2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34872

Your Views Can Be My Views: Understanding Differences in Paradigms Held by Traditionally Marginalized Students in Engineering

Qualla Jo Ketchum, Virginia Polytechnic Institute and State University
Dr. Marie C. Paretti, Virginia Polytechnic Institute and State University

Marie C. Paretti is a Professor of Engineering Education at Virginia Tech, where she directs the Virginia Tech Engineering Communications Center (VTECC). Her research focuses on communication in engineering design, interdisciplinary communication and collaboration, design education, and gender in engineering. She was awarded a CAREER grant from the National Science Foundation to study expert teaching in capstone design courses, and is co-PI on numerous NSF grants exploring communication, design, and identity in engineering. Drawing on theories of situated learning and identity development, her work includes studies on the teaching and learning of communication, effective teaching practices in design education, the effects of differing design pedagogies on retention and motivation, the dynamics of cross-disciplinary collaboration in both academic and industry design environments, and gender and identity in engineering.

Dr. Homero Murzi, Virginia Polytechnic Institute and State University

Homero Murzi is an Assistant Professor in the Department of Engineering Education at Virginia Tech with honorary appointments at the University of Queensland (Australia) and University of Los Andes (Venezuela). He holds degrees in Industrial Engineering (BS, MS), Master of Business Administration (MBA) and Engineering Education (PhD). Homero is the leader of the Engineering Competencies, Learning, and Inclusive Practices for Success (ECLIPS) Lab. His research focuses on contemporary and inclusive pedagogical practices, emotions in engineering, competency development, and understanding the experiences of Latinx and Native Americans in engineering from an asset-based perspective. Homero has been recognized as a Diggs Teaching Scholar, a Graduate Academy for Teaching Excellence Fellow, a Global Perspectives Fellow, a Diversity Scholar, a Fulbright Scholar, and was inducted in the Bouchet Honor Society.

Dr. Andrew Katz, Virginia Polytechnic Institute and State University

Andrew Katz is an assistant professor in the Department of Engineering Education at Virginia Tech. He leads the Improving Decisions in Engineering Education Agents and Systems (IDEEAS) Lab, a group that uses multi-modal data to characterize, understand, and improve decisions made throughout engineering education ecosystems.

Demographic variations in engineering students' environmental worldviews

Abstract

Many attempts have been made in recent decades to make higher education and engineering more inclusive, however, representation of traditionally marginalized populations in engineering is still lacking. Part of the problem is that the culture in the field has been dominated by White perspectives. Hence, it is important to understand how the worldviews of traditionally marginalized populations can be incorporated into engineering education. We used existing data from the CLIMATE survey informed by the New Ecological Paradigm (NEP) to explore if there is a relationship between a participant's race/ethnic background and the paradigm which they hold, specifically that of the NEP. Results suggest that students from traditionally underrepresented populations were 1.50 times more likely to endorse the NEP.

Introduction

Broadening participation and making higher education more inclusive is a national imperative, especially within engineering education. Many attempts have been made in recent decades to make engineering education more inclusive [1]. However, even with these efforts the full participation of traditionally marginalized students in engineering has yet to be achieved [2]. A necessary step towards this goal is changing prevailing beliefs and practices about who belongs in engineering. To create this change, though, we need a better understanding of how the structures and practices of engineering are often grounded in the worldview of the dominant, White culture, which marginalizes non-dominant communities and worldviews [3]. An example of this embeddedness within engineering can be found in the discussion of the history of engineering practice done by Dias de Figueiredo [4]. The beginnings of engineering focus only on the areas of Mesopotamia, Greece, and Italy with no mention of other Asian or African communities. The Americas aren't mentioned until the discussion of the 17th century [4], despite, for example, hundreds of years of civil and agricultural engineering innovations among Indigenous civilizations throughout the continents. This account centralizes White history as the engineering history that matters and exemplifies how this dominant worldview is rooted within the structures and practice of engineering, despite early findings of engineering marvels in Africa and South America. The White dominant perspective, or dominant social paradigm (DSP), is typically characterized as a world view in which humans subdue or conquer the natural world in order to support technological progress [5]. This paradigm is so embedded in engineering that it is considered the norm, hence, we need an understanding of how other worldviews can also be incorporated in engineering. Since worldviews are often influenced by individuals' home cultures [6], conflict and marginalization can particularly occur when a student's worldview differs from the anthropocentric worldview that dominates White cultures – including engineering education. A person's worldview has been defined as "the perspective, or thinking, or school of thought, or set of shared beliefs" that shape how someone sees, interprets, and acts within the world around them [7:26]. In educational research, "paradigm" is the term used to define and describe a worldview [7] and such the two are often used interchangeably. For the purpose of this discussion, "worldview" is used to described one's beliefs or perspective particularly from their home cultures. "Paradigm" will be used to describe a defined set of beliefs or worldviews. In this context, different worldviews can be described by the same paradigm,

such as the DSP. In particular, here we focus on worldviews that describe the relationships among humans, technology, and the natural world. In the dominant Western, White paradigm, humans use technology to subdue the natural world in service to human needs and human progress [5]. In contrast, many Indigenous civilizations are more closely aligned with what has been called the New Ecological Paradigm (NEP), which adopts a more holistic, interdependent view of these relationships oriented more toward an ethic of care for the natural world rather than conquest [5]. These paradigm differences are especially important in the context of engineering education because the DSP positions engineering and the technology it produces as a tool for subduing nature in the service of humanity [8]. Individuals who hold more closely to the NEP may thus find themselves further marginalized and alienated within the field because they hold a fundamentally different understanding of the aims and uses of engineering knowledge.

