International Journal of Engineering Education Vol. 38, No. 3, pp. 727–741, 2022
Printed in Great Britain

0949-149X/91 $3.00+0.00

Integrating Inclusivity and Sustainability in Civil Engineering Courses*

KAUSER JAHAN[1], STEPHANIE FARRELL[2], HARRIET HARTMAN[3] and TIAGO FORIN[4]
[1] Civil and Environmental Engineering, Rowan University, Glassboro, New Jersey, USA. E-mail: jahan@rowan.edu
[2] Experiential Engineering Education, Rowan University, Glassboro, New Jersey, USA. E-mail: farrell@rowan.edu
[3] Sociology and Anthropology, Rowan University, Glassboro, New Jersey, USA. E-mail: hartman@rowan.edu
[4] Experiential Engineering Education, Rowan University, Glassboro, New Jersey, USA. E-mail: forin@rowan.edu

The Department of Civil and Environmental Engineering (CEE) at Rowan University received an NSF RED (Revolutionizing Engineering Departments) grant. A significant focus of this grant is to develop and integrate inclusive curriculum for core civil engineering courses. All core civil engineering courses at the sophomore and junior level are a part of this initiative. Courses included statics, solid mechanics, civil engineering systems, surveying, structural analyses, steel design, fluid mechanics, water resources engineering, material science, civil engineering materials, geotechnical engineering, environmental engineering, sustainable civil and environmental engineering and transportation engineering. The NSF RED initiative was integrated with our CEE goes Green efforts that were initiated in 2004. This initiative allowed the above mentioned courses to incorporate concepts and content on sustainability. Course content included strategies such as faculty training, presenting case studies, rewording course syllabi and problems, assigning team projects, developing extra credit projects. The success of this integration is measured via course evaluations, focus group responses and senior exit interviews. The early assessment data indicates that the strategies for revising course content is successful as the student responses are extremely positive for all courses across the border. Seventy five percent or more students responded favorably to the questions posed for the select courses except for statics, solid mechanics, civil engineering systems and transportation engineering. The courses for the structural engineering sequence (statics, solid mechanics, structural analyses, steel design and transportation engineering) indicated lower scores in comparison to the environmental and water resources engineering courses. The major challenge is to train adjunct or temporary faculty who teach select sections of the core courses when the need arises. Students in the junior year are subject to multiple surveys that leads to survey fatigue.

Keywords: inclusive; pedagogy; sustainability; civil engineering

1. Introduction

Two terms that have gained momentum in engineering education and professional practice are diversity and inclusivity (D&I) [1–5]. This stems from the fact that STEM (Science, Technology, Engineering and Mathematics) fields still lack diversity after three decades of STEM initiatives funded by federal, state agencies, private foundations and companies [6–8]. The key reason for the lack of diversity in STEM fields is the presence of a chilly, unwelcoming atmosphere in general, but especially for students from underrepresented groups [9–11]. The lack of role models from select groups makes the problem worse. Furthermore, engineering faculty are unaware of the fact that their teaching pedagogy may not be appealing to all students from various backgrounds. Sometimes engineering textbooks compound the factor by providing images and examples targeted for only one type of group.

Recent researchers [6–8] have demonstrated that the engineering community needs to restructure teaching pedagogy to attract and retain a diverse student body. Industries indicate that organizations work effectively with successful outcomes when the participating players bring diversity to the workplace [9–12]. Most educational institutions and companies have established D&I offices to promote diversity, equity and inclusion in recent years [13–15]. These initiatives are all targeting meaningful collaborations that promote a diverse and inclusive community. Their overarching goal is to promote better dialogue and opportunities for students who not only meet the definitions of URMs (Under Represented Minorities) but also other vulnerable/historically underserved groups such as first generation, low socio-economic status and other undisclosed groups.

The National Science Foundation introduced the RED (Revolutionizing Engineering Departments) program to build upon previous efforts in engineering education research [16]. The description verbatim on the NSF website about the RED program reads as "*RED Innovation projects will develop new, revolutionary approaches and change strategies that enable the transformation of undergraduate engineering education. Projects will include consideration*

* Accepted 20 November 2021.

of the cultural, organizational, structural, and pedagogical changes needed to transform the department to one in which students are engaged, develop their technical and professional skills, and establish identities as professional engineers. The focus of projects should be on the department's disciplinary courses and program.'' The first RED awards were made official in 2016.

The Civil and Environmental Engineering department at Rowan University is the first recipient of an NSF RED award. The title of our NSF RED grant is ''*Revolutionizing Engineering Diversity (RevED)*''. The goal of this project is to revolutionize the Civil and Environmental Engineering (CEE) Department by radically increasing diversity and achieving high retention and graduation rates of all CEE students. An ambitious plan for curricular and extracurricular reform is being used to increase the representation of women and Underrepresented Minority (URM) students and historically underserved groups. These measures are being deployed using a multi-pronged approach presented in Fig. 1.

Over the years, many aspects of our RevED grant have been disseminated [17–31] via numerous publications and presentations. None have thoroughly reported on the curricular changes made to our core civil engineering courses. This paper will specifically focus on the changes implemented in course content of our civil engineering core courses in the sophomore and junior years. It also indicates how we maintained the sustainability aspects for the core courses and integrated it with inclusive strategies to address the NSF RevED initiative. The paper does not attempt to correlate these results with numbers of students recruited, retained and the other goals of the RevED project.

The CEE department undertook a major initiative titled ''CEE Grows Green'' in response to the growing focus on sustainability by lead professional organizations [32–41]. The need to introduce green engineering/sustainability concepts to undergraduate engineering students became recognized as increasingly important all around the world [42–47] in the late 1990s. *In the USA the Engineering Accreditation Commission ABET in their criteria requires the integration and implementation of a broad education to understand the impact of engineering solutions in a global , economic, environmental and societal context.* Discipline specific criteria, such as in chemical engineering, further specify that engineers must have ''ethics, safety and the environment'' included in the curriculum. Several international professional engineering accreditation bodies from New Zealand, Australia, South Africa, Ireland and Canada have similar wording to that in the USA accreditation requirements [42–46]. The United Kingdom requires that chartered and incorporated engineers must ''*undertake engineering activities in a way that contributes to sustainable development*'' [47]. Therefore there is tremendous international consensus of accreditation bodies on the importance and urgency of introducing green engineering and sustainability concepts in engineering education. As such, the department had already integrated green engineering and sustainability in all their core courses before the NSF RevED grant was funded.

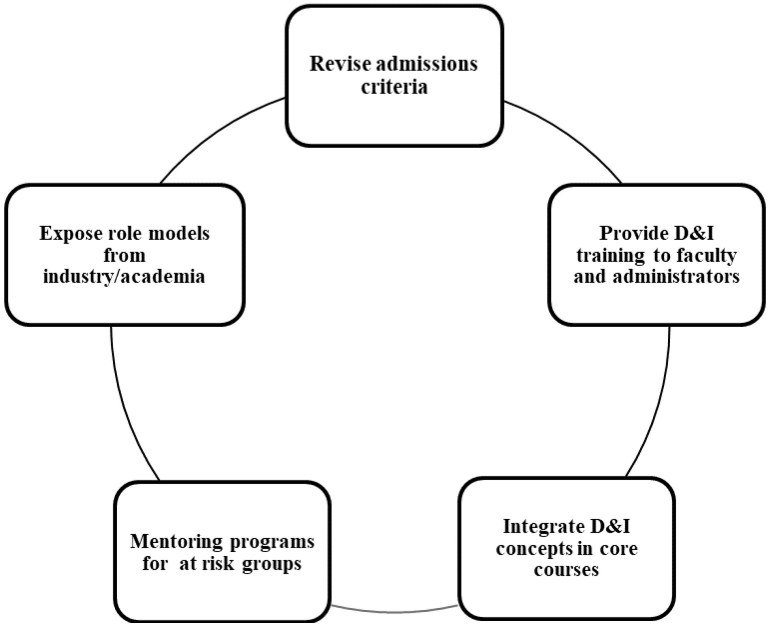

Fig. 1. Components of the RevED program to revolutionize diversity.

