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Increasing Contextualized Social Awareness through Multidisciplinary Teams in Global Service-Learning Projects

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Abstract

This paper is for ongoing work in developing unique collaborations between engineering and non-engineering students in a user-centered design course and humanitarian engineering project work. In this paper, the authors will review their integration of social and emotional competencies into engineering design and practice through a credit-based engineering course in conjunction with an Engineers in Action (EIA) Bridge Project student chapter at a midwestern public university. Previous research has shown that many universities have limited engagement with topics of multicultural engagement, working within diverse interdisciplinary teams, and approaching engineering problems from an awareness of inclusivity, cultural sensitivity and socioeconomic factors, despite the value placed on these qualities by accrediting bodies like ABET and societies like the National Society of Professional Engineers and the National Academy of Engineers. This content is often seen as a single module embedded in general engineering coursework, even though studies have shown students are often eager to connect global and societal concerns with engineering. A small number of engineering educational institutions in the United States have integrated these competencies more broadly into humanitarian or service engineering programs, but these programs are separate from traditional engineering majors such as mechanical or civil engineering.

This project evaluates the professional formation of engineers by examining how engineers apply social attributes (namely those identified by the Social and Emotional Learning (SEL) framework) to user-centered design in a multidisciplinary project. This is facilitated by asking two research questions: "What key social attributes do undergraduate students identify as significant factors within service-learning engineering projects?" and "How does participating in a user-centered design curriculum impact students' identification of key social attributes associated with service-learning projects?".

As part of an NSF proposal, this work is conducted through a multi-year grant that supports the development of the curriculum, as well as the assessment of the student participants. This presentation will review the theoretical framework used for the curriculum and mixed-methods research, as well as present the process of obtaining grant funding for this collaborative effort. The creation of the multidisciplinary advisory board and the program mechanisms for blending engineering and non-engineering students will also be discussed.

Introduction

The professional formation of engineers has long included the social skills of teamwork, communication, and recognition of the ethical impact of engineering on society at large. When reviewing the history of formal evaluation of social competencies in engineering, a significant milestone occurred in 1997, when the national accrediting board for engineering programs, ABET (Accreditation Board for Engineering and Technology) created the Engineering Criteria 2000 (EC 2000). These criteria, which have continued to evolve over the last 20+ years, documented specific

learning outcomes required of engineering educational programs to remain accredited, one of the two pathways for engineering graduates to pursue a Professional Engineering (PE) license [1 –3]. The ABET Engineering Criteria required that future engineers demonstrate proficiencies in multidisciplinary teams, engineering in a global context and an understanding of contemporary issues [2], among other technical skills. This "a-k" (updated to 1-7 in 2019) criteria became a foundational element of learning objectives in engineering coursework and curriculum for all accredited engineering institutions since 2000 [1]. Furthermore, this act was lauded by the National Academy of Engineers (NAE), in their report "Adapting Engineering Education to the New Century" [3] in which the academy noted the increasing disparity between engineering practice and engineering education. In their report, they stated that while engineering faculty had previously demonstrated a resistance to change, the increasing interdependencies of societal needs and technological solutions required engineering education to better prepare students for multidisciplinary work in a global context [3].

The call to action raised by the NAE and other organizations has been echoed by engineering education researchers ever since, with the seminal work of Donna Riley [4] recognizing that engineering education continues to train future engineers in traditions of consumerism, individualist beliefs and functions within existing power structures, rather than within societal contexts. The highly cited work of Cech [5] notes that disengagement with social concerns is often associated with engineering due to prevailing perspective of engineering culture that suggests engineering is neutral, non-political and that technical skills should be held separate from social tasks. The ideologies of technical/social dualism, individual meritocracy and depoliticization exclude public welfare from the engineering domain. More recent studies evaluating engineering education research and current engineering curriculum note that engineering faculty maintain that humanities studies are irrelevant to engineering education and present engineering problem solving devoid of social context [6 – 11].