The purpose of this work is to explore if there is a relationship between a participant's race/ethnic background and the paradigm which they hold, specifically that of the New Ecological Paradigm. This will provide educators and researchers a way to increase our knowledge for broadening the participation of traditionally marginalized populations in engineering. This project utilized existing survey data of senior engineering students at a U.S. university to investigate this relationship. It is hypothesized that students from traditionally underrepresented groups and people of color will be more likely to endorse the New Ecological Paradigm than their White counterparts. A Pearson's chi-square test was utilized to determine if there's a relationship between the two categorical variables of paradigm and race/ethnicity.

Author Positionality

It is a traditional practice by Indigenous people to introduce ourselves first by our community and people in our language. This practice mirrors recent calls for researchers and educators to be transparent in their positionality as well as personal history and perspectives, especially when working with Native communities [9], [10]. Haynes Writer [10] also wrote about the importance of Indigenous perspectives to those outside of the Indigenous community in creating this culturally responsive work, stating: "Our stories and our words are, as well, offerings to non-Indigenous people so they may come to know and move into ally-ship with us for that needed transformative work (p. 10)."

Although this work does not directly affect or work with Indigenous communities, the positionality of our authors is an integral piece of any research done by this team, in particular that of the presenting author, Qualla IW Ketchum. Qualla is a citizen of the Cherokee Nation and grew up within the Nation's boundaries in what is also known as northeastern Oklahoma. Her technical background is in Biological Systems and Agricultural Engineering and is a current PhD student in Virginia Tech's Engineering Education department. She was drawn to this work through trying to better understand why Indigenous students choose and stay in engineering programs.

Homero Murzi is an engineering educator with 15 years of experience interacting with undergraduate engineering students. He has worked most of his academic career to improve the way students learn engineering concepts by making sure they are engaged and their personal experiences are valued in the classroom. He is originally from Venezuela where he worked for 11 years as a faculty member at a public technical university. Here in the U.S., he has also worked at a predominantly white institution and interacted as well as experienced how students from traditionally marginalized populations have barriers to become engineers. He has

intentionally tried to be aware of how to develop more inclusive experiences in both his research and teaching practices, while at the same time considering how his experiences in industry and as a recruiter had a voice in the process. He considers it really important to develop interventions that are not only inclusive but that will also prepare all students to be competent when joining the workforce.

Marie Paretti is a cis, heterosexual White woman with a strong Catholic identity who has being studying issues of oppression, equity, and inclusion for more than twenty years – including recent work on these issues in engineering education. She is a second-generation American whose grandparents immigrated from Italy and from the Austria-Hungary in the early 20th century. She grew up in a working class family embedded in a strong immigrant – predominantly Italian – community just north of New York City, then moved to a mid-sized city in central Pennsylvania. Neither of her parents attended college and were both factory workers. While their education makes her a first-generation college student, both of her parents helped support their siblings through masters and law degrees at Stanford and Cornell, respectively. Education was both a family and a community priority. She also has a sustained interest in issues surrounding environmental work, included past studies of environmental rhetoric and current work on interdisciplinary collaborations related to disaster resilience and risk management.

Andrew Katz is a White, male researcher focusing on ethical decision making and environmental education in engineering. As such, he approaches this work with an interest in the descriptive side of how engineering education currently incorporates environmental impacts of engineers' work but also on the normative side of how engineering should be incorporating environmental considerations. His background is in chemical and civil engineering with an environmental concentration.

Theoretical Framework

The New Ecological Paradigm (NEP) scale measures a person's endorsement of a "pro-ecological" or environmental worldview or framework [11]. This paradigm instrument was first published in 1978 as a way to measure a possible societal shift after the US environmental movement of the 1960s and 1970s [5]. The authors described the argument that many of the ecological challenges facing the United States largely stem from the values, attitudes, and beliefs seen as "traditional" and prevalent in our society also known as the dominant social paradigm or "DSP". Some examples of the DSP are provided as "devotion to growth and prosperity", "faith in science and technology," and even things like "private property rights" [5], all of which, as noted above, invoke a hierarchical relationship of human domination over nature via technology. The term "NEP" was coined in an effort to describe the emergence of ideas that directly challenge the anthropocentric DSP, opting instead for a more environmentally-conscious paradigm that acknowledges the need for balance in which humans honor and protect the natural world even as they also benefit from it. No other instrument has been as widely accepted by researchers as a measure of environmental worldviews [11].

The revised NEP scale has fifteen statements with eight of these corresponding to an endorsement of the NEP, while the other seven statements correspond to endorsement of the DSP [11]. The scale is used widely across disciplines and settings, being used in many different nations including the United States [12], [13], [14]. It has been used in examining relationships between environmental worldviews and constructs such as attitudes on public policy, sustainability behaviors, and even patterns in participation of different recreational activities. The

instrument has also been used as a tool to assess programs and their impact on environmental values or attitudes [11]. These uses align with the goal of this research in examining if a relationship exists between environmental worldviews and ethnic/racial background.

Methods

In order to better understand if there is a relationship between a participant's race/ethnic background and their endorsement of the NEP or DSP, we used a quantitative approach. This project utilized existing data collected using the CLIMATE survey developed by Shealy et al. [15]. The survey measured senior undergraduate engineering students' agency, engineering identity, beliefs about climate change, and career motivations. The survey instrument was described and validated by Shealy et al. (2017) with the goal of providing education researchers with data to better examine students' understanding of climate change, sustainability implications, themselves as engineers, and those relationships with the rest of the world.

This instrument included a question adapted from the revised NEP that had eight statements from the revised NEP scale [11]. The original scale included fifteen items representing both the NEP and DSP [11]. The instrument developed by Shealy et al. [15] included the eight NEP-endorsing statements from the original scale as an independent survey question (Figure 1) as has been done in previous studies utilizing the NEP scale [16]. The question allowed participants to select the extent to which they agreed with each statement utilizing a five-point Likert scale ("Strongly disagree" = 0, 1, 2, 3, 4 = "Strongly agree"). A five-point scale was utilized over a four-point scale as prior research has shown that having the option of a neutral position i.e. a score of "2" in this survey reduces stress for some participants [17].

