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Promoting Diversity, Equity, and Inclusion through Culture-Related Design in First-Year Engineering Curriculum: A Work in Progress

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Abstract

There are critical conversations happening right now around Diversity, Equity, and Inclusion (DEI) in engineering professions and engineering educational settings. Educational settings need to prepare students to collaborate with diverse populations in their engineering workplace. DEI concepts can be incorporated in first-year engineering curriculum to enhance student design and exposure to diverse cultures during this unique design for additive manufacturing (DfAM) teaching module. This paper describes the development of a DfAM workshop that incorporates historical and cultural themes. Students' perception of the design experience will be measured using an engineering self-efficacy validated tool, pre- and post-workshop survey, and measured design outcomes (CAD model) after engaging in a DfAM workshop. The workshop uses activities guided by the Kern Engineering Entrepreneurial Network (KEEN) framework which includes curiosity, connections, and creating value. The workshop introduces the entrepreneurial-minded learning (EML) with DEI efforts through the design prompt. It is beneficial to make connections from historical designs to inspire novel approaches to design opportunities. Reflecting on individual's unique designs and their individual influences from historical approaches can bring awareness. It can be difficult to initiate conversations around DEI, especially in engineering design classrooms. The incorporation of DEI in this DfAM workshop helps to naturally coach students to engage in an inclusive classroom environment where they feel an increased sense of belonging and become more socially aware of others differing cultures by talking about one's own unique background with classmates. This workshop spearheads discussions on diversity, equity, and inclusion focused on engineering design. Historical inspiration can increase student creativity and improve sensitivity and appreciation for other cultures. During the DfAM workshop, students search for art forms from their own cultural background or a significant time in history that are then used as inspiration to create unique logos and CAD designs to then produce 3D printed models. Presentations are made to explain the individual's design. Student work is displayed in an art gallery format and viewed by the entire class. Preliminary evidence showed that the students enjoyed presenting designs with cultural elements. The presentations elicited questions from fellow classmates that provided opportunities for cultural conversations and an in-class discussion that promoted inclusion in the engineering classroom. This work provides a pathway for educators to implement DEI in engineering design activities that can better prepare students for the future of work in a diverse, equitable population.

Keywords: *Design for additive manufacturing (DfAM), student engagement, diversity, equity, and inclusion (DEI), Kern Engineering Entrepreneurial Network (KEEN) framework*

Introduction

There is a need to address the issues surrounding diversity, equity, and inclusion in higher educational institutions. DEI is used in everyday language due to an increase in society's consciousness. The National Institutes of Health (NIH) define diversity as "the range of human differences, including but not limited to race, ethnicity, gender, sexual orientation, age, social class, physical ability or attributes, religious or ethical value system, national origin, and political beliefs". Inclusion is defined as "involvement and empowerment, where the inherent worth and dignity of all people are recognized." Equity is defined as "the state, quality, or ideal of being just, impartial, and fair" [1].

Educational leaders must embody the mission and vision of their institution to frame diversity issues in the campus community. This work can occur in the engineering classroom. Mission driven educational institutions typically prioritize initiatives and activities that support the institution's mission. Historically white and predominantly white institutions (PWI) identify diversity, equity, and inclusion (DEI) as vital topics in the institutions' mission statement. To support this mission, programs and departments need to dedicate time and resources towards increasing diversity, equity, and inclusion. Research studies show that DEI mission statements can be inauthentic based on the high number of studies that document negative experiences of students of color at PWIs in the United States [2].

A students' moral reasoning development is affected by negative interactions with racially diverse peers. It is important for educators to consider the diverse needs of students and design curriculum that equally benefit all identity groups. This can be achieved through integrative learning, diversity experiences, and positive interactions with diverse peers in experiential learning environments. Successful DEI initiatives on college campuses require staying true to the university's mission, maintaining good governance processes, and adapting to changing landscapes. It is important for leaders to commit to the examination of historical legacies, epistemological and societal racism that permeate institutional practices and policies [2].