This paper introduces an ongoing work in developing unique collaborations between engineering and non-engineering students in a user-centered design course and humanitarian engineering project work. In this paper, the authors will review their integration of social and emotional competencies into engineering design and practice through a credit-based engineering course in conjunction with an Engineers in Action (EIA) Bridge Project student chapter at a midwestem public university.

Previous research has shown that many universities have limited engagement with topics of multicultural engagement, working within diverse interdisciplinary teams, and approaching engineering problems from an awareness of inclusivity, cultural sensitivity and socioeconomic factors, despite the value placed on these qualities by accrediting bodies like ABET and societies like the National Society of Professional Engineers and the National Academy of Engineers. This content is often seen as a single module embedded in general engineering coursework, even though studies have shown students are often eager to connect global and societal concerns with engineering. A small number of engineering educational institutions in the United States have integrated these competencies more broadly into humanitarian or service engineering programs, but these programs are separate from traditional engineering majors such as mechanical or civil engineering.

The project described in this paper evaluates the professional formation of engineers by examining how engineers apply social attributes (namely those identified by the Social and Emotional Learning (SEL) framework) to user-centered design in a multidisciplinary project.

Literature Review

The National Academy of Engineers continues to challenge future engineers to view taking on the global "Grand Challenges of Engineering," including one of the four main themes of engineering innovation to include enhancing the "joy of living" for the global community [12]. Roscoe et al. stated that "the solution for many pressing challenges requires engineering innovations that are guided by a keen awareness of human goals, needs, abilities and limitations" (pg. 404) [13]. This is echoed by other researchers who affirm that these skills are not innate but must be intentionally integrated into the curriculum for students to practice engineering from these perspectives [9, 11, 13 – 16]. While humanitarian projects for engineers, such as the work with Engineers Without Borders, Engineers in Action and other project-based learning applications have shown themselves to be effective in increasing awareness of cultural dimensions and skills of communication and teamwork [6, 7, 11, 18, 19], to achieve user-centered systems, a formalized approach is required.

While all engineering disciplines may use their technical areas of expertise in engineering projects benefiting society, it is the field of Human Factors Engineering or Human Systems Engineering that is the technical discipline focused on the intersection of human focused work and technical systems [21]. This intersection is described numerous ways; however, user-centered design is one of the predominate terms within the discipline of Human Systems Engineering that center on cultural, societal, environmental, and ethical as cornerstones for engineering design [9, 14, 16, 18, 20-22]. It has been shown that without intentionality in program design, humanitarian engineering projects can disenfranchise the very communities they are trying to help [23]. Students must engage with the project from a perspective of blended boundaries that meaningfully engages with both the facts and values of a project – values which must be considered from the perspectives of all peoples. This view is not one traditionally held by engineering systems, which often embrace traditional power roles, making determinations on who is worthy of being served [8, 23-25].

Best practices in curriculum design must include students questioning how different contexts and perspectives impact the boundaries of a system and its priorities [6, 7, 13, 14, 20, 22, 23, 25, 26]. To evaluate these concepts properly, previous research has determined a significant gap adequately capturing students' attitudes [6, 7, 13, 14] and how they change as they grow in understanding of the differences in perspectives and values of other cultures and societies. One barrier to contributing to this area of research is the lack of quantitative research examining attitudes related to social justice, especially those working in interdisciplinary or multicultural teams [6]. As noted by Pawley, engineering education has difficulty integrating results from qualitative studies, as they often are case studies with small sample sizes, often found inappropriate for generalizable results [25]. This study makes use of a mixed-methods research design, integrating quantitative survey data with qualitative sources. Another barrier to measuring student attitudes identified by previous research is the lack of definitions associated with social awareness. Previously engineering educational programs have struggled to demonstrate competency in this area due to vague "umbrella" learning outcomes [6, 11] such as "consider the impact of engineering solutions in global, economic, environmental, and societal contexts" [27] from the 2022-2023 ABET program criteria or the need to "work for the advancement of the safety, health, and well-being of their community" as presented by the National Society of Engineering Code of Ethics [28]. To provide