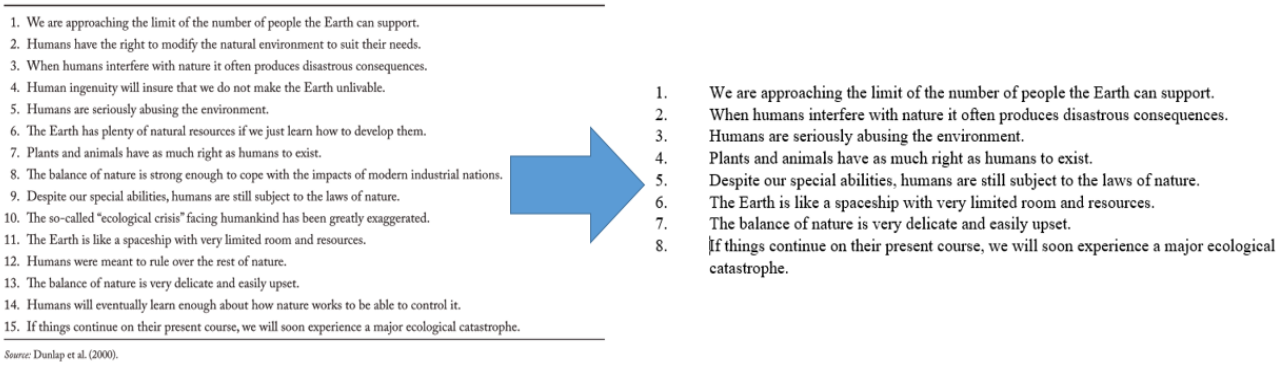

Figure 1: The original fifteen statements utilized in the revised NEP scale (left) and the specific statements used in the CLIMATE survey instrument (right)

Data Collection

The survey was distributed during the Spring and Fall semesters of the 2018-2019 school year to accredited, four-year engineering institutions across the United States chosen randomly from the National Center for Education Statistics and stratified based on student population size from small (<5,400), medium (5,400-14,800), and large (>14,8000) [18]. Capstone instructors at these institutions were mailed surveys and instructions to distribution within their senior engineering capstone courses for two consecutive semesters (Fall and Spring). A national sample of n = 4,605 senior engineering students was collected. Of those who disclosed their gender, 73% were male and 25% were female, which is consistent with the ASEE "Engineering By the

Numbers" report of demographics of graduating seniors earning bachelor's degrees in engineering [19]. The authors would also like to note that 1% of disclosing participants selected that their gender was "Not Listed" and 0.7% identified as Non-Binary.

Data Analysis

Participant's reactions to the NEP statements were divided and analyzed in the five distinct dimensions according to Lück [20] as done previously by Zeqir et al. [21]. The five dimensions of the NEP Scale are "Reality to limits of growth" (LG), "Anti-Anthropocentrism" (AA), "Fragility of Nature's Balance" (BN), "Anti-Exceptionalism" (AE), "Possibility of an Eco-Crisis" (EC) [21]. A participant's NEP Score was taken by calculating the mean from each of each of the dimensional scores. If a participant's NEP score was greater than 3 (min = 0, max = 4), their paradigm was coded as the New Ecological Paradigm, "NEP". If the score was less than 3, then their paradigm was coded as Dominant Social Paradigm, "DSP". For the purpose of this project, we analyzed six racial/ethnic groups: (1) White, making up 67% of the total sample population (2) Black/African American, with 3.8% (3) Hispanic/Latinx, with 8.1%, (4) Asian, with 12.3% (5) Indigenous, with 1% and (6) More than One Race, with 78% of the sample population.

A Pearson's chi-square test was utilized to determine if there was a relationship between the two categorical variables of paradigm and race/ethnicity. This tested the null hypothesis that there is no statistical association between the distribution of students' paradigms and their race/ethnicity. The alternative hypothesis was that there is a statistical association between student paradigm and their race/ethnicity. The assumptions for this test are independent data and that the expected frequencies for each group be larger than five. The method used for coding both race/ethnicity as well as paradigm ensures that each participant is coded into only one category for each variable. The contingency table also allows for the checking of frequencies which were all greater than five for each category. The chi-square test was conducted using R statistical computing software and the completed code can be found in the Appendix.

Results & Discussion

Examining the scores for each dimension of the NEP Scale allows for measurement and evaluation of participants' ecological paradigm. Table 1 sums up the agreement and disagreement statements on each item as a cumulative percentage as well as the percentage of "Unsure" responses as done by Ntanos et al. [12]. This method of displaying the data improves result interpretation for each statement [22]. The mean NEP score for all participants was 2.72 (n = 3407, min = 0, max = 4) indicating that the average student surveyed would fall into the Dominant Social Paradigm category. It is important to note that over half of participants agreed with each of the NEP endorsing statements. In particular, on the statement regarding the Anti-Exceptionalism dimension, which opposes the idea that humans are not limited by, and thus above, nature [21], participants reported a mean score of 3.18, indicating an endorsement of that NEP subscale.

