GIFTS: Transforming First-Year Engineering Curriculum with Diversity, Equity, Inclusion, and Entrepreneurial-Minded Learning

Dr. Lisa K. Murray, Western New England University

Dr. Murray is an a Assistant Professor of Practice in the First Year Program at Western New England University. She holds a BS in biomedical engineering, masters in education and a masters and a PhD in engineering management. Her research interests are in engineering education, advanced manufacturing, design for additive manufacturing, sustainable manufacturing, medical manufacturing, quality and regulatory standards for medical devices, project management, process improvement, and culturally sustaining pedagogies. She serves as a co-advisor for National Society of Black Engineers (NSBE) at Western New England University.

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Lisa K. Murray

Western New England University, Springfield, MA 01119

First Year Program, College of Engineering

Abstract

This Great Ideas For Teaching (and Talking With) Students (GIFTS) paper presents a plan to promote diversity, equity, inclusion (DEI) and entrepreneurial-minded learning (EML) in First-Year introduction to engineering classes. Curricular transformation is encouraged with the creation of new components within first year engineering courses to center and prioritize diversity, equity, and inclusion in conjunction with entrepreneurial minded learning while teaching the design process.

The curricular activities are guided by the Kern Engineering Entrepreneurial Network (KEEN) framework which includes curiosity, connections, and creating value. A module was designed to improve students' exposure to DEI and EML in first year introductory engineering classes. This elicits a just worldview in students to consider multiple perspectives when designing for a diverse market. The module provides a plan for instructors to foster EML while teaching the design process. Educators are able to cultivate innovative students who seek opportunities to create value for individuals that belong to minoritized groups.

Students in two first-year engineering classes used the design process to design a product and later considered the societal impact of their designs. Student teams created a plan and specified a problem definition, created concepts for possible designs, and then prototyped and tested a 3D part for an industry of their choice. Student groups then communicated the engineering solution in terms of the benefits during a gallery walk. Students presented a solution for the challenges and considerations necessary when designing for a diverse group of individuals/users. Student groups collaborated and communicated to the whole group about their motivations and perspectives for their design choices. The students then reflected on the possible value of their designs. Students then wrote reflections that described the societal benefits of creating inclusive designs. Their reflection pieces included thoughts on unconscious bias, challenging/disrupting beliefs, norms, habits and expectations that highlights problems behind oppressive worldviews, and social insight/imagination of what life is like for others considering social circumstances such as cultural identity, privilege, and positionality. A self-reflection rubric is used to assess student self-reflection submissions.

Overall, this module enables educators to develop curriculum that improve students' contribution to society and that encourage students to seek opportunities to create value when designing. This

module has the potential to meet the need of higher-educational institutions' mission to support DEI initiatives on campuses.

Keywords: *student engagement, diversity, equity, and inclusion (DEI), Entrepreneurial-Minded Learning (EML), Kern Engineering Entrepreneurial Network (KEEN) framework*

Introduction

Higher education institutions are currently seeking new approaches to address the new ABET criteria to include diversity, equity, inclusion, and justice in engineering education. Institutions are currently seeking methods to integrate DEI into curriculum, assessment, workplace climate, faculty practice and support, as well as infrastructure [1]. Engineering education must prepare students to be innovative members of society that are able to create products that positively impact a diverse society. Transformational curricular changes in first-year introductory classes that include EML and DEI can have a positive impact on students' and institutions' DEI efforts. Engineering education reform researchers that teach biomedical and mechanical engineering courses have developed and incorporated modules in their classroom that empower engineering students to become champions for DEI [1] [2] [3]. This prepares engineering students for work in a diverse workforce and prepares them to be innovative with high societal impact.

The Kern Engineering Entrepreneurial Network (KEEN) framework [4] provides learning outcomes that can be used in planned educational experiences to cultivate curiosity, connections, and value creation in students. Entrepreneurial-minded learning (EML) combines curiosity, connections, and creating value with skills in seeking opportunities, design, and impact assessment. EML allows students to continually seek opportunity to create value with the intention of creating high societal impact.

Students are exposed to the necessary skills to design a part that is fit for additive manufacturing. Their design knowledge is complemented with seeking opportunity to create designs that are inclusive by considering the lived experiences of a variety individuals from diverse groups. Students also develop the sensitivity to the differences in available resources in low resource communities that must be considered when making design choices.

Experimental Methods and Materials

Students in two sections of a required first-year engineering design class, Introduction to Engineering, at Western New England University, participated in a module that reinforced the design process in conjunction with EML and DEI. The module was approved by the institution's Internal Review Board (IRB). The design process is typically taught in Introduction to Engineering first-year courses which generally takes the students through the process of empathizing, problem definition, ideation, prototyping, and testing. The design process is typically assigned for use in a semester long project that may not require students to consider the societal impacts of the designed product.

