.

Do you have any questions for me before we begin? [wait for the participant's answer]

Great, we are going to begin.

Questions

Background + DEI Training

1. Tell me about the undergraduate classes that you teach within the College of Engineering.
2. In a few sentences, how would you describe your experience teaching in the College of Engineering?
3. Can you tell me about any undergraduate engineering classes you have taught that incorporate DEI topics?
4. In a few sentences, how would you describe your experience teaching these topics in undergraduate classes?
5. What prompted you to incorporate DEI content into your classes?
6. What sort of curriculum design training, if any, have you had when it comes to choosing DEI content and/or DEI learning objectives for your classes?
 - a. Probe for: Did you feel that X training prepared you to teach DEI in a classroom setting? Missing elements, elements that were helpful

Diversity, Equity, and Inclusion (DEI) Teaching and Learning

--INTERACTIVE ACTIVITIES--

1. **MURAL ACTIVITIES**
 - a. **2A- Bullseye Target 1- Importance of Topics:** Rating which DEI topics they feel are most important to cover
 - i. Probe for: Reasons why they put certain topics in the center and others on the margins
 - b. **2B Bullseye Target 2 - Integration of Topics:** Rating which DEI topics they feel are easiest to integrate into their classes
 - i. Probe for: Reasons why they put certain topics in the center and others on the margins
 - c. **2C Circle Figure - Learning Objectives:** Rating which of Fink's learning dimensions from his Significant Learning Theory/Taxnomy on importance, integration, and difficulty to include
 - i. Probe for: Why they chose specific learning objectives for which category
 - d. **2D 2x2 Grid - Learning Activity/Method:** Rating which class activities/methods they use the most often and which ones they are most comfortable with when it comes to DEI topics

- i. Probe for: Why they placed certain activities/methods where they did
- e. 2E- Card Deck Feedback**

- i. For my project, I am developing a card deck for educators to use during course design. My goal is to help educators reflect and consider how they might more strategically link learning objectives, DEI topics, and activities for their classes.
- ii. If you were presented with a deck like this, what are your initial thoughts?
- iii. How might you use a deck like this? If you were asked to place the cards in the bullseye targets and the grid like you just did?
- iv. Would a card deck be helpful in developing DEI content when engaging in course design?
- v. What kind of tools would be helping in developing DEI content for your classes?

Curriculum Design with DEI

1. What sort of explicit DEI content do you include in your class(es)?
 - a. Probe for: specific activities, readings, or other materials and why they choose those
2. How do you decide what DEI topics and content to include in your curriculum?
 - a. Probe for: reasons behind their decision making
3. How does the DEI content relate to the discipline-specific learning objectives for your students?
4. Why do you include DEI topics in your classes?
5. What challenges, if any, do you face when developing DEI content for undergraduate engineering courses?
6. What DEI topics and content would you want to include in your class content but have not yet been able to do so?
 - a. Probe for: Challenges, what has kept them from doing so
7. How do you see DEI content and engineering content overlapping?
8. How do you see DEI content and engineering failing to overlap?

Seeking DEI Resources/ Support

1. Where would you go for help developing DEI content for your class?
 - a. Probe for: challenges to access
 - b. Probe for: potential resources within the CoE and outside the CoE
2. What kinds of support would be helpful in developing/refining DEI content within your classes?

Closing Questions

1. Is there anyone else in the College of Engineering you think I should reach out to?
2. Should I have any follow-up questions, can I reach out to you in the future?
3. Before we end the interview, is there anything else you wish to share?

Conclusion

Thank you again for your time, and for sharing your experiences and expertise. You should receive a Sweetwaters Coffee and Tea \$20 e-gift card within the next week. Feel free to reach out to me if you have any questions or if there is anything else you think about that you would like to share.

[STOP RECORDING]

Probing Prompts If Needed

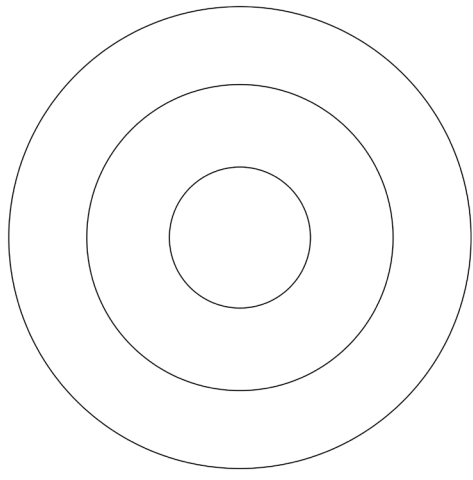
- Can you tell me more about...?
- I notice you said, "X" would you elaborate on X...
- What do you think about...
- How do you feel about...
- What was it like for you...
- Can you share your reasons for that decision?
- How would you describe ___?
- How does that make you feel?
- What was going through your head at that moment?