Common DEI educational approaches include workshops that encourage cultural humility, bias training, and mentoring improvement to diversify the workforce. This training can be most impactful when offered as an institution-wide intervention. Cultural humility requires self-reflection and self-critique where individuals learn about other cultures and examines his/her beliefs and cultural identities. There is important work being done in the field of culturally sustaining pedagogies that is leading the way in terms of conversations around art and culture [2]. Exposure to high-impact practices leads to both the awareness as well as the understanding and acceptance of others. DEI training must address the significant impact that implicit or unconscious bias plays in an individual's life. DEI training is important components of research, training, and education. However, the intervention should be perceived as authentic and natural without feeling forced on its participants [2]. There are few published examples to guide engineering faculty through the process of incorporating authentic DEI activities into the engineering classroom but there are some important published works leading the charge [4, 5, 6]. There are many unanswered questions about the best approaches, strategies, and programs that can be implemented in engineering education [1]. This work aims to offer a strategy to naturally incorporate DEI in engineering first-year design classrooms.

Methodology

The main goal of this module is to use the KEEN framework [3] to incorporate the 3C's which are curiosity, connections, and creating value in a lesson that reinforces the design for additive manufacturing guidelines that are taught in most engineering schools. At the beginning of the module the following learning objectives were clearly stated by the instructor, who is one of the authors.

Learning Objectives:

By the end of this module, students will be able to:

1. Investigate how culture and the events in history affect design choices.
2. Apply design for additive manufacturing (DfAM) design guidelines to generate designs.
3. Design 3D objects with inspiration from a significant time in history or from a culture of their choice.
4. Discuss cultural relevance of their design choices.

In a first-year engineering design class titled: Introduction to Engineering, at Western New England University in the Fall 2022, 25 students were exposed to DEI concepts through a design for additive manufacturing (DfAM) module. Students were required to incorporate historical and cultural themes in the design of the team's logo that was then integrated into Computer Aided Design (CAD) models. The class consisted of 92% white male (1 male from West African descent) and 8% female (1 African American female).

The design teams were chosen based on the student's availability for meetings, CAD experience, programming experience, and engineering major. The student makeup of each team required varying expertise in CAD and programming, as well as individual's engineering major.

Each design team was required to make connections to historical designs or utilize cultural connections to inspire a novel approach to design opportunities. Students first worked together to create logos that represented different cultures. During the DfAM workshop, students searched for art forms or manufactured objects from their own cultural background or a significant time in history that was then used as inspiration to create their unique team logo. This logo was to then be incorporated into CAD designs and constructed into 3D printed models. Students followed the ideation process to generate culturally inspired design concepts. Each team designed a group logo and wrote a narrative that was presented to the entire class using a PowerPoint presentation. Students were encouraged to discuss the cultural influences in their designs focusing on the reasons for design choices and its cultural relevance.

This natural incorporation of DEI in a DfAM workshop focused on design aspects helped students to engage in an inclusive classroom environment. Students anecdotally reported an increased sense of belonging and felt more socially aware of differing backgrounds and better appreciation after the completion of the module. This type of outcome has the potential for students to become more aware of differing cultures and could assist them in their development of becoming a global citizen. It might also make a strong impact when utilized in first-year engineering programs to ensure students feel supported in their community, and confident in their identity. This has the potential to ensure students do not sense pressure to drop their own cultural heritage in order to feel integrated in order to succeed in a predominantly all-white American school [4].

To expose students to the technical applications of DfAM, the students were instructed to utilize smart manufacturing design considerations such as weight reduction and waste material reduction in their design process. The design was required to be manufacturable on a fused deposition desktop 3D printer and follow DfAM guidelines. Methodologies related to DfAM were taught in lecture-based content throughout the semester. Students were provided a detailed rubric to help guide the decision-making and incorporation of technical content (Appendix 1) [7].

Preliminary Results

Presentations of student work led to in-class discussions based on curiosity about student's culture and life experience. The team presentations elicited questions from fellow classmates and community members that promoted broad curiosity. This allowed a classwide venue to ask questions about cultural difference and become more informed about others, beyond that of just technical design. The figure below shows a sample design logo from a student team. The logo was inspired by the West African culture where the hedgehog is used to show speed with colors from the East, West, and Central African flags.

Figure 1. An example of a team logo that utilizes the cultural influence of Africa to inspire the team's identity.