A widely accepted definition of sustainable development is that presented by the UN World Commission on Environment and Development: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [48]. Sustainable solutions support the complex and interconnected issues of environmental health, social equity and economic vitality for thriving, resilient communities. A lack of sustainable practices results in social inequality, economic disparity, and environmental degradation. The integration of diversity, equity and inclusion (DEI) into the engineering curriculum is a critical part of the education of engineers who will understand the social and environmental impacts of engineering design and contribute to the development of sustainable practices. Developing sustainable solutions requires cultural understanding and social awareness, diverse representation to provide multiple perspectives, and inclusive practices to ensure that all voices are heard and valued. Thus, diversity, equity and inclusion are an integral part of the professional skillset and ethical responsibility of practicing engineers. The Civil Engineering profession has embraced sustainability and sustainable design as strategic priorities. As sustainability increases in importance to the Civil Engineering profession, education of the current and future engineering workforce on issues related to sustainability becomes a priority. The integration of sustainability into the Civil Engineering curriculum has been reviewed previously [49]. The interlinkages between sustainability and equity can be illustrated through many examples related to civil engineering and infrastructure, for example, water resources management [50], the broadband divide [51], transportation equity [52], and health equity associated with the built environment [53].

2. Project Implementation

A number of major steps were planned to implement course content change to incorporate inclusivity and diversity. The strategies used were similar to those steps used for the Green Engineering initiative. These steps are presented in Fig. 2.

2.1 Faculty Buy-in and Training

The CEE faculty were all invited to a one-day mandatory workshop presented by a professional duo (Julia M. Williams and Ella Lee Ingram) from Rose-Hulman Institute of Technology [54–55] . The goal of this workshop was to:

- Educate. publicize and celebrate a departmentally-adopted definition of inclusion and inclusive teaching.
- List at least ten approaches consistent with inclusive teaching.
- Integrate the premises and language of inclusion in course objectives.
- Reorganize at least four topics in courses to target inclusive teaching practices that also adopted sustainability

This workshop allowed faculty to develop a diversity statement for the department. This reads as follows and is posted on the department website: "*The Rowan University Civil and Environmental Engineering Department welcomes individuals of all races, religions, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. We want to*

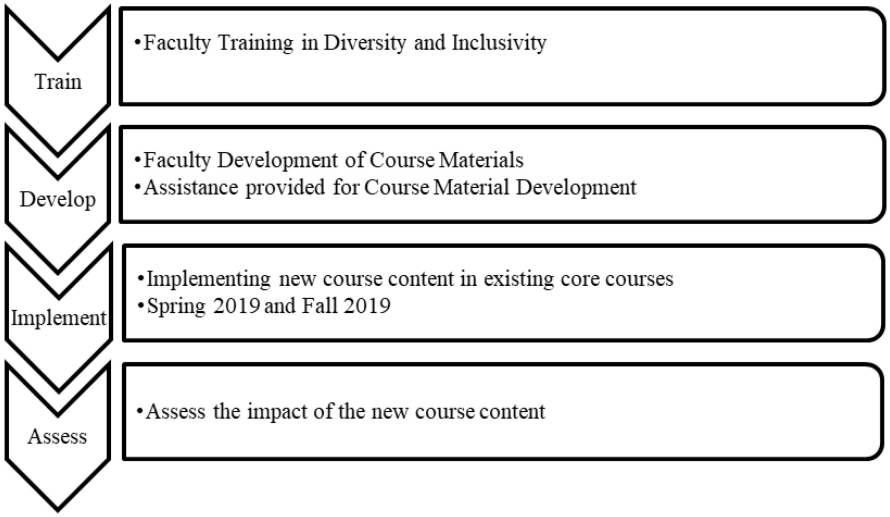

Fig. 2. Steps in implementing inclusive diverse course content.

expand opportunities for all students and strongly believe that we will be better people and engineers when we embrace diversity''.

Faculty were encouraged to share their understanding of inclusive pedagogy and offer their course syllabi, classroom exercises that they believed were examples of inclusive strategies for constructive criticism. The professional team articulated and clarified that inclusive pedagogy is not only a method of teaching but also a change in values and at certain times beliefs. This type of teaching brings instructors and students together to establish a healthy learning environment where all are welcome and valued. The course content sets the tone that the instructor values contributions from all around the world and not from a set community or demographic.

The faculty were also made familiar with the institution's definition of inclusivity which has been adopted from AAC&U [56] ''*Inclusion is the active, intentional, and ongoing engagement with diversity – in people, in the curriculum, in the co-curriculum, and in communities (intellectual, social, cultural, geographical) with which individuals might connect – in ways that increase one's awareness, content knowledge, cognitive sophistication, and empathic understanding of the complex ways individuals interact within systems and institutions*''.

This active training session exposed faculty to understand D&I issues in relevance to the courses they taught. Faculty worked on rewording course syllabi, learning objectives, rewording problems and reworking course content. Faculty were then paid a small honorarium from the RevED grant over the summer of 2017 to start developing inclusive course content. The department also invested in assigning students to faculty to assist them with curriculum development. This co-construction of inclusive content with students was really important as it allowed our major stakeholders (students) to provide input.

Faculty training is a continuous process and they participate in mini summer workshops annually. The institution also has a new D&I certificate that all faculty have to complete. The Department Tenure and Recontracting documents were revised to include verbiage that reflected that Inclusive Curriculum development was a part of the teaching evaluation process. Furthermore, monthly department meetings include enriching discussions on our inclusive and sustainable course content to keep us momentum and continuous improvement in our offerings.

The RevED Inclusive curriculum update is on the department monthly meetings agenda. The RevED coordinator also attends these meetings to share course changes, success stories and areas for improvement. The RevED program coordinator was also assigned to meet with faculty regularly to ensure their progress. The coordinator also helped with the implementation of the course content. A dedicated website with an innovative curriculum placeholder allows all to have access to the developed course content, inclusive curriculum strategies, samples of syllabi etc [57]. Inclusive curriculum strategies and samples of inclusive language for syllabi are presented in the appendix.

2.2 Development of Inclusive Course Materials

Fourteen core civil engineering courses in the sophomore and junior years were identified for this initiative. All students are required to enroll for these courses. The following courses shown in Table 1 were identified for content changes. These courses had already integrated sustainability and green engineering practices.

Faculty were trained and provided with select inclusive strategies for their courses. The goal for the faculty is to demonstrate that diversity and inclusivity is important to them by casually blending topics in their day to day lectures instead of dedicating one lecture in the semester to inclusivity.

2.3 Development of Sustainable Course Materials

The above mentioned core courses were also included in a ''CEE Grows Green'' initiative that was implemented in 2007 and is continued to this day. The objective of this endeavor was to ensure that all CEE core courses were integrating sustainability across the curriculum. Faculty were trained

Table 1. Civil Engineering Core Course Selected for D&I Content Revision

Sophomore Year (4)	**Statics**	**Solid Mechanics**	**Civil Engineering Systems**	**Surveying**
Junior Year (10)	Structural Analyses	Analyses & Design of Steel Frames*	Fluid Mechanics*	Water Resources Engineering*
	Material Science	Civil Engineering Materials*	Geotechnical Engineering*	Transportation Engineering
	Environmental Engineering*	Sustainable Civil and Environmental Engineering (SCEE)		

* Courses with lab.

