Work in Progress: Quality Indicators for Community-Engaged Education, Scholarship, and Research

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Abstract
Academia can engage with communities in a variety of ways, including an education focus (such as service-learning) or geared toward research (community engaged research, CER). These different forms of community engagement (CE) share many elements in common while other attributes differ. This paper first compares and contrasts educationally-focused CE with CER. We then present a rubric that was developed to evaluate CER in environmental engineering, indicating what aspects are appropriate for community engaged education. The CER rubric proposes nine evaluation categories: centering on communities, capacity building, action-oriented outcome, shared leadership, shared funding, shared data, equitable valuing of CER scholarship, culturally specific assessment, and culturally specific communication and dissemination. For illustrative purposes, the rubric is applied to two case studies. In the educationally-focused CE case study, a senior capstone design course in environmental engineering worked on a project defined by a community partner. The rubric did a good job revealing where improvements in the project could have been realized and demonstrating that the non-profit facilitator was instrumental in engaging the community. In the second case study, a community sub-contracted an academic partner to explore residential indoor air quality. The project was at a higher level of the rubric for most criteria compared to the educationally-focused case study. Use of the rubric at the start of a project will open important conversations, thereby contributing to the community and academic partners more fully meeting their needs.

Background
There is a long history of engagement of academics with communities [1-4]. Historically some of this work was termed service-learning (SL) where the goal was for students to reap educational benefits from credit-bearing activities through a process of reflecting on their work, while community partners also benefited from the collaboration. SL work often faced challenges with equitable benefits and power sharing. SL in engineering is now often being framed under the larger umbrella of community engagement (CE). CE is a broader idea that encompasses community partnerships in co-curricular activities (such as Engineers Without Borders student chapters). CE work can also be focused on scholarship and research, termed Community Engaged Scholarship (CES) or Community Engaged Research (CER). Ultimately, high quality CE can span all of the traditional faculty activities of teaching, research, and service. While this is a win-win in terms of beneficial impacts, it can also pose challenges in the faculty promotion and tenure process where academia traditionally compartmentalizes these activities and research-intensive institutions place outsized weight on the importance of research. In STEM fields, fundamental research (including laboratory experiments and numerical modeling) is often viewed as more scholarly than applied research. CES/CER is at risk of being devalued under traditional academic standards [5-6] given its dual purpose of real-world benefits for communities.

CES is increasingly being recognized and promoted, and various groups have published guiding principles [7-9]. Different fields use different terms; for example, community based participatory research (CBPR) is common in public health [10-11] and participatory action research (PAR) is

common in education [12]. However, complexity, confusion, and sometimes misuse among terms are concerns. A few examples of definitions from the literature follow:

> CE: "the application of institutional resources to solve problems facing communities through collaboration with those communities… leverages the capacities of all the participants to improve community well-being" [13, p. 59]. In some cases, SL may not fit this definition of CE, such as when faculty and/or students hold deficit views of communities, bring a savior complex to their work, and/or are overly focused on student learning.

> CES: CE that takes "a scholarly approach", which means being grounded in previous work and "documented through products that can be disseminated and subjected to critique by peers from a variety of contexts"; a goal of CES is "to generate, disseminate, and apply new knowledge." Further, "Effective CES demands that the scholar produce diverse forms of scholarship in innovative formats—such as documentaries, websites, briefs, or manuals—for non-academic audiences and uses." [13, p. 59]

> "CES is recognized as teaching, discovery, integration, application and engagement that involves the faculty member in a mutually beneficial partnership with the community and has the following characteristics: clear goals, adequate preparation, appropriate methods, significant results, effective presentation, reflective critique, rigor and peer-review." [14, p. 1]

Based on the CES definition from Bloodworth et al. [14], education via CES is implied. Academic research in engineering often involves graduate students and undergraduate students, who will learn through the process. The students may be earning dissertation, thesis, or independent study credits. Faculty and community members should also be expanding their knowledge. Optimal CES recognizes the expertise of community members and academics, where all members have the opportunity to teach and learn.

The Urban Institute has proposed five principles for using CE to drive radical equity [15]; see Table 1. Most CE work in engineering has not had 'radical equity' as one of its goals, falling short in the ways shown in the table.