a mechanism for rigorous educational research with both qualitative and quantitative measures, a mixed-methods design, using principles from grounded theory provides a framework for investigation on the evolution of student attitudes on social attributes [29]. To create a previously undocumented level of precision in the terminology being used with respect to engineering students' attitudes towards social and cultural competencies, this study utilizes a structure of transformative social and emotional learning. The transformative social and emotional learning (SEL) framework integrates competencies in self-awareness, social awareness and relationship skills [30], all categories previously identified as critical elements for engineers in user-centered design [6, 9, 15, 17]. These align with the transactional epistemology proposed by Biesta which recognizes that all interventions of experimentation are within a context of a dynamic global system [31]. The SEL self-awareness category involves not only understanding your own emotions, values, strengths and self-efficacy, but also recognizing personal bias and how to recognize the interconnection of thoughts and feelings and actions across diverse contexts. Competencies in social awareness address empathy and compassion for those from same and different backgrounds and cultures, understanding social norms for constructive behaviors and supporting the collective well-being. Relationship skills include the ability to establish, navigate and maintain healthy relationships across social and cultural norms; communicating clearly, actively listening and working collaboratively whenever possible. Curriculum from this orientation honors and connects to lived experiences of oneself and others, as well as enhancing and foregrounding the social and emotional competencies for civic engagement and social change [32]. This philosophy, while applicable to any level of education and any subject matter or discipline, directly aligns to the objectives established by human systems engineering and user centered design, thereby providing a research framework of educational competencies which can be measured using mixed-methods techniques. For the sake of clarity, these concepts are summarized as "social attributes."

Theoretical Framework

To investigate the development of students' awareness, understanding and application of these social attributes, this research examines the independent identification of factors most significant to the work of user-centered design, especially through the progression of classroom active learning strategies, to collaborative multidisciplinary teams and finally in international service-learning projects. An extension of this learning progression is the examination of changes in students' attitudes with varying levels of exposure to project-based learning in international settings. To provide students with the necessary scaffolding to undergo this professional formation, curriculum on user-centered design will be provided, following the examples of previous engineering educational research. This leads to the research questions of:

RQ1: What key social attributes do undergraduate students identify as significant factors within service-learning engineering projects?

RQ2: How does participating in a user-centered design curriculum impact students' identification of key social attributes associated with service-learning projects?

By utilizing a mixed-methods design, a varied and robust body of work will be produced examining the development of engineers in social attributes impacting the practice of user-centered design principles in multicultural contexts. These results will provide engineering education researchers with insight not previously captured by the existing literature. These results will also facilitate the revision and improvement of the user-centered design curriculum supporting this work.

Curriculum design: In this section, the approach to the curriculum design and integration of humanities students within engineering coursework will be presented. Following the model presented by Oakes, Khalifah, Sigworth, Fuchs, and Lefebvre in their EPICS and EWB collaboration [17] this project engages students first with a user-centered design curriculum, in addition to the Engineers in Action training materials to develop an awareness and appreciation of social contexts for service-learning projects. Oakes, et al., have demonstrated higher levels on engagement with professional engineering competencies (such as communication, ethical evaluation, teamwork, critical thinking, and engineering design) by integrating a structured curriculum with service-learning. This project builds on the EPICS model by expanding from a multidisciplinary engineering curriculum to a blend of social sciences and engineering model through co-enrolling engineering and non-engineering students together in one course. As students work in multidisciplinary groups (engineering students with non-engineering students) on case studies and project-based learning activities, students will practice user-centered design concepts from both a technical and sociological perspective prior to traveling to an international community for the EIA project. Once on site, students will work alongside community members in building the pedestrian bridge.