In this module, student groups used the design process to design and fabricate a product from an industry of their choosing. The design process was used and detailed on posters. 3D models were made in SolidWorks which was then sent to the fabrication lab for printing or laser cutting. The students assembled the products using the fabricated parts and any other materials from the maker space such as wooden dowels, cardboard, etc. Team posters and designed products were then displayed in a gallery walk. During the gallery walk, students observed other student work and asked questions about details on design choices.

After the gallery walk, students were then asked to consider the target market for each product. The students were also asked to consider if the designed product can be utilized by a diverse group of users and if it can be readily manufactured in a low-resource environment. Students were then asked to rank the products based on the following criteria:

1. Usefulness
2. Clear detailing of the design process
3. Ability to be manufactured in a low-resource area
4. Ability to meet the needs of a diverse group of users

After ranking the posters and products, students were required to individually write self-reflections on their team's product design. They were required to note planned changes to the designs that could benefit a wide group of individuals. Students were also required to note changes to the product's manufacturability and reproducibility in low-resource areas.

The lesson duration, learning objectives, assignment prompt, materials, post module prompt, and deliverables are detailed below.

Duration

The activity was performed in two consecutive three-hour classes. During the three-hour classes, students have access to lab computers and a fabrication space. The design process and CAD modeling are taught prior to the module.

Learning Objectives

The learning objectives of the module include:

1. Define the design process.
2. Implement the design process to design a product.
3. Integrate entrepreneurial minded thinking in the design process.
4. Discuss the role of DEI in design decisions.
5. Reflecting on design decisions and the societal impact of designs.

Assignment Prompt:

Design a part for use in any industry. Detail the design process used to design the part. Describe how the part will be manufactured? What will the cost be to create the part? State at least 2 designs for additive manufacturing (DfAM) consideration.

Materials:

- Access to 3D printers and possibly a laser cutter
- Solid modeling software
- Poster boards
- Cardboard
- Tools or prototyping such as a Dremel, saws, hammers, screwdrivers, and scissors.

Post Module Prompt:

A post module prompt was posed to the students at the end of the gallery walk portion of the lesson. The following questions were asked:

1. What individuals were your target market?
2. Can this product be produced in a low-resource area?
3. Can your product be utilized by a wide range of individuals?

Deliverables:

- 3D model of the parts that make up the product
- Prototype of the product
- Poster or use in a gallery walk
- Post module self-reflection

Results

At the end of the module, an opportunity was created for students to consider the end-users of the products that are designed. This elicited a conversation about the importance of designing with the lens of diverse groups' lived experiences in mind.

Student Reflection Samples

- *This whole project was impressive, and the walkthrough taught me a lot about the things that should be considered when creating and designing a product. Mainly, my group and I had not exactly considered a societal impact, and because of this, the scope of people who use it might be narrower than we would like.*

- *As for the ranking of the other products in the class, the one with the most societal impact was the Prosthetic Thumb prototype. This group found a real problem in the world and offered a solution that could be easily manufactured using only a rigid base, an elastic component, and a string with which to control the contraption.*

- *I would adjust a lot of the physical parts for the prosthetic thumb, but very little of the design. The thumb design is cheap and accessible, as well as repairable in most environments regardless of resource availability. The biggest change I would make to the design of the thumb is possible a more effective string box to provide tension on the thumb.*

Student Artifacts

Students displayed posters and 3D models during the gallery walk. Figure 1 shows four student artifacts along with 3D models of the designed product.