Table 2. Inclusive Strategies for Courses

Strategy	
Syllabus Rewording	Required
Reword technical problem wording	Required
PowerPoint Presentations on case studies	Required
Assign a team project (report, presentation, video, brochure)	Required
Assign team names based on people of influence or the team adopts a country	Encouraged
Assign teams to watch a movie that focuses on diversity, social injustices, ethic violations, gender biases	Encouraged
Add questions on quizzes/exams	Encouraged
Test students in different ways (Take home, Team assignment, Open book)	Encouraged
Field Trip	Encouraged
Extra credit – Diversity issues	Encouraged
Extra Credit – Appreciation for the arts from various cultures	Encouraged

in the definition of sustainability according to the Bruntland Commission's *Our Common Future* [58]. They were also exposed to the USEPA Green Engineering Strategies and definition along with the United Nations Millennial Development Goals [59, 60]. The strategies presented in Table 2 were used for integrating sustainability, inclusivity and diverse course content.

2.4 Implementation

The course content implementation phase was initiated in Spring and Fall of 2019 for diverse and inclusive curriculum. There were very little challenges in implementing the new changes as the courses were being taught by faculty who had already been trained and had received assistance in developing course content. The challenges were posed when select sections were assigned to new adjunct faculty who had not received any training and were asked to implement the content in the sections they were teaching. Faculty were specifically encouraged to take the following steps:

(a) Mention the importance of sustainability, diversity and inclusivity at the beginning of the semester and point out the language in their syllabi
(b) Provide socially relevant global examples that integrate ethics and social injustices
(c) Tie the need for the arts, social sciences and humanities; and
(d) Provide variation in graded deliverables such as quizzes, homework, classwork, team assignments etc.

Samples of these (syllabi, examples of lecture slides and assignments are provided in the Appendix and are also posted on the RevED website).

2.5 Assessment

A team of faculty were invested in developing an online survey to assess the impact of the revised course content. This survey is presented in Fig. 3.

All core courses (14 total) presented in Table 1 were subject to this survey. The department head implemented this survey by sending the survey link

Curriculum Survey
Question 1: Do you think the course adequately covered the following topics?
(1 = Not Covered 5 = Adequately Covered)
(a) Global Issues
(b) Societal Issues
(c) Ethical Issues
(d) Problem Solving Techniques
(e) Engineering Design
(f) Diversity & Inclusivity
Question 2: The course (1 = Strongly Agree 5 = Strongly Disagree)
(a) Included socially relevant examples of engineering work
(b) Increased my interdisciplinary knowledge
(c) Exposed me to the arts, social sciences and humanities as relevant
Question 3: The course (1 = Strongly Agree 5 = Strongly Disagree)
(a) Used various types of graded work
(b) Used open-ended problems
(c) Provided opportunities for collaborative work

Fig. 3. Survey instrument developed for course assessment.

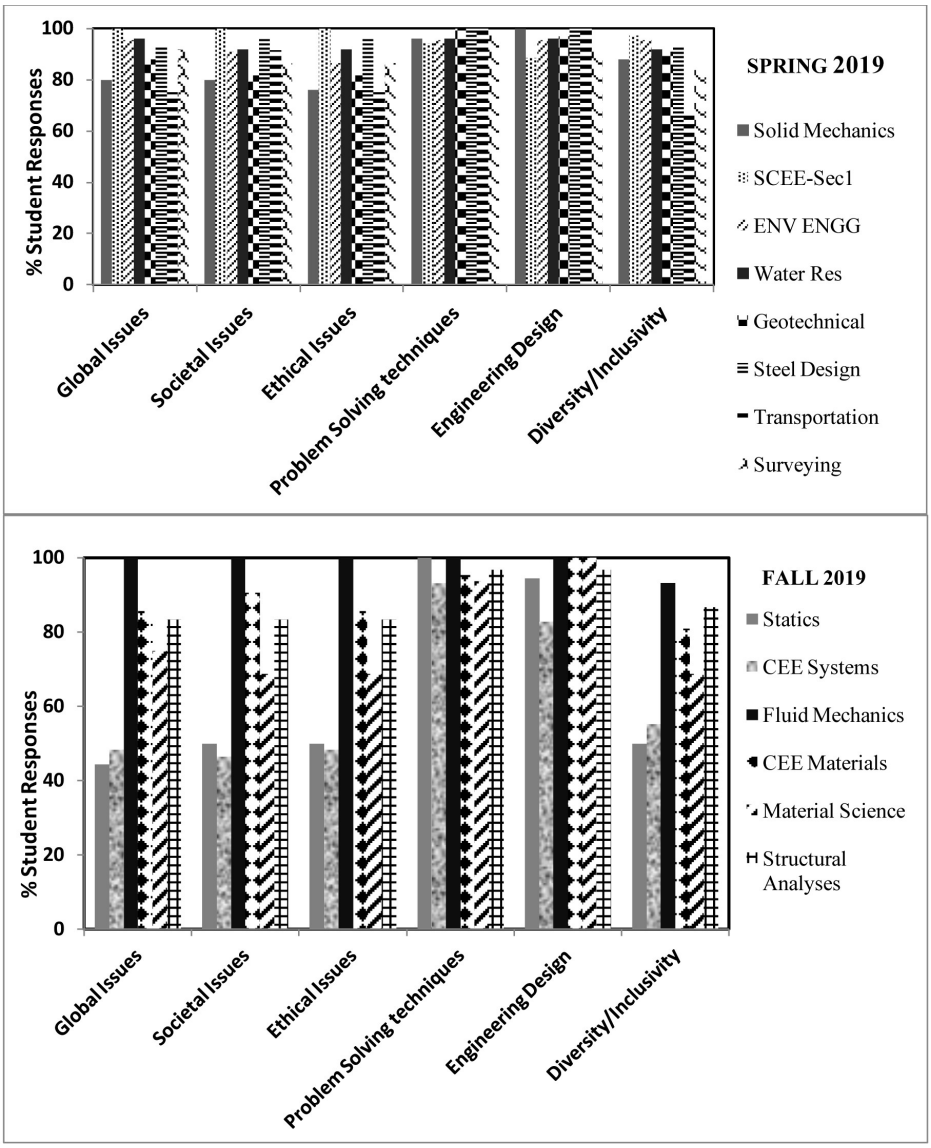

Fig. 4. Results from Question 1 of Survey (Scores of 3 Covered – 5 Adequately Covered were lumped together as an indication of students showing content).

to students enrolled for a specific course via email. Repeated emails were sent out and the faculty also made announcements in their classes and provided time to ensure that 80% of the students completed the survey. Survey results for the Spring 2019 and Fall 2019 are presented in Figs. 4, 5 and 6. These figures include results from Spring 2019 and Fall 2019 of core CEE courses. The y axes represent the percent of students who responded favorably to the question. The number of students participating in these surveys was always at 85% of the total # of students. Our class sizes for core CEE courses are usually between 35–40 students.

The same courses are evaluated for exposure to sustainability via our annual senior student exit survey. This survey is conducted every spring semester for our graduating students. The question specifically asks "This course exposed me to sustainability and green engineering" with score 1 = Strongly Agree to 5 = Strongly Disagree. The results of Spring 2019 are presented in Fig. 7. It is important to note that the students have taken these courses in their Sophomore and Junior years. As such they are providing feedback a year later. This was undertaken to assess knowledge retention.