The entire project centers upon new curriculum, as such the first step is to develop and offer a user-centered design course (ENGR 241 – Introduction to User-Centered Design in Global Applications) to engineering and non-engineering students, teaching social and emotional (SEL) competencies using project-based learning strategies. This course will not have any prerequisite requirements, facilitating enrollment from engineering and non-engineering disciplines at all grade levels. While the first offering of the course will focus on social work students as part of the collaboration with the university's Center for Social Justice Education, the course will be open to any enrolled student at the institution, regardless of field of study. Campus-wide recruitment will occur through publicizing the new course to the advising centers and through student-centered media outlets, such as email, websites and electronic displays in student common areas. In this course, interdisciplinary engineering students will work with non-engineering students in multidisciplinary teams on case studies and projects to learn to identify and apply understanding of social attributes to engineering problems. Course activities will include lecture to introduce social and emotional competencies and the principles of user-centered design, case studies to facilitate discussion of the impact of social attributes on engineering projects in a multicultural and global context, and projects using multidisciplinary teams to work with small scale engineer projects, applying a user-centered design framework. Students will journal to support reflection on social and emotional competencies, user-centered design principles and multidisciplinary teamwork. It is expected that students will increase in understanding about how social and emotional competencies impact user-centered design. With increased understanding, students will integrate these principles into their class projects and other learning activities. It is also anticipated that students will positively reflect on the contributions of their team members and better appreciate the impact of multidisciplinary teams on the design process. Students from both engineering and non-engineering programs will correctly identify how these same principles can apply to their specific career field and in context of their communities, enriching the professional formation not only of engineers but of the humanities students who participate.

Out of the enrollment of this course, the service-learning extension of the coursework will include participation in the EIA Bridge project. The course facilitates the integration of non-engineering students in the existing student chapter of EIA and will provide opportunities for designating team

roles for both engineering and non-engineering students. EIA supplies each student chapter with training materials and guidelines for team formation to ensure that each role required for the completion of pedestrian footbridge is led by a specific student who is responsible for tasks associated with that team role. While these roles are traditionally held by engineering students, this team will reflect both engineering and non-engineering students. Participation in the EIA student chapter team will include attending regularly scheduled student led meetings to coordinate team activities, execution of assigned tasks, as required by the EIA training materials and ongoing communication with the international EIA staff and professional engineers who mentor students throughout the project and approve the final bridge design.

With the foundation of the interdisciplinary user-centered design course, students will integrate their knowledge of SEL competencies into their pedestrian bridge design process and relate SEL competencies to their team dynamics and communication, both within the university and within the EIA project team, EIA staff and professional engineers. For the EIA project, students will travel to an international community and build a pedestrian bridge over the course of 5-7 weeks during the summer. During this time, students will work alongside community members building a pedestrian bridge. During this trip, students reside in the community they are serving, sharing meals, social events, and engage with the community in their day-to-day life. During this time, reflection will be recorded using journal entries to capture the thoughts, feelings and experiences of the students on site. Additionally, focus groups will be conducted to facilitate group discussions about the experience with local community members and students.

It is expected that students who have participated in the ENGR 241 curriculum will be able to identify critical social attributes impacting the collaborative international bridge building project and provide leadership within the build project and engage meaningfully with the community stakeholders, demonstrating the application of SEL competencies, especially in areas of social awareness and relationship skills.

Assessment: In this section, the assessment strategies for this research project are presented. For this study, a convergent parallel mixed-methods design will be carried out utilizing the following assessments: a cross-sectional survey, followed by prompted journal reflections, and focus group discussions, as modeled by Schoonenboom and Johnson [29]. For purposes of corroboration and validation, this research aims to triangulate the results by directly comparing the quantitative statistical results and qualitative findings from the journal entries and focus groups. In the research process, three data sets for each group of student participants will be obtained, analyzed separately, and compared. Additional data will be gathered from the other participant groups as noted in the activities below. The participant groups include engineering students from the university, non-engineering students from the university, and residents of the community in which the service-learning project occurs.