Table 1: Responses concerning NEP Scale items for each of the five dimensions of the scale as well as the total mean NEP score for surveyed participants

NEP Scale's Dimensions	Item #	Cumulative Percent			Mean	S.D.
		Agree	Disagree	Neutral		
Reality to limits of growth (LG)	1	54.8	21.10	24.1	2.47	1.24
	6	58.9	15.38	25.8	2.67	1.15
Anti-Anthropocentrism (AA)	4	62.3	16.78	20.9	2.67	1.15
Fragility of Nature's Balance (BN)	2	64.1	17.58	18.3	2.47	1.08
	7	61.1	14.11	24.8	2.64	1.07
Anti-Exceptionalism (AE)	5	78.9	4.91	16.1	3.18	0.93
Possibility of an Eco-Crisis (EC)	3	69.4	9.95	20.6	2.91	1.05
	8	62.5	14.07	23.4	2.76	1.15
			Total NEP Score		2.72125	1.1025

In order to dive into these dimensions and scores more and explore the research question, a Pearson's chi-square test was utilized to determine if there was a relationship between paradigm and race/ethnicity. Frequencies for each paradigm and racial/ethnic demographic were determined using R statistical computing software (Table 2). The analysis found that there is a statistically significant relationship between which paradigm is endorsed by the participant and their race/ethnicity, $X^2(5) = 32.02, p < .05$. Since a statistically significant relationship was found, further analysis was conducted on each demographics' mean NEP and NEP subset scores (Table 3). More White, Black/African American, and More than One Race students endorsed the DSP than NEP. For Black/African American students, this finding is slightly lower than that found by Lee [23] in African American HBCU college students. This may suggest that African American students that hold a more ecological worldview or perspective are less likely to enroll in engineering. The Total NEP Score mean for Black/African American students and those reporting more than one race was still higher than that of their White peers along with the percentage of those endorsing the NEP. Hispanic/Latinx students had the highest mean scores in all subscale scores except one as well as the highest overall NEP mean score. This aligns with work done previously which found strong pro-NEP beliefs in Hispanic/Latinx populations [16]. It is important to note that the one subscale in which Hispanic/Latinx students were not the highest scoring demographic was "Reality to Limits of Growth", in which Indigenous students had the highest score. This dimension mirrors Indigenous Traditional Ecological Knowledge that teaches there is a limit to the growth of humankind and the use of the Earth's resources [24]. The histories of these two groups can be very connected in many ways around the United States

which supports these two demographics having the highest scores on each of the NEP subscales [24].

Table 2: Contingency table showing the frequencies for each racial/ethnic demographic and whether the participant endorsed the New Ecological Paradigm

Race/Ethnicity		DSP	NEP	Total	% NEP
White		1291	990	2281	43%
Black/African American		71	58	129	45%
Hispanic/Latinx		117	160	277	58%
Asian		194	224	418	54%
Indigenous		17	18	35	51%
More than One Race		139	128	267	48%
Column Totals		1829	1578	3407	46%

Table 3: Breakdown of mean NEP subscale scores and mean Total NEP scores for each racial/ethnic demographic. Red cells indicated means below that of their White peers.

Race/Ethnicity	Reality to limits of growth (LG)	Anti-Anthropocentrism (AA)	Fragility of Nature's Balance (BN)	Anti-Exceptionalism (AE)	Possibility of an Eco-Crisis (EC)	Total NEP Score Mean	Total NEP Score S.D
White	2.55	2.65	2.51	3.20	2.81	2.74	0.80
Black/African American	2.40	2.95	2.72	3.18	2.87	2.82	0.72
Hispanic/Latinx	2.72	3.04	2.76	3.28	3.09	2.98	0.72
Asian	2.73	2.99	2.73	3.11	2.96	2.90	0.74
Indigenous	2.81	2.86	2.73	3.00	2.87	2.82	1.00
More than One Race	2.54	2.78	2.56	3.30	2.84	2.80	0.81
Underrepresented Minorities	2.63	2.78	2.73	3.23	3.00	2.92	0.75
Non-White POC	2.65	2.94	2.73	3.20	2.95	2.89	0.76

To explore this relationship, odds and odds ratios were also calculated for each racial/ethnic demographic (Table 4). Each demographic was analyzed separately as well as in a couple combinations including underrepresented minorities in STEM (Black/African Americans, Hispanic/Latinx, and Indigenous students) and non-white students (Black/African Americans, Hispanic/Latinx, Asian, Indigenous, and More than One Race). The “NEP Odds” values indicate the odds of a participant in that demographic endorsing the NEP instead of the DSP. The “Odds Ratio” values indicate the odds of a participant in that demographic endorsing the NEP compared to their White peers.

Table 4: Calculated odds of participant's paradigm being coded as NEP based on provided race/ethnicity as well as the odds ratio for each racial/ethnic demographic against their White peers, along with Confidence Intervals

Race/Ethnicity	NEP Odds	Odds Ratio w/ White	Lower CI	Upper CI
White	0.77			
Black/African American	0.82	1.07	0.71	1.42
Hispanic/Latinx	1.37	1.78	1.53	2.04
Asian	1.15	1.51	1.30	1.72
Indigenous	1.06	1.38	0.71	2.05
More than One Race	0.92	1.20	0.95	1.45
Underrepresented Minorities	1.15	1.50	1.22	1.84
Non-White POC	1.09	1.43	1.22	1.64

Based on the odds ratio, students in underrepresented minorities in STEM were 1.50 (CI: 1.22, 1.84) times more likely to endorse the NEP than their White peers. This relationship seems to be driven particularly by the Hispanic/Latinx demographic in this dataset. This demographic was the only individual demographic with significant standard residuals or confidence intervals that do not include one. Hispanic/Latinx participants also had the highest odds ratio with being 1.78 (CI: 1.53, 2.04) more likely than their White peers to endorse the NEP rather than DSP. Students traditionally underrepresented in STEM and Non-White students are more likely to endorse the NEP over that of the dominant engineering culture supporting the initial hypothesis. This suggests the presence of a cultural component that could influence the acceptance of this paradigm. In contrast to the DSP view of nature being separate from humans, Latinx and Indigenous communities perceive humans as closely connected with the natural environment [25] [24]. Likewise, traditional Eastern cultures (Asian) and Indigenous cultures see humans as having to "exist in a harmonious relationship with nature" [25 p162]. All of these support the findings in this study.