3. Discussion of Results

The overall results for the core civil engineering course assessments are highly encouraging. Before assessment, the faculty had indicated that the courses which would pose challenges were Statics, Solid Mechanics, CEE Systems and Structural Analyses. The first three of these courses are sopho-

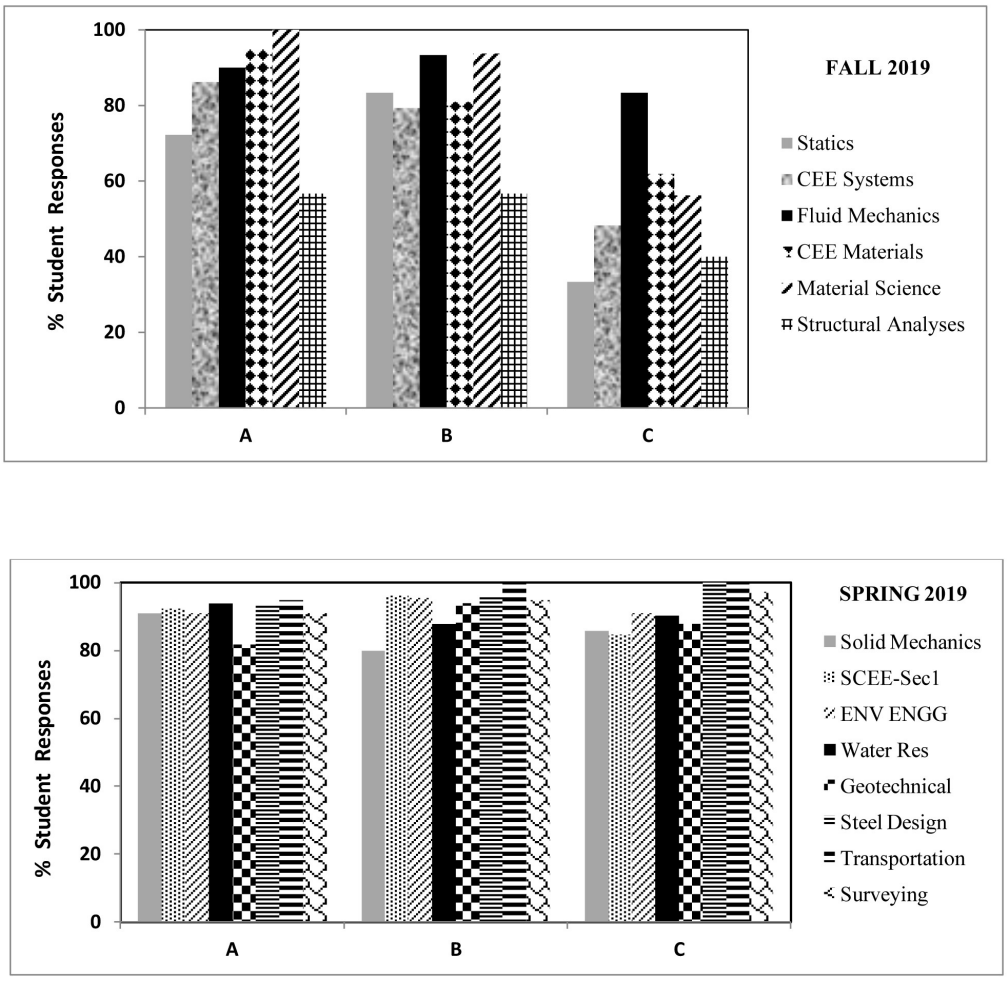

Fig. 5. Results from Question 2 of Survey (Scores of 1 Strongly Agree – 2 Agree were lumped together as an indication of students showing content).

more level courses. This overall trend was observed in the assessment results. Faculty also indicated that the Environmental Engineering and Water related courses would fare well because of the course content being an easier fit for integrating inclusive and green engineering content. Courses with a laboratory component also fared well as students have more time and interaction with the course instructor in the laboratory.

3.1 Results from Curriculum Survey (Diversity and Inclusivity)

Question 1: 80% or more students in all courses except Statics, CEE Systems and Transportation Engineering indicated that the course adequately covered topics focusing on (a) Global Issues (b) Societal Issues (c) Ethical Issues and (f) Diversity & Inclusivity. 90% or more students indicated that all courses adequately covered Problem Solving Techniques and Engineering Design. The CEE Systems course is primarily a statistics course and the sections were taught by an adjunct. The Transportation Engineering course was taught by a new tenure track faculty for the first time. Our Statics course is only a two credit sophomore course unlike other institutions where it is a three credit course. This is challenging for faculty who need to cover a lot of basic core concepts while also addressing inclusive pedagogy strategies in a short period of time.

Question 2: This question was aimed at assessing if the course was incorporating inclusive examples of engineering work that could lead to an increased knowledge about the nature of interdisciplinary engineering work. In this category 75% or more students indicated that the courses included socially relevant examples of engineering work and increased their interdisciplinary knowledge. When asked whether the course exposed students to the arts, social sciences and humanities Statics, CEE Systems, Material Science, CEE Materials and Structural Analyses failed to make the 75% mark.

Question 3: This question was primarily aimed to see if students were exposed to different techniques

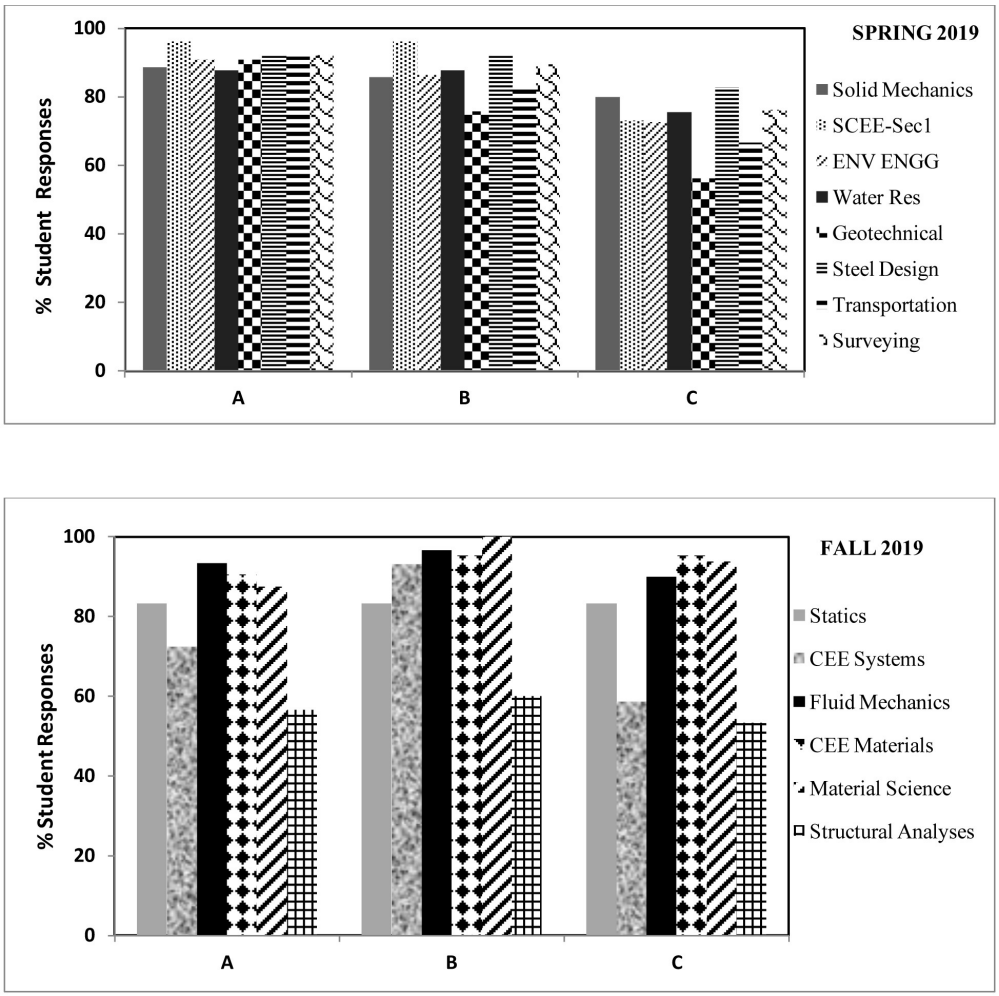

Fig. 6. Results from Question 3 of Survey (Scores of 1 Strongly Agree – 2 Agree were lumped together as an indication of students showing content).