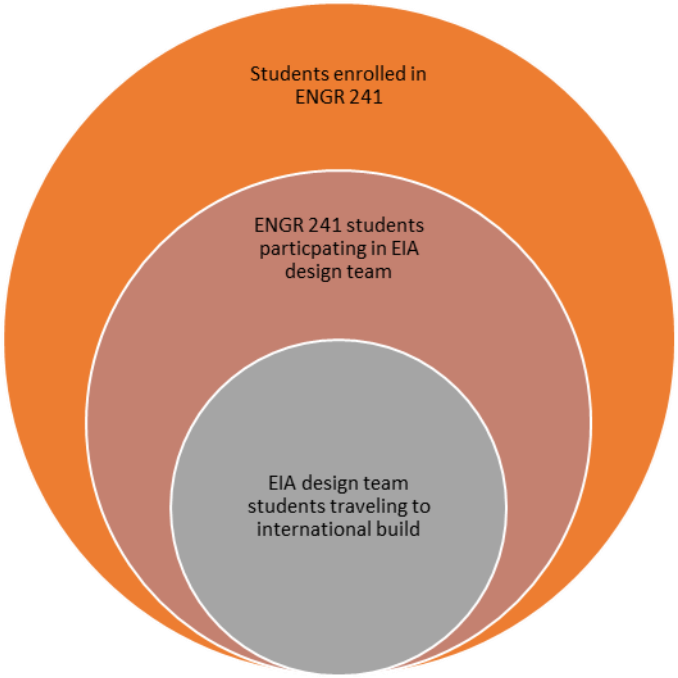

Figure 1: Student participant groups

This research engages with students at several key points throughout their experience with a user-centered design interdisciplinary course and participation in a global service-learning project through collaboration with the EIA Bridge Program. Figure 1 illustrates how students will engage with the research in several groupings. The mixed-methods research design uses multiple assessments with the students to observe differences within and between participant groups throughout the project. Qualitative data gathered in country from community members will also be collected to better understand the communities experience working with the students. Figure 2 illustrates the assessments for the participant groups included in this work. While building bridges is not the only application for the ENGR 241 curriculum, the existing partnership with the EIA Bridge Program facilitates student participation in international service-learning projects in collaboration with professional engineers for the benefit of a community in need.

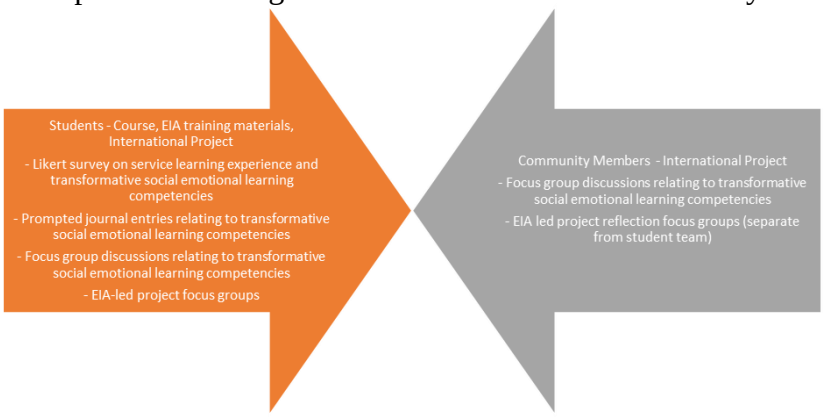

Figure 2: Assessments for research participants

To determine the impact of service-learning on students' awareness and perceived significance of social attributes, a mixed methods research approach will be used, as previously noted. First, a

survey designed to measure students' views on engineering, engineering careers and social consciousness will be used for quantitative data collection and analysis. The survey is a validated instrument, presented by Brown and Bauer [19] to assess student learning and is titled the "Questionnaire for Service-Learning Participation." Minor adjustments will be made to the wording of a few items to better connect the assessment tool for this specific research. This survey will be distributed to all students enrolled in the user-centered engineering design course at the beginning of the semester. It will be distributed again at completion of the course, after the completion of participation in the design team and after the completion of participation in the international pedestrian bridge building project. Using a Likert scale, differences between engineering and non-engineering students will be noted, as well as changes over time. Additionally, students will answer journal prompts on the identification and significance of social attributes associated with engineering service-learning projects. These journal prompts will be administered at the same points in time as the survey, to deepen the understanding of the student perspective, as well as provide comparison to the strength of response over time. A thematic analysis will be conducted following the model presented by Roscoe et. al. in their work on "A Conceptual Qualitative Framework for Assessing Human Systems Engineering Education Outcomes and Opportunities" [16] specifically looking for the students' use of the SEL framework in their journal responses. This work was chosen as a model as Roscoe et al. integrated user-centered design in engineering curriculum and analyzed journal responses to capture student perceptions with respect to conceptual dimensions, application dimensions, source dimensions and depth dimensions. With this analysis, the researchers will be able to assess the students' application of user-centered design principles in conjunction with international humanitarian engineering projects. The researchers will conduct focus group discussions with students and community members at the international project site. These discussions will include open-ended questions and will make use of translators as necessary. Finally, the last EIA team meeting (after the completion of the build) will serve as a focus group for additional reflection at the completion of all research activities.