There are some limitations with this analysis. As seen in Table 1, the percentage of students endorsing the NEP was roughly half for the entire dataset as well as each demographic. This could be partly because the survey was designed as part of a study researching engineering students' beliefs on climate change. Students who connect more to using engineering as a way to mitigate environmental concerns might have been more likely to participate in the survey than those who hold no connection between their engineering work and climate change. Another limitation was that the survey question addressing paradigm endorsement only utilized statements positively coded items of the NEP Scale. It is possible that this could have introduced some positive response bias in the resulting dataset as there are not DSP statements to compare against the endorsements of NEP [26]. Another limitation is the categorizations of racial/ethnic groups in this study. Participants who identified as South or East Asian, were considered together as "Asian" participants and not distinguished as individual identities. As such, generalizations should not be made as to why Asian students are more likely to endorse the NEP than their other peers. Future work should disaggregate racial/ethnic demographics further particularly for Asian students and to include Middle Eastern students. A final limitation to using the NEP Scale is that although it is the most widely used measure of environmental worldview, recent studies have suggested that the scale be further explored to more adequately capture the diversity of modern environmentalism [27].

With these limitations in mind, there is still much to glean from the implications of this study for engineering research and practice. The data here indicates that the views of almost half of White engineering students also align with the NEP. Thus, embracing more of the NEP framework for the engineering classroom as well as the nature of engineering work can create a more inclusive space for all students, not just benefiting those from underrepresented communities. A shift from the dominant social paradigm of engineering that sees its work as a method for conquering and controlling nature for its own purposes to one more closely aligned with the NEP, could help more students feel better connected to the field. These include students who once felt alienated due to their different understanding of the use of engineering, such as underrepresented minority students. Understanding the NEP and worldview also prepares and engages students with the broader applications of engineering work throughout the world, ensuring the consideration of global, economic, environmental, and societal contexts and factors [28].

Conclusions

These results demonstrate that there is a relationship between racial/ethnic background and endorsement of the NEP. Students from traditionally underrepresented populations in engineering are more likely to endorse the New Ecological Paradigm indicating that they are more inclined to hold environmental values or attitudes. This could be related to having these values and attitudes expressed by their home culture and worldview. Future work will be exploring more of the nuances between disaggregated racial/ethnic demographics. A better understanding of how culture and background influence paradigms can help inform initiatives geared towards broadening the participation of underrepresented minorities in STEM and make the culture of engineering more inclusive for all students. By shifting the frame of engineering work towards one more aligned with the NEP, underrepresented minority students can feel more connected to the field of engineering and all students can be better prepared for the broader, global work of engineering work.

Acknowledgement

This material is based upon work collected and supported by the National Science Foundation under Grant No. 1635534 and 1635204. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We would like to thank the researchers Dr. Tripp Shealy of Virginia Tech and Dr. Allison Godwin of Purdue University at West Lafayette for providing access to the data. We also like to thank the students who participated in the research by completing the survey.

References

[1] A. Hira and M. M. Hynes, “Broadening participation in engineering: Making in the K-12 classroom following an interest-based framework (RTP, Strand 4),” *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015.

[2] K. Fu *et al.*, “Broadening participation: A report on a series of workshops aimed at building community and increasing the number of women and minorities in engineering design,” *ASEE Annu. Conf. Expo. Conf. Proc.*, 2013.

[3] C. Garibay and R. M. Teasdale, “Equity and Evaluation in Informal STEM Education,”