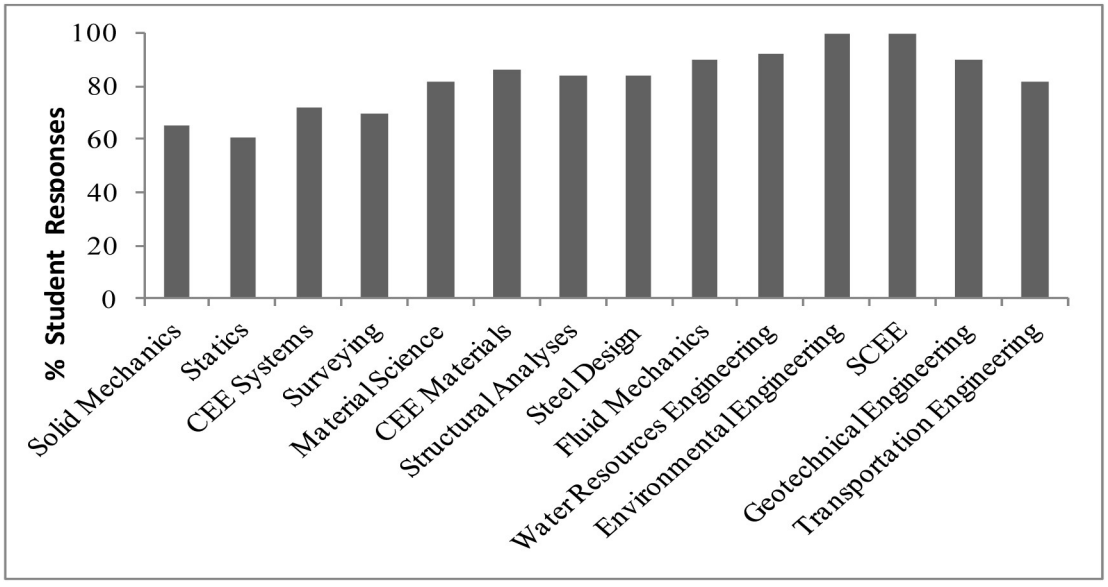

Fig. 7. Results from Sustainability Question from Exit Survey (Scores of Agree and Strongly Agree were lumped together as an indication of students showing content).

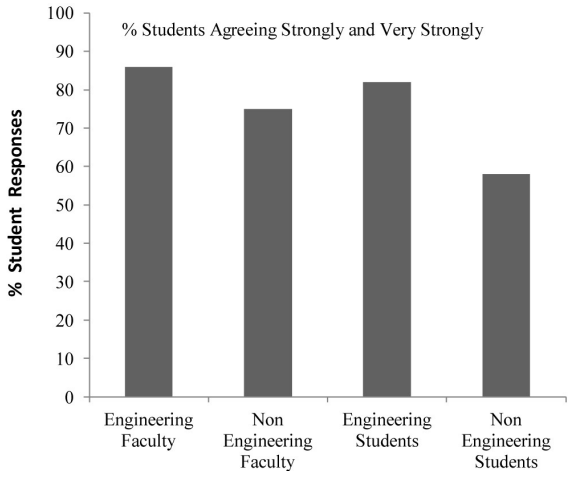

Fig. 8. Student responses about fair treatment.

in the classroom that enhanced their learning experiences. All courses fared well (>75% favorable responses) on the use of various types of graded work and use of open-ended problems except Structural Analyses. Courses that need improvement on collaborative work opportunities included Structural Analyses, Transportation Engineering and Geotechnical Engineering.

Overall these results are encouraging. Out of fourteen core courses that were evaluated, two sophomore and four junior courses did not meet all requirements favorably. These courses are currently being reassessed for improvements in content and delivery. Courses that used more than the four required inclusive curriculum strategies fared better than the ones that did not.

Preparing inclusive course content is the easier part than the implementation. It is challenging to ensure that all faculty tenure-track and adjuncts deliver the prepared course content in an appealing, effective manner. Another problem that has surfaced is student survey fatigue. Students participating in these course surveys are enrolled in all the core courses. This means that the juniors are taking 10 surveys for this specific RevED component. There are other RevED surveys on classroom climate, diversity etc and other NSF grant surveys that the students are asked to participate. Students also have to participate in course and instructor evaluations at the end of the semester. There is not an easy way to stagger these surveys or to repeatedly appeal to the students to complete the surveys.

3.2 Results from Curriculum Survey (Sustainability)

The results from the sustainability content for the select courses showed a similar trend. Statics, Solid Mechanics, Surveying and CEE Systems scored less than 80% in comparison to the other courses. All four courses are sophomore level courses with the first three being 2 credits each. The overall results are encouraging as all the Junior level core courses indicate that the students agree that the course exposes them to sustainability and green engineering topics adequately. Students are also asked to provide samples of sustainability that they learnt from their coursework. This additional information complements the scores received for the courses and is also indicative of what the student perceives as examples of green engineering and sustainability.

3.3 Results from Curriculum Survey (Climate)

In the Spring of 2019, the CEE seniors who were graduating (60) were also asked the following questions on assessing the climate of their environment. The results are presented in Fig. 8 for questions "a" through "d".

(a) Were you treated fairly and with respect by the engineering faculty?
(b) Were you treated fairly and with respect by the non-engineering faculty?
(c) Were you treated fairly and with respect by the engineering students?
(d) Were you treated fairly and with respect by the non-engineering students?
(e) How was the climate of diversity in the department/college/university (in classrooms, outside of classrooms)? Comment question.
(f) Do you have any suggestions for how we could improve the climate for diversity and inclusion in the department/college? Comment question.

The responses for questions "d" and "e" (text) are presented in the appendix. The comments indicate that students recognize that our classrooms are not diverse but we are focused on improving our diversity numbers. There are very few negative comments regarding our D&I initiatives.

Focus groups also confirmed the comments made in response to questions d and e. Students recognized that the classroom was not diverse. They indicated that the faculty were diverse. Few students indicated that they were isolated in the department as most CEE courses require teamwork. The CEE department has seen a steady rise in numbers of LatinX and African American students. This group pointed out that this is not reflected in the faculty or the overall engineering community.

4. Future Work

The CEE faculty will continue to invest in developing and implementing inclusive pedagogy in all courses core and electives. Some elective courses are already being offered with these curricular

changes. Our goal is to revolutionize all courses including our Senior Capstone design course. The department has a number of steps in place to sustain this initiative. This includes student support for faculty for content development and improvement every year along with assessment for rapid feedback. Faculty will also be required to participate in institutional D&I certificates, training on unconscious biases and other relevant workshops. Our college of engineering is heavily invested in project based learning when it was established in 1996. The College of Engineering's key features include collaborative teamwork in inter- and multi-disciplinary laboratory and coursework and the incorporation of state of the art technologies and innovative teaching methodologies. All engineering students share a common engineering *clinic* class for their eight semesters of study. This clinic course is a major hallmark of our engineering program. Faculty use the upper level clinic courses to involved students in developing innovative inclusive curriculum. Our future work will include involving students to develop interactive materials such as videos, social media content for broader impact.

5. Conclusions

The NSF RevED grant has allowed the CEE department at Rowan University to investigate course content of core sophomore and junior courses and develop and integrate inclusive course content. Faculty have to continuously improve their course content and delivery to ensure successful inclusive strategies. The first batch of course assessments are very encouraging. Most of the strategies adopted have worked in the majority of the courses. The CEE department will have to be invested in its commitment to the development of inclusive pedagogy and stay committed to recruiting a diverse student body.

Acknowledgements – We appreciate the support of many undergraduate students who assisted in developing the course content, presentation slides and rewording of problems. This material is based upon work supported by the National Science Foundation under IUSE/PFE:RED Grant No. 1623053 and NSF IUSE 1610164. 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.