Table 1. Principles of CE to Achieve Radical Equity [15] compared to typical CE in engineering

Principles	Typical CE in Engineering
Empower historically excluded voices	While engineering may often work with low income and marginalized communities, empowering community members is not ensured
Recognize people's intersectional identities	May focus on single identity aspects (e.g., low income) versus more holistic intersectional identities
Understand historical context and challenge pervasive stereotypes	Engineers may be too focused on technical aspects, not spending the time to understand historical or cultural contexts and perhaps perpetuating deficit-oriented stereotypes
Compensate expertise and efforts	If the work has funding, it often pays for student and faculty needs (e.g., travel, supplies) while community members are expected to donate their time
Develop accountability measures for sustainable systems change	Education-focused CE work often fails to measure change in the community, and solutions are short-term fixes versus having long-term sustainable impacts

Communities that reach out to academia for assistance may not have a clear grasp of whether their needs are best served through educationally focused CE or CER / CES. The community may also not know the specific type of expertise that is most relevant. A centralized CE effort on campus might be an effective model to deal with these challenges. When well-meaning faculty members with a core set of expertise reach out to communities, they are more likely to bias their lens to work within their (narrow) field of expertise – regardless of whether or not that is the best fit for the community or meets their most pressing needs.

Federal agencies are presently funding research that utilizes CER, including the U.S. Environmental Protection Agency (e.g., [16]) and the National Institutes of Health (e.g., [17]). These initiatives may attract more scholars to CER, but there is a legitimate risk of these individuals failing to work in respectful and equitable ways with their community partners and exploiting and further marginalizing these groups. Researchers from underserved communities and/or historically underrepresented groups may be best situated to lead this research [18, 19], but they are often marginalized in academia when they engage in CER [20].

A current ADVANCE grant (ADVANCE Partnership: Strategic Partnership for Alignment of Community Engagement in STEM (SPACES)) is conducting training activities to help those interested in CER in environmental engineering and science (EnvES) better understand the spectrum of engagement types and be intentional and equitable in their work with communities. The types of engagement with communities can vary [21-22], and there is value in clearly designing and communicating these aspects. In an effort associated with the ADVANCE project, different forms of CER were identified, and a small number of EnvES faculty indicated what types of CER they had conducted on a survey (Table 2). The types of CER where communities exercise the most power (i.e., community directed) were the least common among the respondents.

Table 2. Percent of Environmental Engineering Faculty engaged in various types of CER (n=19, average 2.9 different types identified per person) [partnership with the Association of Environmental Engineering & Science Professors (AEESP) and the University of Colorado Boulder, IRB Protocol 2021-0422]

CER Type	%
Outreach, information flows from researchers to the community	68
Consultation / community informed / community as advisor	84
Community involved / community as collaborator	79
Shared leadership / participatory	32
Community directed / community as leader	26

CER Rubric

A work-in-progress of the ADVANCE project is to develop a rubric that rates nine elements of effective CER. A number of these attributes are appropriate for all community engagement, including CE with an educational rather than a research focus. The rubric is shown in Table 3 including the elements that apply equally well to educationally focused and research focused CE. Only the criterion in gray (CER scholarship) is less well suited to educationally focused CE. These attributes of CER were distilled from an array of sources [e.g., 7,11,15,22-27].