Student excerpt describing their team's logo:

> *"Our team logo was inspired by West African Culture due to our team's name being iSonic, inspired after Sonic the Hedgehog. Now you may stop and ask yourself, what does Sonic the Hedgehog have to do with West African Culture? However, it is not the hedgehog in the virtual world that is being referred to, but the hedgehogs in real life. Hedgehogs are inhabitants of East, West, and Central Africa and they have been living there for millions of years. We decided to specifically pick West African culture as our design for our logo because we want our robot to be fast, and in the past seven years West Africa has seen over 56 decedents in the 100 m finals at the Olympics. Not to mention, the colors chosen are colors most flags from East, West, and Central Africa, so we are representing the whole area in which the hedgehogs inhabit. We also want to create a robot that is overly aggressive, as most hedgehogs can be, so it can get as many balls as fast as possible."*

Student engagement with culture, and connections to their team project in design helped to inform them of unique differences among classmates and exposure to cultures beyond Western New

England University’s community. Each team had a unique story with interesting narratives that helped to start conversations and educate the class about global communities.

Future Work

This culturally-responsive DfAM module will be executed and assessed in the Fall 2023. Introduction to Engineering will allow two student-cohort groups to be measured during the first two weeks in the academic semester. The students will be presented with a CAD model created by the instructor that shows the incorporation of a design choice that is inspired by the instructor’s unique culture. The students will be required to create an individual CAD design that incorporates their cultural background or a significant time from history. Students will be placed in groups of 3 to report-out the design choices in a small group setting. Together, the small teams will have the chance to discuss varying cultures and how it inspires art and design. This work will be executed using the following activities over a 3-week period:

1. Completion of pre-survey on self-efficacy with cultural awareness

Activity: In-class discussion with small break out groups

2. A quick sketch or logo idea to incorporate culture into the structure/design
3. Report-out in small groups of 3 discussing each person’s cultural inspiration
4. CAD models of student designs with engineering drawings

Activity: DfAM tutorial on manufacturing

5. A second revision of design after exploring appropriate manufacturing choices evaluated using the DfAM rubric (Appendix 1)

Post-Module:

6. Student reflections on their experience during the module that will be graded using the rubric (Appendix 2)
7. Completion of post-survey on self-efficacy with cultural awareness

The DfAM rubric will be used to assess student design choices after the module. This will assess their use of DfAM limitations and opportunities. Self-efficacy will be scored in pre- and post-survey forms to determine if individual's engineering self-efficacy was influenced during this 3-week implementation period.

In the pilot version of the implementation, from Spring 2023, students enjoyed the module. A more robust assessment rubric to evaluate student responses and work product will be utilized during the final execution of the learning module. A detailed rubric will be utilized to evaluate their ability to make connections between design and culture and to demonstrate their ability to learn through class discussion about other people's differing cultural experiences (Appendix 2).

Reflecting on individuals' unique designs based on their individual historical perspectives and influences was a natural way to start conversations on the culture. Student perceptions of learning about culture, and a self-reflection will be evaluated to determine if students can make connections between design and culture as well as broaden awareness of other cultures through the student-led presentations throughout the next academic year. The student survey is under review by Western New England University's Institutional Review Board (IRB).

Conclusion

This work provides a unique module and direct pathway that can be implemented into an engineering classroom using only 1-3 class periods. This module has the potential to help educators implement conversations around DEI in engineering design activities that can better prepare students for the future of work in a global setting. This could lead to a natural platform for the necessary conversations on cultural humility and bias training that are desperately needed in the academic teaching and learning environment. We believe it will initiate an avenue to improve inclusion in the engineering design classroom by creating authentic conversations about diverse cultures around unique design activities that can spark students' curiosity, and expose them to each other's diverse cultures. The utilization of culture to promote inclusion within design courses could be embedded at all levels of the undergraduate curriculum. Initiating this work early in the curriculum like this one, helps to build an engineering community that values diversity and inclusion.

References

[1] L. Corsino and A. T. Fuller, "Educating for diversity, equity, and inclusion: A review of commonly used educational approaches," *J. Clin. Transl. Sci.*, vol. 5, no. 1, 2021, doi: 10.1017/cts.2021.834.

[2] R. M. Barnett, "Leading with meaning: why diversity, equity and inclusion matters in us higher education," *Perspect. Educ.*, vol. 8, no. 2, pp. 20–35, 2020, doi: 10.18820/2519593X/PIE.V38.I2.02.