References

1. D. A. Delaine, R. Tull, R. Sigamoney and D. N. Williams Global Diversity and Inclusion in Engineering Education: Developing Platforms toward Global Alignment, *Int. Journal of Eng. Pedagogy*, **6**(1), pp. 56–71, 2016.
2. D. A. Delaine, R. G. Tull and D. Williams, Global Diversity in Engineering Education – An Exploratory Analysis, *Proceedings of World Engineering Education Forum/International Conference on Interactive Collaborative Learning*, Florence, Italy, 2016.
3. A. Peixoto, M. Castro, A. J. Swart, J. J. Greeff and C. S. G. González, Diversity and inclusion in engineering education: Looking through the gender question, *IEEE Global Engineering Education Conference (EDUCON)*, Tenerife, Spain, pp. 17–20, 2018.
4. R. D. Reason, B. E. Cox, B. R. L. Quaye and P. T. Terenzini, Faculty and institutional factors that promote student encounters with difference in first-year courses, *Review of Higher Education*, **33**, pp. 391–414, 2010.
5. H. Smith, R. Parr, R. Woods, B. Bauer and T. Abraham, Five years after graduation: Undergraduate cross-group friendships and multicultural curriculum predict current attitudes and activities, *Journal of College Student Development*, **51**, pp. 385–402, 2010.
6. D. Knight, L. R. Lattuca, A. Yin, G. Kremer, T. York and K. Hyum, An exploration of gender diversity in engineering programs: a curriculum and instruction-based perspective, *Journal of Women and Minorities in Science and Engineering*, **18**, pp. 55–78, 2012.
7. K. Phillips, *How diversity makes us smarter*, Scientific American, 2014.
8. D. M. Riley and L. Claris, From Persistence to Resistance: Pedagogies of Liberation for Inclusive Science and Engineering, *International Journal of Gender, Science and Technology*, **1**, pp. 36–60, 2009.
9. D. Riley and L. Claris, Pedagogies of Liberation in an Engineering Thermodynamics Class, *ASEE Annual Conference and Exposition*, American Society for Engineering Education, Nashville, Tennessee, June 22–25, 2003.
10. D. M. Riley, L. Claris, N. Paul-Schultz and I. Ngambeki, Learning/Assessment: A Tool for Assessing Liberative Pedagogies in Engineering Education, *American Society for Engineering Education Annual Conference*, 2006.
11. M. A. Beasley and M. J. Fischer, Why they leave: The Impact of Stereotype Threat on the Attention of Women and Minorities from Science, Math and Engineering Majors. *Social Psychol. Educ. Int. J.* **15**(4), pp. 427–448 2012.
12. M. Besterfield-Sacre, C. J. Atman and L. J. Shuman, Engineering student attitudes assessment. *J. Eng. Educ.*, **87**(2), pp. 133–141, 1998.
13. P. Bourdieu, The Forms of Capital, *Handbook of Theory and Research for the Sociology of Education*, edited by J. Richardson, Westport, CT: Greenwood, pp. 241–258, 1986.
14. The Clorox Company, https://www.thecloroxcompany.com/who-we-are/our-people/inclusion-diversity/, Accessed 11 December 2020.
15. Inclusion and Diversity https://corporate.dow.com/en-us/about/company/beliefs-and-culture/diversity.html, Accessed 12 January 2021.
16. IUSE/Professional Formation of Engineers: Revolutionizing Departments https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505105, Accessed 14 December 2020.
17. Hartman, First-Generation College Students and Othering in Undergraduate Engineering, *ASEE Annual Conference & Exposition*, American Society for Engineering Education, Tampa, Florida, June 24–28 2019.
18. T. Forin, B. Sukumaran, S. Farrell, H. Hartman, K. Jahan, R. Dusseau, P. Bhavsar, J. Hand and T. Bruckerhoff, Rethinking Engineering Diversity, Transforming Engineering Diversity, *ASEE Annual Conference & Exposition*, American Society for Engineering Education, Columbus, Ohio, June 24–28, 2017.

19. Hartman: Strategies for Improving Diversity and Inclusion in an Engineering Department, *J. Prof. Issues Eng. Educ. Pract.*, **145**(2), 2019.
20. S. Farrell, T. Forin and C. Bodnar, Using concept mapping to develop inclusive curriculum, *FIE Annual Conference, 2017*, 2017.
21. E. Ingram, T. Forin, B. Sukumaran and E. Litzler, Increase Your Project's Success Through Coordinated Communication: Research and Practice, *FIE Annual Conference, 2017*, **145**(2), 2017.
22. P. Cole and S. Farrell. Development of an online, strategy-based intervention to improve spatial skills, *World Engineering Education Forum, Kuala Lumpur, Malaysia*, 2017.
23. S. Farrell & A. R. Minerick. The stealth of implicit bias in chemical engineering education, its threat to diversity, and what professors can do to promote an inclusive future, *Chemical Engineering Education*, **52**, p. 129, 2018.
24. S. Farrell, T. Forin, K. Jahan, R. Dusseau, P. Bhasvar and B. Sukumaran. Developing Multiple Strategies for an Inclusive Curriculum in Civil Engineering, *ASEE Annual Conference, Columbus, OH, 2017*, 2017.
25. B. Sukumaran, T. Forin, H. Hartman, S. Farrell, P. Bhavsar, K. Jahan, R. Dusseau and T. Bruckerhoff, Rethinking Engineering Diversity, Transforming Engineering Diversity (REDTED), *ASEE Annual Conference, Columbus, OH, 2017*, 2017.
26. S. M. Lord, B. Sukumaran, E. L. Ingram, A. A. Maciejewski, J. D. Sweeney, T. Martin, J. M. LeDoux, J. S. London and N. Salzman. Work in Progress: Progress of the NSF RED Revolution, *Annual ASEE Conference, Salt Lake City, Utah*, 2018.
27. T. R Forin, B. Sukumaran, S. Farrell, K. Jahan, T. Bruckerhoff and S. Lezotte. Revolutionizing Engineering Diversity, *Annual ASEE Conference, Salt Lake City, Utah.*, 2018.
28. T. Forin, P. Bhavsar, A. Nolan, H. Pandya and Y. Mehta, Work-in-Progress: Integration of Inclusivity Activity in Civil Engineering Materials Course, *Frontiers in Education*, 2018.
29. H. Hartman, B. Sukumaran, T. Forin, S. Farrell, P. Bhavsar, K. Jahan, R. Dusseau and T. Bruckerhoff, Strategies for Improving Diversity and Inclusion in an Engineering Department, *Journal of Professional Issues in Engineering Education and Practice*, 2018.
30. S. Lezotte, B. Sukumaran, T. Forin, H. Hartman, S. Farrell and T. Bruckerhoff. Interrupting Symbolic Violence by Understanding Underrepresented STEM Student's Perception of Campus Climate, *Association for the Study of Higher Education 2018.*, 2019.
31. S. Farrell and A. Minerick. The stealth of implicit bias in chemical engineering education, its threat to diversity, and what professors can do to promote an inclusive future, *Chemical Engineering Education*, **52**, 2018.
32. K. Jahan, J. Everett, R. P. Hesketh, P. Jannson and K. Hollar, Environmental Education for All Engineers, *Water Science and Technology*, **49**(8), 2004.
33. B. Sukumaran, J. Chen, Y. Mehta, D. Mirchandani and K. Hollar, A sustained effort for educating students about sustainable development, Session 1793, *Proceedings of the 2004 Annual Conference of the American Society for Engineering Education*, (2004).
34. K. Jahan and Y. Mehta. Sustainability Across the Curriculum, *International Journal of Engineering Education*, **23**(2), pp. 209–217, 1997.
35. K. Jahan, C. Bodnar, S. Farrell, Y. Tang, I. Noshadi, C. S. Slater and D. S. Miller, Improving Students' Learning Behaviors through Hands-on Algae Based Project, *International Journal of Engineering Education*, **35**(5), pp. 1343–1352, 2019.
36. K. Jahan, R. Breen, P. Hurley, E. Pepe and J. Shen, "An Algae-Based Curriculum for Globally Conscious Engineering Education," *International Journal for Cross-Disciplinary Subjects in Education*, **9**(1), ISSN 2042–6364, 2018.
37. W. E. Wells, Environmental Education for All Engineers, *Proceedings of the 1997 Annual ASEE Conference*, Milwaukee, Wisconsin, 1997.
38. S. K. Ritter, A Green Agenda for Engineering: New set of principles provides guidance to improve designs for sustainability needs, *Chemical & Engineering News*, **81**(29), pp. 30–32, 2003.
39. C. F. Murphy, D. Allen, B. Allenby, J. Crittenden, C. I. Davidson, C. Hendrickson and H. S. Matthews, Sustainability in Engineering Education and Research at U.S. Universities, *Environmental Science & Technology* **43**(15), pp. 5558–5564, 2009.
40. S. Perdan and A. Azapagic, Sustainable engineering design: an interactive multimedia case study, *International Journal of Sustainability in Higher Education*, **4**(1), pp. 33–43, 2003.
41. K. Jahan and Y. Mehta, Environmental Education for All Engineers, *Proceedings of the 1997 Annual ASEE Conference*, Milwaukee, Wisconsin, **81**(29), 1997.
42. Institution of Professional Engineers of New Zealand. *Requirements for Initial Academic Education for Professional Engineers*, http://www.ipenz.org.nz/ipenz/forms/pdfs/Initial_Academic_Education.pdf, Accessed December 2020.
43. The Institution of Engineers, Australia, Manual for the Accreditation of Professional Engineering Programs, http://www.ieaust.org.au/membership/res/downloads/AccredManual.pdf 7 October 1999, Accessed November 2020.
44. Engineering Council of South Africa, Standards and Procedures System – Standards for Accredited University Engineering Bachelors Degrees, Document: PE-61, http://www.ee.wits.ac.za/~ecsa/pe/pe-61.pdf, Accessed 20 July 2015.
45. The Institution of Engineers of Ireland, *Accreditation Criteria for Engineering Education Programmes*, http://www.iei.ie/uploads/common/files/IEI%20AccredCriteria.pdf, Accessed November 2019.
46. Canadian Council of Professional Engineers, *2003 Accreditation Criteria and Procedures*, http://www.ccpe.ca/e/files/report_ceab.pdf, Accessed December 2020.
47. Engineering Council UK, *UK Standard for Professional Engineering Competence, Chartered Engineer and Incorporated Engineer Standard*, http://www.engc.org.uk/publications/pdf/ukspec_CE_IE_Standard.pdf, Accessed January 2021.
48. World Commission on Environment and Development (1987) *Our Common Future.* United Nations General Assembly document A/42/427.
49. V. Sisiopiku, R.W. Peters and O. E. Ramadan Introducing sustainability into the civil engineering curriculum, 2015, *ASEE Annual Conference Proceedings*. DOI: 10.18260/p.24366.
50. J. Allouche, Where Is Equity in Integrated Approaches for Water Resources Management? Oxford Research Encyclopedia of Environmental Science. DOI: 10.1093/acrefore/9780199389414.013.619.
51. How can civil engineers bridge the broadband divide? *Civil Engineering Magazine*. Accessed online 8/26/21. https://www.asce.org/publications-and-news/civil-engineering-source/article/2021/08/26/how-do-civil-engineers-bridge-the-broadband-divide, 2021.
52. N. L Fields, V. J. Miller, C. Cronley, K. Hyun, S. K. Mattingly, S. R. R. Nargesi and J. Williams *Transportation Research Interdisciplinary Perspectives*, **5**. 2020, 100110.
53. M. Smith, J. Hosking and A. Woodward, Systematic literature review of built environment effects on physical activity and active transport – an update and new findings on health equity. *Int. J. Behav. Nutr. Phys. Act.*, **14,** 158, 2017.