New Dir. Eval., vol. 2019, no. 161, pp. 87–106, 2019.
[4] B. Williams, J. Figueiredo, and J. Trevelyan, *Engineering Practice in a Global Context*. 2013.
[5] R. E. Dunlap and K. D. Van Liere, "The 'new environmental paradigm,'" *J. Environ. Educ.*, vol. 9, no. 4, pp. 10–19, 1978.
[6] A. Byars-Winston, "Toward a framework for multicultural STEM-focused career interventions," *Career Dev. Q.*, vol. 62, no. 4, pp. 340–357, 2014.
[7] C. Kivunja and A. B. Kuyini, "Understanding and Applying Research Paradigms in Educational Contexts," *Int. J. High. Educ.*, vol. 6, no. 5, p. 26, 2017.
[8] G. Catalano and C. Baillie, "Engineering, social justice and peace: A revolution of the heart," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2006.
[9] A. E. Castagno and B. M. K. J. Brayboy, "Culturally responsive schooling for indigenous youth: A review of the literature," *Rev. Educ. Res.*, vol. 78, no. 4, pp. 941–993, 2008.
[10] J. H. Writer, "Unmasking, exposing, and confronting: Critical Race Theory, Tribal Critical Race Theory and multicultural education," *Int. J. Multicult. Educ.*, vol. 10, no. 2, pp. 1–15, 2008.
[11] M. Anderson, "New Ecological Paradigm (NEP) Scale," *Berksh. Encycl. Sustain.*, pp. 260–262, 2012.
[12] S. Ntanos, G. Kyriakopoulos, M. Skordoulis, M. Chalikias, and G. Arabatzis, "An application of the new environmental paradigm (NEP) scale in a Greek context," *Energies*, vol. 12, no. 2, pp. 1–18, 2019.
[13] N. E. Esposito, V. Viswanathan, and J. S. Linsey, "A study on the factors influencing the usage of environmentally friendly products," *ASEE Annu. Conf. Expo. Conf. Proc.*, 2014.
[14] P. C. Stern, T. Dietz, and G. A. Guagnano, "The New Ecological Paradigm in Social-Psychological Context," *Environ. Behav.*, vol. 27, no. 6, pp. 723–743, 1995.
[15] T. Shealy, A. Godwin, and H. M. Gardner, "Survey development to measure the gap between student awareness, literacy, and action To address human-caused climate change," *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2017-June, 2017.
[16] L. Kalof, T. Dietz, G. Guagnano, and P. Stern, "Race, gender and environmentalism: The atypical values and beliefs of white men," *Race, Gend. Cl.*, vol. 9, no. 2, pp. 112–130, 2002.
[17] E. P. C. III, "The Optimal Number of Response Alternatives for a Scale: A Review," *J. Mark. Res.*, vol. 17, no. 4, p. 407, 1980.
[18] B. Baugher, T. Shealy, J. Iorio, and D. B. Knight, "Impact of International Service Learning on Macro-Ethics:," *Int. J. Serv. Learn. Eng. Humanit. Eng. Soc. Entrep.*, vol. 14, no. 2, pp. 1–15, 2019.
[19] J. Roy, "E ngineering by the N umbers," *Am. Soc. Eng. Educ.*, pp. 11–47, 2019.
[20] M. Lück, "The 'New Environmental Paradigm': Is the scale of Dunlap and Van Liere applicable in a tourism context?," *Tour. Geogr.*, vol. 5, no. 2, pp. 228–240, 2003.
[21] V. Zeqir, M. Behxhet, and K. Zenel, "Pro-ecological views of Kosovar teachers measured by endorsement of The new ecological paradigm statements," *J. Teach. Educ. Sustain.*, vol. 21, no. 1, pp. 88–102, 2019.
[22] C. A. Ogunbode, "The NEP scale: Measuring ecological attitudes/worldviews in an African context," *Environ. Dev. Sustain.*, vol. 15, no. 6, pp. 1477–1494, 2013.
[23] E. Lee, "Environmental attitudes and information sources among African American college students," *J. Environ. Educ.*, vol. 40, no. 1, pp. 29–42, 2008.

[24] M.D. Parman. personal interview. Cherokee Elder & Program Evaluator for the Cherokee Nation Community & Cultural Outreach Depart
[25] C. Y. Johnson, J. M. Bowker, and H. K. Cordell, “Ethnic variation in environmental belief and behavior: An examination of the new ecological paradigm in a social psychological context,” *Environ. Behav.*, vol. 36, no. 2, pp. 157–186, 2004.
[26] R. W. Foley, A. Dennis, K. Eggleson, A. Sunda-Meya, and K. Haas, “Learner types: A means to expand the definition of diversity and to redesign ethics modules,” *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 2018-June, 2018.
[27] J. M. Bernstein, B. Szuster, and L. Philips, “Assessing the Diversity of Contemporary Environmentalism: Time for a New Paradigm,” *Int. J. Environ. Res.*, vol. 11, no. 5–6, pp. 641–652, 2017.
[28] E. A. C. ABET, “Criteria for Accrediting Engineering Programs,” 2019.

Appendix
R Studio Code

```
---
title: "ClimateDataProject"
author: "---"
date: "3/4/2020"
output:
  word_document: default
  pdf_document: default
  html_document:
    df_print: paged
---

## Setting up the data


```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)

library(tidyverse)
library(broom)
library(psych)
#install.packages("expss")
library(expss)
#install.packages("gmodels")
library(gmodels)

data_path<- "G:/My Drive/Spring 2020/Data Analysis Projects"
setwd(data_path)

#read in data
```
```

```
#all_data <- climate  #not sure if this will work when I come back into this file?

#write_csv(climate, "CLIMATEdata.csv")

file_pathclimate <- "CLIMATEdata.csv"
climate <- read_csv(file_pathclimate)
```

```

### Figuring out Gender Distribution ###

```{r load and clean data}

data2 <- climate %>%
     select(Litho, Q37, Q37_writein)


#### how can I filter out those who didn't answer Q37 at all?

check1 <- data2 %>% drop_na(Q37)

#remove those that didn't answer Q37 at all from the dataset
projectdata1 <- check1


#adding a single gender column

Q37_vars<-projectdata1 %>% select(Q37, Q37_writein)

projectdata1 <- projectdata1 %>%
  mutate(gender = case_when(Q37 == 1 ~ "Male",
                            Q37 == 2 ~ "Female",
                            Q37 == 3 ~ "Non-binary",
                            Q37 == 4 ~ "Not listed"))
gender = projectdata1$gender
gender.freq = table(gender)
print(gender.freq)

#barplot(gender.freq)
# Pie Chart with Percentages
```
```

```
values <- c(1016, 2985, 29, 44)
lbls <- c("Female", "Male", "Non-Binary", "Not Listed")
pct <- (values/sum(values)*100)
#lbls <- paste(lbls, pct) # add percents to labels
#lbls <- paste(lbls,"%",sep="") # ad % to labels
#pie(values,labels = lbls, col=rainbow(length(lbls)),
 #  main="Pie Chart of Participant Reported Gender")
pct.freq = table(pct)
print(pct.freq)
```