Interview MURAL Template

Start here...

Question 2A- Importance of Topics

Bullseye Target 1



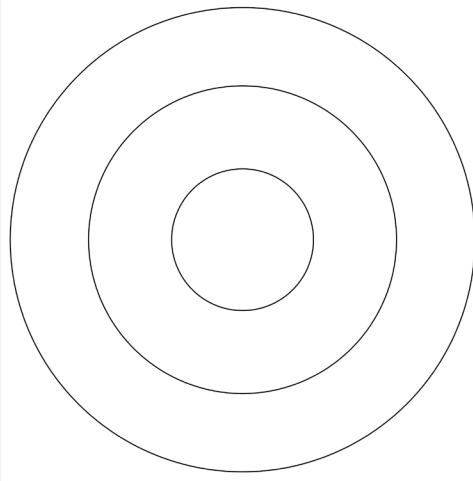
Which DEI topics do you feel are the most important to address in your classes?

Move the topics that you think are the most important to cover and teach to the center of the circle and the harder ones to the margins of the circle.



Question 2B- Integration of Topics

Bullseye Target 2



Which topics do you feel are the easiest to integrate into your classes?

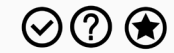
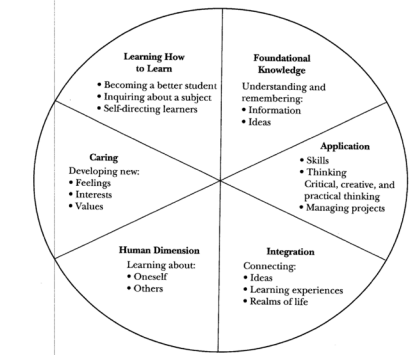
Move the topics you feel are the easiest to integrate to the center and the harder ones to the margins of the circle.



Question 2C- Learning Objectives

Fink, L. Dee. *Creating significant learning experiences: An integrated approach to designing college courses*. John Wiley & Sons, 2013.

FIGURE 2.1. TAXONOMY OF SIGNIFICANT LEARNING.

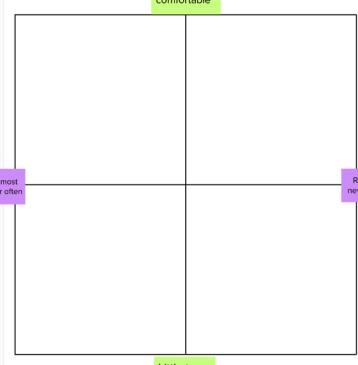


Above is a figure describing Dr. L. Dee Fink's Significant Learning Taxonomy. After taking a few moments to read the learning objectives, consider how these learning dimensions would be specifically related to DEI topics.

- Place the **check mark** on the learning dimension you feel is the **easiest learning objective to meet** for including DEI topics in class.
- Place the **question mark** on the learning dimension you feel is the **hardest learning objective to integrate** when including DEI topics for class.
- Place the **star** on the learning dimension that is **most important to you** when including DEI topics for class.

Question 2D - Learning Activities and Methods

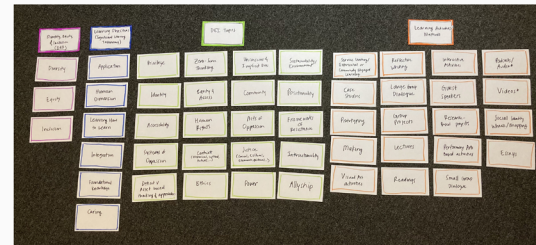
Grid



Place each learning activity/method on the grid denoting how often you use the activity/method for DEI in your curriculum.