Table 3. Evolving Rubric for CER in EnvES

Element	Below Expected Level	Meets Expected Level	Exceeds Expectations
Centering on Communities	• *Some involvement with community*	• Centralize community knowledge, values, realities and priorities	• Scientific questions arise from community members
Capacity Building	• Academics appropriate community knowledge • Community remains dependent on outsiders to address their problems • Training documents may be created, but training of community members may not occur	• Capacity-building activities intentionally designed to be bidirectional • Community gains independence with time in identifying and addressing their own problems	• Assessment data documents that capacity has been built on both sides • Community is fully independent to identify and address their problems • Residents can continue training other community members
Action Oriented Outcome	• Community has unrealized direct benefits	• Outcomes meet community approval • Framework for continued action	• Outcomes meet stated needs • Continued relationship with community • Measurable criteria
Equitable Valuing of CER Scholarship	• Unequal valuing of knowledge and scholarship	• All stakeholders given appropriate credit in scholarly outcomes	• Valuing of knowledge and scholarship consider intersectionality, historical and cultural contexts
Shared Leadership	• Community involved after it is possible to have a meaningful impact on goals and methods • Leadership comprised of a single outsider • No community representation in decision-making	• Community involved before goals and methods are solidified • Leadership is comprised of an outside organization that is not representative • At least one person from community and academia as representation in decision-making	• Community involved from the very beginning • Leadership works as a roundtable style mixing community and academia • Multiple community members as representatives in decision-making
Shared Funding	• Undercompensating the community partners • No plan for long-term operations & maintenance	• Provide fair & equitable funding to community for duration of project • Funding is centered around what the community needs and the goals of researchers	• Set up a sustainable funding system for the future • Community can generate value after the project has ended
Shared Data	• Directing communities to paper / report / technical document for information	• Providing communities with usable data that respects their needs and meets academic norms • Appropriate data archiving • Respecting community boundaries/responsible conduct of research practices	• Co-design data management and ownership rights to data • Personalized data sharing • Sustainable data collection • Co-design data collection
Culturally Specific Communication & Dissemination	• One-way communication • No community input • Language barrier maintained (poor or no translation)	• Consistent check-ins/ communication • Actively and continually listening and responding to community needs	• Advocacy for community • Prolonged commitment • Fluent communication (no need to consciously translate; understand each other)
Culturally Specific Assessment [26]	• No dissemination plan • No common language provided • No framework for administering equity • No focus on social equity frameworks	• Dissemination plan created with community • Common language provided • Framework for when equity is ineffectively administered is provided • Focus is on social equity frameworks	• Each of the areas of needs are met: cultural, resource, policy • Framework is defined with the community

Case Studies

Case Study 1: The first author conducted a project with a Native American community in 2002-2006, primarily as part of an environmental engineering capstone design course at the University of Colorado Boulder [28]. At the time, she was largely unaware of different frameworks for service-learning. As a thought exercise, different attributes of that project were mapped to the elements in the CER framework from Table 3; the results are summarized in Table 4.

This project was facilitated by a non-profit group, the International Center for Appropriate and Sustainable Technology (ICAST). The first author entered into a Memorandum of Understanding with ICAST in summer 2003. ICAST connected with communities about their needs and then reached out to the first author with potential projects for her capstone design course. This arrangement is perhaps atypical for many service-learning / community engagement projects that are led by either the academic partner or the community. In this case, ICAST had met with leaders of a Native American community (the first lieutenant governor, the second lieutenant governor, and the director of resource planning) to discuss issues and challenges facing the community. The community generated a list of nine needs, which they rated in terms of importance as either high, medium, or low. The three items rated high were then ranked in terms of priority (1 wastewater management, 2 municipal drinking water, etc.).

ICAST wrote up this information, along with short descriptions of the three top issues, and provided this document to the first author in December 2002. In spring 2003, a Master's student did a scoping study on the wastewater management project and earned independent study credit for it. The wastewater project was later selected as a good fit for an environmental engineering senior capstone design course, which began in August 2003; however, the single semester course timeframe was limiting. The student team, ICAST collaborator, and first author took a single trip to the partner community during the semester. The student team met with one community leader and operators at the wastewater lagoon, was able to complete water quality measurements, develop a number of potential design alternatives, and recommend a treatment option. Following the student design project, one student continued the work in spring 2004 as an independent study project. This student and the first author traveled to the community and presented the findings to the community leadership and in a K-12 classroom. During this visit, community feedback on the proposed solution was acquired and additional water quality measurements were conducted. The student then refined the design.

After the academic side of the project was completed, ICAST engaged an environmental consultant (with professional engineers licensed in the state) to continue the project as pro bono work to complete the design. ICAST also worked with the community on fundraising activities. Ultimately, the water quality measurements, alternatives assessment, and partial student design were folded into a larger effort that was ultimately implemented in the community in 2006.

Analysis using the evolving CER EnvES rubric finds the project *Below/Meets* expectations on the criteria. The five criteria where the project rated at a *meet* level were largely due to the critical role of ICAST. Without ICAST to serve as a facilitator and key partner, the direct interaction between the community and the academic side would be rated much lower. The academic partner on the project brought technical expertise related to environmental engineering

but lacked community engagement experience or knowledge to establish a direct collaboration with the community. For four criteria the project ranked at the *below* level of the rubric. Had the partners been using the rubric, these would be clear opportunities for improvement that could have been acted upon.