54. E. L. Ingram, Changing your department: examples from revolutionizing engineering departments, *2016 IEEE Frontiers in Education Conference*, Erie, PA, October 2016.
55. E. L. Ingram, E. Litzler, C. Margherio and J. M. Williams, Learning to make change by revolutionizing departments: initial team experiences, *2017 ASEE Annual Conference & Exposition*, Columbus, OH, 2017.
56. Diversity, Equity, and Student Success, https://www.aacu.org/diversity-equity-and-student-success, Accessed 20 January 2021.
57. Rowan University: Inclusive Curriculum https://research.rowan.edu/research-areas/engineering/reved/curriculum/index.html, Accessed December 2020.
58. G. Bruntland, *Our common future: The World Commission on Environment and Development*, Oxford University Press, Oxford, 1987.
59. We can end Poverty: News on Millennium Development Goals, https://www.un.org/millenniumgoals/ , Accessed January 2021.
60. U.S. Environmental Protection Agency, Green Engineering web site – http://www.epa.gov/opptintr/greenengineering/index.html, Accessed 30 November 2020.

Appendix

Language for Syllabus

Accommodation:
Your academic success is important. If you have a documented disability that may have an impact upon your work in this class, please contact me. Students must provide documentation of their disability to the Academic Success Center in order to receive official University services and accommodations. The Academic Success Center can be reached at 856-256-4234. The Center is located on the 3rd floor of Savitz Hall. The staff is available to answer questions regarding accommodations or assist you in your pursuit of accommodations. We look forward to working with you to meet your learning goals.

Inclusive Learning Environment:
It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diversity that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. If you feel that your contribution is not being valued for any reason, please speak with me privately. If you wish to communicate anonymously you may do so in writing or speak with the Office of Social Justice, Inclusion, Conflict Resolution (socialjustice@rowan.edu, 856-256-5496, Room 118, Robinson Hall).

Lived Name / Pronoun Syllabus Statement:
I will gladly honor your request to address you by the name or gender pronoun that you choose. I will provide the opportunity for you to indicate your choice on the first day of class so that I may make appropriate changes to my records, and I am always open to change.

Professional Behavior:
As an engineering professional, it is extremely important that you treat people with respect and consideration. It is expected, therefore, that you will maintain good professional conduct throughout this course, in all your interactions with your peers and the instructor.

Rowan Success Network:
The Rowan Success Network powered by Starfish is designed to make it easier for you to connect with the resources you need to be successful at Rowan. Throughout the term, you may receive email from the Rowan Success Network team regarding your academic performance. Please pay attention to these emails and consider taking the recommended actions. Utilize the scheduling tools to make appointments at your convenience including tutoring.

Samples of Inclusive Strategies and Course Content

Using a Global example:
Ask students in Water Resources Engineering to determine how the waterworks were constructed in the Al-Hambra Palace in Granada Spain. Students learn about the Sierra Nevada Mountains, the Moor civilization, the Nasrid Scholars and their contributions to science and technology.

Case Study (Sample) Structural Analyses:
The Structural Analysis course is a relatively math-intensive course with no design component. In order to illustrate the importance of structural analysis in the design of safe structures and to increase the level of empathy among

students for the victims of structural engineering failures, the first class session in Fall 2017 was devoted to the I35W Bridge Collapse in Minneapolis, MN. A presentation on the collapse focused on the following topics: a history of the structure, the cause of the collapse, and the 13 victims of the collapse. The class divided itself into teams of 4 or 5 students and several topics/questions were discussed including: how could the collapse have been prevented; the agencies, groups, or companies responsible for the collapse; why no action was taken when evidence of imminent collapse was discovered six years earlier; why loads were added to the structure despite the evidence of imminent collapse; and a detailed discussion of the 13 individuals who were killed. The goal in discussing the victims of the collapse was to elicit empathy among the students for these victims and to show the students the very real consequences of engineering error and structural failure.