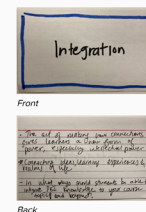


Question 2E - Card Deck Prototype

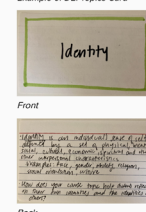


Initial Prototype of Card deck

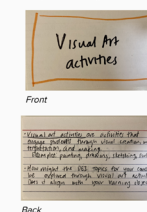
Example of Learning Objective Card



Example of DEI Topics Card



Example of Learning Activities Card

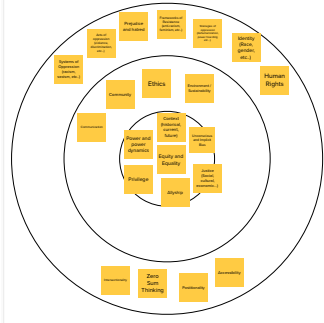


Finished Example of MURAL Template

Start here...

Question 2A- Importance of Topics

Bullseye Target 1

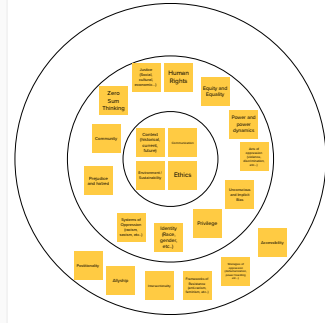


Which DEI topics do you feel are the most important to address in your classes?

Move the topics that you think are the most important to cover and teach to the center of the circle and the ones that are less important to the margins of the circle.

Question 2B- Integration of Topics

Bullseye Target 2



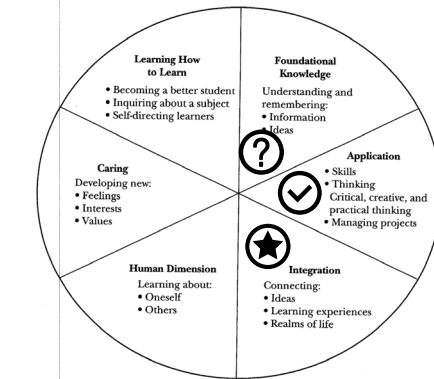
Which topics do you feel are the easiest to integrate into your classes?

Move the topics you feel are the easiest to integrate to the center and the harder ones to the margins of the circle.

Question 2C- Learning Objectives

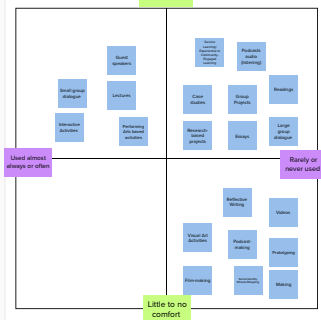
Fink, L. Dee. *Creating significant learning experiences: An integrated approach to designing college courses*. John Wiley & Sons, 2013.

FIGURE 2.1. TAXONOMY OF SIGNIFICANT LEARNING.



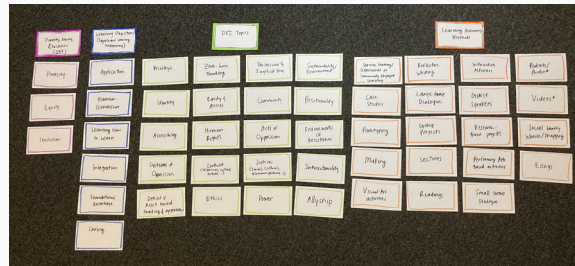
Question 2D - Learning Activities and Methods

Grid



Place each learning activity/method on the grid denoting how often you use the activity/method for DEI in your curriculum.

Question 2E - Card Deck Prototype

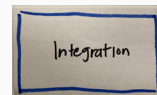


Initial Prototype of Card deck

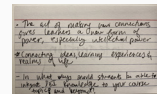
Above is a figure describing Dr. L. Dee Fink's Significant Learning Taxonomy. After taking a few moments to read the learning objectives, consider how these learning dimensions would be specifically related to DEI topics.

- Place the **check mark** on the learning dimension you feel is the **easiest learning objective to meet** for including DEI topics in class.
- Place the **question mark** on the learning dimension you feel is the **hardest learning objective to integrate** when including DEI topics in class.
- Place the **star** on the learning dimension that is **most important to you** when including DEI topics in class.

Example of Learning Objective Card

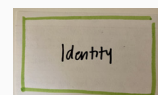


Front

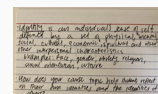


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Example of DEI Topics Card

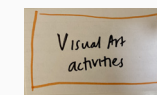


Front

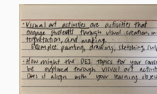


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Example of Learning Activities Card



Front



Back