As students may participate in more than one EIA build project, it is possible that students will have the opportunity serve on the design team and international build team twice during the length of the project. As such, the data collected will be analyzed for differences between students completing a service-learning project for the first time and those who are repeating the experience. This analysis will include survey data prior to and after the build experience, journal entries and focus group participation. All assessment tools match those described above. Repeat participants will also be asked to reflect on their perceived difference in social attributes from their first experience to their second experience. While this may be only 1 or 2 students, their unique perspective from participating in multiple projects will provide insight into student growth in SEL attributes over multiple years.

Multidisciplinary Advisory Board

This work enlists the support of multiple disciplines, as such, the research team is interdisciplinary in nature. The research team includes: an assistant professor in Industrial Engineering with a background in curriculum development and humanitarian engineering projects; an associate professor in Civil Engineering (PE & PhD) with extensive experience working as a professional engineer, as well as leading students in EIA Bridge Program international and domestic projects; an associate professor of Teacher Education, with a background in educational research for STEM fields. The research team is supported by an external evaluator is a Sociologist with a specialty in research methods, with over 15 years working in the research and evaluation of NSF projects.

As this curriculum is built on the collaborations between engineering, humanities, and a non-profit organization for the purposes of engineering educational research, the research team has created an advisory board to oversee the work conducted and provide valuable subject-matter expertise and feedback throughout the research process. Meetings will be conducted using Zoom to facilitate the collaboration of a network of professionals which is geographically diverse. Membership of the board includes individuals representing the Center for Excellence in Teaching and Learning, the Center for Social Justice Education and EIA. Additional professionals in the areas of engineering educational research, humanitarian engineering and user-centered design curriculum and service-learning programs may be added throughout the duration of the project if seen fit by the members of the advisory board.

Conclusion

This paper has reviewed the ongoing work of developing and deploying new curriculum that integrates humanities students with engineering students in an interdisciplinary user-centered design course with an extension for service-learning in collaboration with Engineers in Action. The theoretical framework for both the curriculum development and the assessment methodology have been reviewed. The composition of the advisory board was also presented. Below, research limitations, anticipated broader outcomes and future opportunities are included.

Limitations: This research is heavily dependent on student responses to reflective prompts, open-ended questions and narrative provided during focus group discussions and from journal entries. While the work of Slaton and Pawley [25] provides a meaningful way of engaging with a small sample of narrative responses, this study recognizes the limitations associated with small sample sizes. This work serves as a pilot program which will be replicated through the EIA Bridge Program network of partnering institutions, providing a method of increasing the number of participants over time. It is also acknowledged that the work of this project will reflect the attitudes of the participants. Those participating in this work will have shown preference to engaging in humanitarian engineering work by volunteering to participate in the class, design team and international build project, as depicted in Figure 1. The community members will also be predisposed to receiving students from the United States, as the EIA organization will have worked extensively with the international community prior to the arrival of the students. Results of this work will therefore represent a sample of individuals open to engaging with other cultures and open to collaborating in a multidisciplinary manner. The results may not adequately represent engineering students in general, however, the work will demonstrate changes in knowledge, attitudes and skills of students predisposed to engaging with service-learning projects.

Outcomes: The outcomes of this study will advance research in professional formation in engineering education by determining the impact of interdisciplinary user-centered design curricula and service-learning projects on the knowledge, attitudes, and skills of engineering students with respect to critical multicultural social attributes. Additionally, this project evaluates the impact of engineers on society through collaboration with social science students and international communities. As such, it builds on previous studies examining the impact of service-learning on engineering students, by also evaluating the impact of shared perspectives from social science students on engineering students' design process. The project also imparts understanding insight not only into how community engagement impacts engineers but how engineers impact a global community. As previous studies have noted the lack of emphasis on understanding

community perspectives, this research provides new insights into reciprocal learning and community empowerment. These experiences build on previously researched best practices in engineering service-learning but expand the work by engaging non-engineering students and global communities as active partners throughout the design and implementation process.