Rewording a Problem:

- Design a batch reactor with . . . > *A developing community needs to have access to safe drinking water. A batch reactor will serve their needs.*
- A steel beam needs to be designed . . . > *The city of XX lost their "yy" structure due to Hurricane Sandy.*
- *Recycled concrete was used as a green material for use in xx.*
- Determine the sheer force . . . > *Bamboo was used for xx member. This was to address sustainable green engineering. Determine the sheer force.*
- Calculate the alum dose . . . > Alum is an universal coagulant and is used extensively in poor and developing communities. Calculate the alum dose . . .

Team Names (Samples)

- Assign teams a name of a person of influence or the team adopts a country. Use examples that are global and a learning opportunity for the students. *Not every person assigned has to be a scientist or engineer. Have the team use the name throughout the semester.* Present for 2 minutes about the assigned person every other week.
- *Example – Henrietta Lacks, Ruth Bader Ginsburg, Nelson Mandela, Queen Victoria (major scientific contributions made during her reign), Vandana Shiva, Arundhati Roy, F. R. Khan etc.*

Movies (Samples)

Assign teams to watch a movie/documentary – not all need to be on a technical contribution.

- Legally Blonde – Good message – you can be blonde, beautiful and like pink and be smart!
- Whale Rider – Society wants women to prove themselves before they can be picked as a leader.
- Rosalind Franklin: The Dark Lady of DNA- struggled with lack of confidence-a very human trait in our students.
- Stephanie Kwolek – Confident about her knowledge.
- Bhopal Express – How India forced Union Carbide to change laws in the USA for People Right to Know!
- Erin Brockovich – Her curiosity and compassion led to justice and the largest class action law suit. Still an activist to this day.
- A Civil Action – John Travolta; movie based on real case.
- The Imitation Game – Life of Alan Turing

Interview Responses to Questions d and e

How was the climate of diversity in the department/college/university (in classrooms, outside of classrooms)?
Diverse . . .
Very welcoming, especially for girls.
Department does a lot but there is still work to do. Compared with universities in Philly or North NJ, we are in a less diverse and less forward thinking region. I have never witnessed overt discrimination, but seen many times people appear indifferent to injustice. When the hate group came to campus, everyone was outraged. But when discussing something such as why there aren't more women or minorities in engineering, there are many (especially ECEs) who will dismiss structural economic factors and biases as a prime culprit.
The university clearly encourages diversity inside and outside of the classrooms.
There was a shocking lack of people of color.
Good.
The diversity at and within Engineering was very good. There was a lot of diversity and never did it feel as if anyone was favored.
Above average climate diversity.

Good.
Diversity was fine.
Average.
Fine? Doesn't really have anything to do with my school work. I met cool people. That's it.
Diversity is not an issue here at . . . No one cares about race/gender/religion in engineering. The quality of the person matters.
Cold in some and warm in others.
Fine.
Less diverse in classrooms than out of classrooms (more gender diversity than race).
Good diversity. Less diversity throughout engineering than the entire university.
I come from a very diverse community so coming to Rowan was much less diverse than I was used to.
Since it's honestly pretty male dominated, diversity is something that needs to be worked on within the college.
As a gay Male, I felt the climate for diversity was great and inclusive.
Do you have any suggestions for how we could improve the climate for diversity and inclusion in the department/college?
Survival of the fittest.
We need to bring in more dynamic speakers to the classroom, especially people who aren't from the engineering field, to break the STEM cultural bubble. Allowing people to take courses like public speaking outside engineering will help integrate engineers with the university as a whole, which is more diverse. There also needs to be greater emphasis on teaching people how numerical data and other scientific principals we are taught can be misused. Whether it is a polluting plant or an unsafe pedestrian crossing, low income communities often don't have the data (at least initially) to go against well funded actors. Having the ability to go into communities and gather facts on the ground should be seen as equally important to being able to read a technical report. Other majors such as psychology and urban planning teach this way and they have a much better reputation for listening to underrepresented groups. Changing this fundamental lens is the only way to really correct many issues.
No.
None.
I Think its fine.
Stop pushing so hard for student and faculty diversity. I'd rather see a push for more class sections, better resources, etc.
More variety of students.
Not care about it at all. All that matters is working hard and being nice.
No diversity climate is fine.
Nah.
It's not about diversity and inclusion. Commadery and unity are the real issues. I do not know many of my classmates' names and they do not know mine.
Diversity is increasing within the college, however, it is still a white-male-dominated field, so diversity still needs improvement. More individuals need to be encouraged to pursue engineering in order for the college to be more diverse.
Teach about pronouns, gender, and sexual orientation.
I feel that diversity and inclusion is already apparent in the department/college, so I do not have any suggestions Provide more readings and exposure to people who are doing engineering projects around the world, rather than a micro focus on south jersey.
The barrier for entry shouldn't be identity. The only identity you should need is a hard work ethic and drive to obtain knowledge in engineering.
More women!! Accept more women and less boys!!
Have the professors work together more so students aren't swamped with 80 hours of work each week Not at the moment.

Kauser Jahan, PhD is Professor and Head of the Civil and Environmental Engineering (CEE) Department of the Henry M. Rowan College of Engineering at Rowan University. She completed her PhD studies in the Department of Civil and Environmental Engineering at the University of Minnesota, Minneapolis in 1993. Dr. Jahan is a Fulbright Scholar and a registered Professional Civil Engineer. She joined Rowan as a founding faculty member of CEE in 1996. She is a leader and innovator in the area of curriculum development and is a nationally and internationally known expert in teaching. She is actively involved in environmental engineering education/research and outreach for K-12 students/educators. Her research interests include pollution prevention, alternate energy and teaching pedagogy. She has been recognized as an outstanding educator and mentor by various national and state professional organizations.

Stephanie Farrell, PhD is Interim Dean of the Henry M. Rowan College of Engineering at Rowan University and Professor and Founding Chair of the Department of Experiential Engineering Education (ExEEd). She joined Rowan as a founding faculty member of the Chemical Engineering Department in 1998, where she served until launching ExEEd in 2016. Stephanie is past president of the American Society for Engineering Education. Stephanie serves as PI on the *Revolutionizing Engineering Diversity* in Civil and Environmental Engineering at Rowan, funded through NSF's Revolutionizing Engineering Departments (RED) Program. She is on Rowan's ADVANCE team for intersectional gender equity in STEM, and she leads ASEE's national initiative to promote LGBTQ+ inclusion in engineering, funded by NSF. Dr. Farrell has been recognized nationally and internationally for contributions to engineering education.

Harriet Hartman Harriet Hartman, PhD is professor of sociology and chair of the Department of Sociology and Anthropology at Rowan University, Glassboro, NJ. She received the 2019 CHSS Award for Research and is the 2019 Marshall Sklare awardee, an honor given annually by ASSJ, the Association for the Social Scientific Study of Jewry. Hartman is editor-in-chief of *Contemporary Jewry.* She is co-P.I. of the RevED grant focusing on advancing the diversity of engineering students. She received her BA in Public Service from UCLA, MA in Sociology from University of Michigan, PhD in Sociology from Hebrew University of Jerusalem. She has published widely in the fields of gender and engineering, including "Strategies for Improving Diversity and Inclusion in an Engineering Department," *Journal of Professional Issues in Engineering Education and Practice* (2019). She is currently doing research on the COVID-19 impact on higher education, with a special focus on first-generation college students and on undergraduate engineering students in comparison with other undergraduate students.

Tiago Forin is a Lecturer in the Experiential Engineering Education department at Rowan University. He is also the project manager for the NSF RED grant awarded to the Civil and Environmental Engineering Department at Rowan. His research for the RED grant covers methods for developing a more inclusive environment for engineering students and faculty. Through this research, he actively gives workshops on how to better develop an inclusive environment in academic settings. His other research interests cover water resources, developing global competency, and design education. He is an active participant in an ASEE Virtual Community of Practice which advocates for developing an inclusive climate for LGBTQIA+ STEM students and professionals. Tiago Forin is a graduate of Florida State University and Purdue University where he studied civil and environmental engineering and engineering education.