Select Q19 responses & Q39

```{r load and clean data}

data1 <- climate %>%
     select(Litho,
Q19a,Q19b,Q19c,Q19d,Q19e,Q19f,Q19g,Q19h,Q39a,Q39b,Q39c,Q39d,Q39e,Q39f,Q39g,Q39h,
Q39i,Q39_writein)


#### how can I filter out those who didn't answer Q19 at all?
#check <- data1 %>%
 # filter_at(vars(Q19a, Q19b, Q19c, Q19d, Q19e, Q19f, Q19g, Q19h),all_vars(is.na(.)))

#Q19_vars <- paste("Q19", letters[1:8]) # creates a vector containing "Q19 a", "Q19 b", etc.
which it doesn't like
#check <- data1 %>% drop_na(Q19_vars)
check <- data1 %>% drop_na(Q19a, Q19b, Q19c, Q19d, Q19e, Q19f, Q19g, Q19h) #this gave
me 3660 which is the # I had before so we're going to call this good.

#remove those that didn't answer Q19 at all from the dataset
projectdata <- check
 #filter_at(vars(data1$Q19a, data1$Q19b, data1$Q19c, data1$Q19d, data1$Q19e, data1$Q19f,
data1$Q19g, data1$Q19h), all_vars(!is.na(.)))

#### from my calculations this should give me 3852 observations but I only have 3660 now??

### now need to filter those who didn't answer Q39
#check2 <- projectdata %>%
 # drop_na(Q39a, Q39b, Q39c, Q39d, Q39e, Q39f, Q39g, Q39h,Q39i) #this didn't work.
Anything that had an NA in it got dropped.

#adding a single race column
```

```
Q39_vars<-projectdata %>% select(Q39a,Q39b,Q39c,Q39d,Q39e,Q39f,Q39g,Q39h,Q39i)

projectdata <- projectdata %>%
  mutate(race_sum = rowSums(Q39_vars,na.rm = TRUE)) %>%
  mutate(race = case_when(race_sum > 1 ~ "More than One Race",
                          race_sum == 0 ~ "NA",
                          Q39a == 1 ~ "Black/African American",
                          Q39b == 1 ~ "White",
                          Q39c == 1 ~ "South Asian",
                          Q39d == 1 ~ "East Asian",
                          Q39e == 1 ~ "Other Asian",
                          Q39f == 1 ~ "Pacific Islander",
                          Q39g == 1 ~ "American Indian",
                          Q39h == 1 ~ "Hispanic/Latinx",
                          Q39i == 1 ~ "Not Listed"))
```

Determining Paradigms

Now that I have my dataset, I need to determine the paradigm with which the participant most identifies with - DSP (Dominant Social Paradigm) or NEP (New Ecological Paradigm).

```{r paradigm, echo=FALSE}

#first, make each statement a binary -> if the participant agreed with the statement (score of 3 (agree) or 4(strongly agree)) then give them a score of 1 for that statement

projectdata <- projectdata  %>%
  mutate(q19a_bin = case_when(Q19a <3 ~ 0,
                          Q19a >2 ~ 1,))   %>%
 mutate(q19b_bin = case_when(Q19b <3 ~ 0,
                          Q19b >2 ~ 1,))  %>%
  mutate(q19c_bin = case_when(Q19c <3 ~ 0,
                          Q19c >2 ~ 1,))   %>%
   mutate(q19d_bin = case_when(Q19d <3 ~ 0,
                          Q19d >2 ~ 1,))   %>%
    mutate(q19e_bin = case_when(Q19e <3 ~ 0,
                          Q19e >2 ~ 1,))   %>%
    mutate(q19f_bin = case_when(Q19f <3 ~ 0,
                          Q19f >2 ~ 1,))   %>%
    mutate(q19g_bin = case_when(Q19g <3 ~ 0,
                          Q19g >2 ~ 1,))   %>%
    mutate(q19h_bin = case_when(Q19h <3 ~ 0,
                          Q19h >2 ~ 1,))
```

#now, sum up the binary scores to see how many of the eight statement the participant agreed with

```
projectdata <- projectdata %>%
  mutate(q19_bin_sum = q19a_bin + q19b_bin + q19c_bin + q19d_bin + q19e_bin + q19f_bin + q19g_bin + q19h_bin)


#last, create paradigm colm -> if a participant agreed with 5 or more statements we can determine their paradigm to be NEP. If not, then it is DSP.

projectdata <- projectdata  %>%
  mutate(para_bin = case_when(q19_bin_sum <5 ~ 0,
                              q19_bin_sum >4 ~ 1,))


#create paradigm colm w/ a binary outcome of whether the participant's paradigm is NEP = 1, or not = 0 Do I need this?

projectdata <- projectdata  %>%
  mutate(paradigm = case_when(para_bin == 0 ~ "DSP",
                              para_bin == 1 ~ "NEP"))
```

Hypothesis Testing

Now we can get into our hypothesis testing. Is there a signficiant relationship between a participant's race/ethnicity and whether their paradigm. I will test this question using the Pearson's chi-squared test.

```{r testing , echo=FALSE}
CrossTable(projectdata$race, projectdata$paradigm, fisher = TRUE, chisq = TRUE, expected = TRUE, sresid = TRUE, format = "SPSS")

contingency_tab <- xtabs(~ race + paradigm, data = projectdata, na.action = na.pass)
contingency_tab

chisq <- chisq.test(contingency_tab)

chisq
chisq$observed
chisq$expected
```

```
conttable <- projectdata  %>%
  CrossTable(projectdata$paradigm, projectdata$race, fisher = TRUE, chisq = TRUE, expected = TRUE, sresid = TRUE, format = "SPSS")
```

```

From this general Chi-squared we can see that

### Quant Class Project Analysis

The above sections are going to be used for future analysis on the complete dataset. The following sections will be the paired down version for the purposes of this class project.