Future Direction: With the established curriculum and program structures for co-enrollment, non-engineering students will be able to continue to engage with interdisciplinary engineering students both in the classroom and in the service-learning projects. The program cycle (coursework, EIA Bridge Program training and international build) will continue annually. Consequently, numerous opportunities exist for longitudinal studies providing for future work with a focus on underrepresented groups within engineering. Future research could examine differences within participant groups as the number of participants increases. The Institutional Review Board (IRB) of the university will oversee the research activities both for the duration of the grant and for any additional studies that are initiated through this work.

References

[1] ABET, "ABET History", About ABET, October, 2021. [Online]. Available: https://www.abet.org/about-abet/history/ [Accessed: October 30, 2022].
[2] J. Ventura, "Accreditation Criteria for Engineering Programs," in *Proceedings of the 2003 ASEE Annual Conference. Nashville, TN, USA,* June 22-25, 2003, 3560 pp. 1-8.
[3] National Academy of Engineering, "*Educating the Engineer of 2020: Adapting Engineering Education to the New Century",* Washington, DC: The National Academies Press, 2005.
[4] D. Riley, *Engineering and Social Justice,* Williston, VA: Morgan and Claypool Publishers, 2008.
[5] E. Cech, "Culture of disengagement in engineering education?," *Science, Technology and Human Values,* vol. 39, no. 1, pp. 42-72, 2014.
[6] C. Vargas-Ordonez and M. Hynes, "Engineering design and social justice: a systematized literature review," In Proc. American Society for Engineering Education, 2020.
[7] P. Jiménez, J. Pascual, and A. Mejía, "Towards a pedagogical model of social justice in engineering education," *ICSIE*, pp. 55–59, 2019.
[8] A. Pawley, "What counts as "Engineering": Toward a redefinition", in *Engineering and Social Justice: in the university and beyond,* A. Pawley, D. Riley and C. Baillie West, Eds. Lafayette, IN: Purdue University Press, 2012, pp. 59-86.
[9] M. Cardella, C. Zoltowski, W. Oakes, "Developing human-centered design practices and perspectives through service learning" in Engineering *and Social Justice: in the university and beyond,* A. Pawley, D. Riley and C. Baillie West, Eds. Lafayette, IN: Purdue University Press, 2012, pp. 11-30.
[10] A. Pawley, "Learning from small numbers: Studying ruling relations that gender and race the structure of U.S. engineering education," *Journal of Engineering Education*, vol. 108, no. 1, pp. 13–31, 2019.
[11] S. Niles, S. Roudbari and S. Contreras, "Integrating Social Justice and Political Engagement into Engineering," *International Journal of Engineering, Social Justice and Peace,* vol. 7, no. 1, pp. 57-69, 2020.
[12] National Academy of Engineers, "NAE Grand Challenges for Engineering", Engineering Challenges, 2022. [Online]. Available: http://www.engineeringchallenges.org/challenges.aspx [Accessed: October 27, 2022].