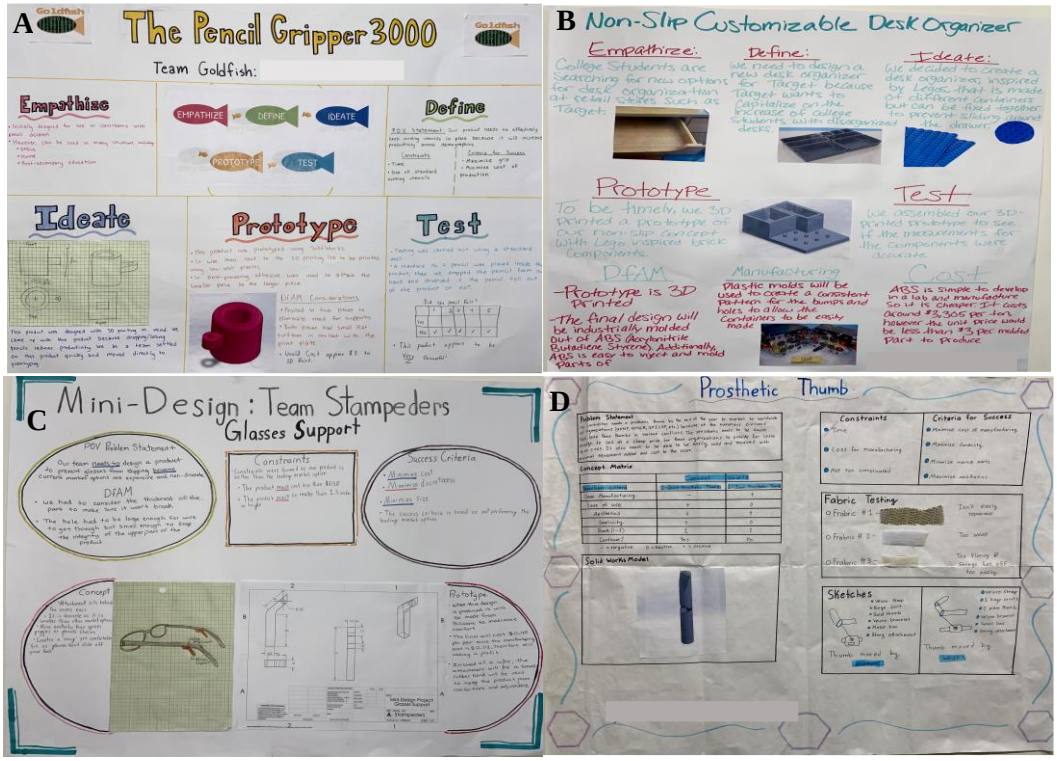

Figure 1. **Student Posters used during the Gallery walk**. A. Pencil gripper prototype. B. Desk organizer. C. Glasses support. D. Prosthetic Thumb

The student teams detailed the design process and the design for additive manufacturing considerations used during the development of the products.

Future Work and Conclusion

Future development of this module involves the use of the rubric shown in Appendix A. Students will be given the DEI rubric to use as a guide to reflect on their experience after the module. After the gallery walk, opportunities can be created to allow students to share stories about their experiences as well as the lived experiences of differing groups that may use their product. Future work should emphasize justice to promote awareness of the injustices some groups face such as racial disparities in design and development.

This module enables educators to incorporate DEI and EML in first year engineering courses. Educators can transform the way engineering students approach and seek opportunities to make value for individuals from diverse groups. First year students will be prepared to consider the societal impacts of their work and designs from the first year of their engineering education.

References

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Appendix A

Diversity, Equity & Inclusion Reflection Rubric				Total Score:_____		
Metric	**4**	**3**	**2**	**1**	**0**	**Score**
Cultural Influence	Thoroughly explains how the generated CAD design shows cultural influence and makes 3 connections to cultural information learned in the gallery walk	Adequately explains how the generated CAD design show cultural influence and makes 2 connections to cultural information learned in the gallery walk	Adequately explains how the generated CAD design shows cultural influence and makes 1 connection to cultural information learned in the gallery walk	Offers a limited explanation of how the generated CAD design shows cultural influence and does not refer to any culture	Not present	
Historical Perspective	Explicitly states a factual event/time in history that inspired the design and provided an IEEE citation with additional facts about that landmark	Adequately states factual event/time in history that inspired the design and provided an IEEE citation with limited facts about that landmark	States a factual event/time in history that inspired the design but did not provide a reference	States a connection to generalized knowledge about an event/time in history but is not cited	Not present	
Cultural Awareness	Includes a thorough description of culture learned from other student presentations. Uses 3 or more concrete examples presented by others in the gallery walk	Includes a description of culture learned from other student presentations. Uses 1-2 concrete examples presented by others in the gallery walk	Includes a brief description of culture learned from other student presentations. Uses 1concrete examples presented in the gallery walk but limited in detail	Includes a vague description of culture learned from other student presentations. Only discusses examples in aggregate from examples presented in the gallery walk	Not present	
Inclusion and Social Awareness	Thoroughly describes EITHER a personal experience during the module of feelings of inclusion OR ways they could improve inclusion of others in future collaborations using culture as a bridge	Adequately describes EITHER a personal experience within the module of feelings of inclusion OR ways they could improve inclusion of others in future collaborations using culture as a bridge	Vaguely describes EITHER a personal experience within the module of feelings of inclusion OR ways to improve inclusion of others in future collaborations using culture as a bridge	Only mentions EITHER a personal experience of inclusion OR ways they could improve inclusion of others in future collaborations using culture as a bridge	Not present	