```{r setup data for analysis}

data2 <- climate %>%
     select(Litho,
Q19a,Q19b,Q19c,Q19d,Q19e,Q19f,Q19g,Q19h,Q39a,Q39b,Q39c,Q39d,Q39e,Q39f,Q39g,Q39h)


check2 <- data2 %>% drop_na(Q19a, Q19b, Q19c, Q19d, Q19e, Q19f, Q19g, Q19h)


quantprojdata <- check2



#adding a single race column

Q39_vars2<-quantprojdata %>% select(Q39a,Q39b,Q39c,Q39d,Q39e,Q39f,Q39g,Q39h)

quantprojdata <- quantprojdata %>%
  mutate(race_sum = rowSums(Q39_vars2,na.rm = TRUE)) %>%
  mutate(race = case_when(race_sum > 1 ~ "More than One Race",
                          Q39a == 1 ~ "Black/African American",
                          Q39b == 1 ~ "White",
                          Q39c == 1 ~ "Asian",
                          Q39d == 1 ~ "Asian",
                          Q39e == 1 ~ "Asian",
                          Q39f == 1 ~ "Indigenous",
                          Q39g == 1 ~ "Indigenous",
```
```

```
                    Q39h == 1 ~ "Hispanic/Latinx"))

#drop NAs from race/ethnicity column
quantprojdata <- quantprojdata %>% drop_na(race)

quantprojdata <- quantprojdata  %>%
  mutate(q19a_bin = case_when(Q19a <3 ~ 0,
                        Q19a >2 ~ 1,))   %>%
 mutate(q19b_bin = case_when(Q19b <3 ~ 0,
                        Q19b >2 ~ 1,))  %>%
  mutate(q19c_bin = case_when(Q19c <3 ~ 0,
                        Q19c >2 ~ 1,))   %>%
   mutate(q19d_bin = case_when(Q19d <3 ~ 0,
                        Q19d >2 ~ 1,))   %>%
    mutate(q19e_bin = case_when(Q19e <3 ~ 0,
                        Q19e >2 ~ 1,))   %>%
    mutate(q19f_bin = case_when(Q19f <3 ~ 0,
                        Q19f >2 ~ 1,))   %>%
    mutate(q19g_bin = case_when(Q19g <3 ~ 0,
                        Q19g >2 ~ 1,))   %>%
    mutate(q19h_bin = case_when(Q19h <3 ~ 0,
                        Q19h >2 ~ 1,))

quantprojdata <- quantprojdata %>%
  mutate(q19_bin_sum = q19a_bin + q19b_bin + q19c_bin + q19d_bin + q19e_bin + q19f_bin +
q19g_bin + q19h_bin)


quantprojdata <- quantprojdata  %>%
  mutate(para_bin = case_when(q19_bin_sum <5 ~ 0,
                        q19_bin_sum >4 ~ 1,))


#create paradigm colm w/ a binary outcome of whether the participant's paradigm is NEP = 1, or
not = 0 Do I need this?

quantprojdata <- quantprojdata  %>%
  mutate(paradigm = case_when(para_bin == 0 ~ "DSP",
                        para_bin == 1 ~ "NEP"))

```

So now that the data is all set up like we want it, we can run the hypothesis testing analysis

```{r testing , echo=FALSE}
```

```
CrossTable(quantprojdata$race, quantprojdata$paradigm, fisher = TRUE, chisq = TRUE, expected = TRUE, sresid = TRUE, format = "SPSS")
```

```

Finding: There is a significant relationship between which paradigm is held by the participant and their race/ethnicity, X^2 (5,N = 3407) = 13.84, p < .05.

```{r effect size vs white participants , echo=FALSE}

```
IndigOdds = 20/15 # number w/ NEP / number w/ DSP
print(IndigOdds) # 1.33

WhiteOdds = 1348/933
print(WhiteOdds) #1.45

AsianOdds = 268/150
print(AsianOdds) #1.79

BlackOdds = 79/50
print(BlackOdds) #1.58

LatinxOdds = 192/85
print(LatinxOdds) #2.26

TwoRaceOdds = 168/99
print(TwoRaceOdds) #1.70

URMOdds_2 = (79+192+20)/(15+85+50) #African Am, Hispanic/Latinx, & Indigenous
print(URMOdds_2) # = 1.94

#Odds Ratio i.e. effect size vs. White participants

URMOddsRatio = URMOdds_2/WhiteOdds
print(URMOddsRatio) #1.34 URM participants were 1.34x more likely to hold the NEP Paradigm rather than the DSP than the White participants.

POCodds = (268+79+192+20+168)/(150+99+15+85+50) #African Am, Hispanic/Latinx, Indigenous, Asian & More than One Race
```

```
print(POCodds) #1.82

POC_oddsratio = POCodds/WhiteOdds
print(POC_oddsratio)  #1.26

Ind_oddsratio = IndigOdds/WhiteOdds
print(Ind_oddsratio) #0.92

Asian_oddsratio = AsianOdds/WhiteOdds
print(Asian_oddsratio) #1.24

Black_oddsratio = BlackOdds/WhiteOdds
print(Black_oddsratio) #1.09

Latinx_oddsratio = LatinxOdds/WhiteOdds
print(Latinx_oddsratio) #1.56

TwoRace_oddsratio = TwoRaceOdds/WhiteOdds
print(TwoRace_oddsratio) #1.17


```

```{r Confidence Intervals  , echo=FALSE}

URM_upCI =
exp(log(URMOddsRatio)+1.96*sqrt((1/(79+192+20)+(1/1348)+(1/(15+85+50)+(1/(933))))))
print(URM_upCI)

URM_lowCI = exp(log(URMOddsRatio)-
1.96*sqrt((1/(79+192+20)+(1/1348)+(1/(15+85+50)+(1/(933))))))
print(URM_lowCI)

Latinx_upCI = exp(log(Latinx_oddsratio+1.96*sqrt((1/192)+(1/1348)+(1/85)+(1/933))))
print(Latinx_upCI)

Latinx_lowCI = exp(log(Latinx_oddsratio-1.96*sqrt((1/192)+(1/1348)+(1/85)+(1/933))))
print(Latinx_lowCI)


```