[13] R. Roscoe, D. Becker, R. Branaghan, E. Chiou, R. Gray, S. Craig, R. Gutzwiller and N. Cooke, "Bridging Psychology and Engineering to Make Technology Work for People," *American Psychologist.* vol. 74, no. 3, pp. 394-406, 2019.
[14] B. Altay, "User-centered design through learner-centered instruction," *Teaching in Higher Education,* vol. 19, no. 2, pp. 138-155, 2013.
[15] D. Karwat, W. Eagle, M. Wooldrige and T. Princen, "Activist Engineering: Changing Engineering Practice by Deploying Praxis," *Science and Engineering Ethics,* vol. 21, pp. 227-239, 2015.
[16] R. Roscoe, C. Johnson, M. Lande, S. Craig, and R. Gray, "A Conceptual Qualitative Framework for Assessing Human Systems Engineering Education Outcomes and Opportunities", In Proc. Human Factors and Ergonomics Society Annual Meeting, 2018, vol. 62, no. 1, pp. 349–353.
[17] W. Oakes, S. Khalifah, C. Sigworth, P. Fuchs and A. Lefebvre, "EWB-USA and EPICS: Academic Credit, Community Impact, and Student Learning," *International Journal for Service Learning in Engineering*, vol. 14, no. 3, pp. 29–48, 2019.
[18] J. Mueller, M. Dotson, J. Dietzel, J. Peters, G. Astrurias, A. Cheatham, M. Krieger, B. Taylor, S. Broverman, and N. Ramanujam, "Using Human-Centered Design to Connect Engineering Concepts to Sustainable Development Goals," *Advances in Engineering Education,* vol. 8, no. 2, pp. 1-24, 2008.
[19] A. Brown and M. Bauer, "Merging engineering education with service-learning: How community-based projects encourage socially conscious engineers," *Athens Journal of Education,* vol. 8, no. 1, pp. 9-22, 2021.
[20] R. Roscoe, E. Chiou, & A. Wooldridge, *Advancing Diversity, Inclusion, and Social Justice Through Human Systems Engineering*. CRC Press, 2020.
[21] N. Cooke, "Human systems engineering for societal transformation: a tale of two cities" in *Advancing Diversity, Inclusion, and Social Justice Through Human Systems Engineering*. R. Roscoe, E. Chiou, & A. Wooldridge, Eds. CRC Press, 2020, pp. 3 - 9.
[22] J. Stonewall, M. Dorneich, L. Shenk, C. Krejci and U. Passe, "Inclusive decision-making: Applying human factors methods to capture the needs and voices of marginalized populations" in *Advancing Diversity, Inclusion, and Social Justice Through Human Systems Engineering*. R. Roscoe, E. Chiou, & A. Wooldridge, Eds. CRC Press, 2020, pp. 11 - 29.
[23] C. Birzer and J. Hamilton, "Humanitarian engineering education fieldwork and the risk of doing more harm than good," *Australasian Journal of Engineering Education*, vol. 24, no. 2, pp. 51-60, 2019.
[24] W. Ulrich, "Werner Ulrich's Home Page: Systems Thinking as if People Mattered", Ulrich's Bimonthly, April, 2022. [Online]. Available: https://wulrich.com/bimonthly_november2017.html [Accessed: October 17, 2022].
[25] A. Slaton and A. Pawley, "The Power and Politics of Engineering Education Research Design: Saving the "Small N."," *Engineering Studies*, vol. 10 no.2, pp. 133–157, 2018.
[26] P. Jiménez, J. Pascual, and A. Mejía, "Educating engineers under a social justice perspective," *iJEP*, vol. 10, no. 3, pp. 82-97, 2020.
[27] ABET, Criteria for Accrediting Engineering Programs, Baltimore, MD, 2021.
[28] National Society of Professional Engineers, "*Code of Ethics for Engineers"* Publication #1102, National Society of Professional Engineers, 2019.
[29] J. Schoonenboom and R. Johnson, "How to construct a mixed methods research design," *Köln Z Soziol* vol. 69, no. 2, pp. 107–131, 2017.

[30] R. Jagers, D. Rivas-Drake, and Brittney Williams, “Transformative Social and Emotional Learning (SEL): Toward SEL in service of educational equity and excellence”, *Educational Psychologist,* vol. 54, no. 3, pp. 162-184, 2019.
[31] G. Biesta, “Why ‘What works’ won’t work: Evidence based practice and democratic deficit in educational research,” *Studies of Philosophy and Education,* vol. 29, no. 5, pp. 491-503, 2010.
[32] Collaborative for Academic, Social and Emotional Learning, “Transformative SEL”, CASEL, 2022. [Online]. Available: https://casel.org/fundamentals-of-sel/how-does-sel-support-educational-equity-and-excellence/transformative-sel/ [Accessed: October 28, 2022].