[3] Kern Entrepreneurial Education Network (KEEN). Mindset + skillset: Education in tandem: https://engineeringunleashed.com/Mindset-Matters/Framework.aspx, 2016.

[4] Paris D, "Culturally Sustaining Pedagogy: A Needed Change in Stance, Terminology, and Practice" *Educational Researcher*, Vol. 41, No. 3, pp. 93–97. 2012, doi: 10.3102/0013189X12441244

[5] Wilson-Lopez, A., Mejia, J. A., Hasbún, I. M., & Kasun, G. S. Latina/o Adolescents' Funds of Knowledge Related to Engineering. Journal of Engineering Education, 105(2), 278–311, 2016, https://doi.org/10.1002/jee.20117

[6] Winchester, III, WW, "Engaging the Black Ethos: Afrofuturism as a Design Lens for Inclusive Technological Innovation" *Journal of Futures Studies*, 24(2), 55–62, 2019.

[7] L. K. Murray, J. Ekong, S. A. Niknam, and M. J. Rust, "A Framework for Implementing

Design for Additive Manufacturing Methods in First-Year Engineering Curriculum: Investigating the effects of specialized training on engineering design and student self-efficacy," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2022.

Appendix 1

Metric	4	3	2	1	0	Score
Part Complexity	Complex curves that cannot be machined. There are interior features or surface curves that are too complex to be machined.	The part curvature is complex (splines or arcs) for a machining operation such as a mill or lathe	The part can be made in a mill or lathe, but only after repositioning it on the clamp at least once	The part is mostly 2D and can be made in a mill or lather without repositioning it in the clamp	The part is the same shape as common stock materials (square, cylinder) or is completely 2D	
Assembly Complexity	Assembly has unidirectional joints with locking features	Contains joints (slider that allows for linear motion along a single axis) with locking features. Includes a screw pair.	Contains 1 joint(slider that allows for linear motion along a single axis)	Contains joints with no locking features	not present	
Number of separate parts	Part is made as one structure and meets desired function	Part is made as 2 structures and meets the desired function	Part is made as 3 structures and meets the desired function	Part is made of 4 or more structures and meets desired function	n/a	
Functionality	Mating surfaces move and experience moderate forces or are expected to last 10-100 cycles.	Mating surfaces move minimally, experience low forces, or are intended to endure 2-10 cycles	Mating surfaces move minimally and experience low forces and cannot endure any cylces	Surfaces are all non-functional or experience no cylces	Mating surfaces are bearing surfaces or are expected to endure 1000+ cycles. Mating surfaces significantly move, experiencing large forces or must endure 100-1000 cycles	
Thin/Smallest Feature size	Walls are more than 1/8" (3mm) thick	All walls are between 1/16" (1.5mm) and 1/8" (3mm) thick	Some walls are between 1/16" (1.5mm) and 1/8" (3mm) thick	Some walls are less than 1/16" (1.5mm) thick	All walls are less than 1/16" (1.5mm) thick	
Smallest Tolerance	Holes and length tolerances are considered or are not important	All hole or length tolerances are adjusted for shrinkage or fit	Some hole or length tolerances are adjusted for shrinkage or fit	Some intended assemblies do not fit.	Hole or length dimensions are nominal/minimal. Parts do not fit the intended diameter. Parts with overlaps do not connect	
Unsupported Features	Part is oriented so there are no overhanging features	Overhanging features have a mimmum of 45 degrees of support	Overhanging features have a sloped support	There are short, unsupported features	There are long, unsupported features	
Support material removal	No support material needed. There are no internal cavities, channels, or holes	Easily asscessible support material. Material can be easily removed from internal cavities, channels, or holes	Internal cavities, channels, or holes do not have openings for removing materials. Hard to remove.	There are small gaps that will require support structures	The part is smaller than or is the same size as the required support structure	
Largest build plate contact	The part has 1 small or no flat surfaces or forms that need to be exact	The part has 2 small or 2 flat surfaces or forms that need to be exact	The part has 1 medium sized, flat surfaces, or forms that should be close to exact	The part has more than 1 medium sized, flat surfaces, or forms that should be close to exact	The part has large flat surfaces or has a form that is important to be exact	

Appendix 2

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 generalalized 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	