Table 4. Evaluation of CE partnership project to improve municipal wastewater treatment

Element	Apparent Level and Reasoning
Centering on Communities	MEETS: ICAST met with community leaders, they identified and prioritized needs; academic partner working on their top priority.
Capacity Building	BELOW: Capstone design course did not create training documents nor trained the community.
Action Oriented Outcome	MEETS: ICAST worked with community and consultant after the academic partner to complete PE-stamped design, collaborated to raise funds, student recommended design installed and working in YEAR; longer term sustainability unknown.
Equitable Valuing of CER Scholarship	BELOW: Scholarship was not produced. A 'case study' for educational purposes was written by first author and ICAST director; community members were not co-authors.
Shared Leadership	MEETS: Community involved before goals and methods were solidified. Leadership comprised of an outside organization (ICAST), academia, and community. Multiple community members were representatives in decision-making
Shared Funding	MEETS: Provided funding to community for duration of project. ICAST provided funding for students to travel to community and basic supplies. CH2M Hill provided pro bono the PE review and final design built on student work. ICAST partnered to write grants for funding the project to construction after the student design.
Shared Data	MEETS: The community was provided with the data and reports generated by academics including the graduate student independent study project, senior capstone final report, and undergraduate student independent study report. The community consented to all data collection trips. The community did not have input into the water quality measurement methods that were used in the lagoons; this was deemed within the expertise of the academics.
Culturally Specific Communication & Dissemination	BELOW: Academic group had little direct communication with community representatives, but rather facilitated through ICAST. Academics presented their findings to community, with some effort to adjust communication style . No dissemination plan, no common language provided.
Culturally Specific Assessment	BELOW: No explicit cultural assessment of impact of project on community or whether it met the needs of the community based on their own criteria. There was no framework for administering equity nor a focus on social equity frameworks.

Case Study 2: The third author conducted a project with a Native American community in 2013-2014 that focused on improving residential indoor air quality (IAQ), funded by a regional EPA Environmental Justice grant to the community with a subcontract to the academic partner. Different attributes of the Case Study 2 project were mapped to the elements in the CER rubric in Table 3, and the results are summarized in Table 5.

This project was initiated and led by the community, with technical expertise and equipment provided by the academic partner. The community and academic partner developed and piloted the study methods together, and institutional review board (IRB) approval was obtained by the academic partner at their institution. Briefly, the community recruited 40 non-smoking adult participants for a month-long intervention project to improve IAQ in their homes. For the pre-intervention, the participants filled out a questionnaire (residential survey), and low-cost IAQ sensors were placed in the main living area of each home. The monitors collected data for two weeks and the participants filled out hourly activity diaries. The intervention consisted of an in-home IAQ inspection by the community environmental technicians. The technician reviewed the IAQ sensor data and diary with the participant to identify relationships between indoor activities, ventilation/filtration, and air quality. The technician provided targeted mitigation strategies and educational materials. For post-intervention, the IAQ monitors and diaries were continued for two weeks to quantify the impact of the intervention. Finally, the participants were given an exit survey to communicate their experience with the program. Both partners had full access to the study's raw data, but the academic partner analyzed the data and shared the results with the community. The community recently obtained funding for personnel and equipment to adapt and expand the program. The expanded program will reach hundreds of community residents.

From an educational perspective for the academic partner, individuals who participated included: 1 post doc (environmental engineering), 1 graduate student (electrical engineering for data collection / dashboard), and two undergraduate researchers (environmental engineering Honors thesis and NSF Research Experience for Undergraduates (REU) summer fellow in chemistry). On the community side, an air quality manager in the tribal environment division and an air quality technician were directly involved.

Analysis using the evolving CER EnvES rubric finds that on six criteria, the project rates at a *meets* or *exceeds* level. The high rankings are primarily due to the strong partnership between the community and academic partner. The community initiated the project, understood the community needs, and tailored the communication so that it was culturally specific. The academic partner brought technical expertise related to air quality, provided input on data collection methods and experimental design, and provided instrumentation and data analysis. Three criteria appear at the *below* level of the rubric, including "Equitable Valuing of CER Scholarship", "Shared Data", and "Culturally Specific Communication & Dissemination". Had the rubric been in place, these are areas that could have been improved with upfront discussions and associated adjustments of the program.

Table 5. Evaluation of CE partnership project to improve residential indoor air quality

Element	Apparent Level and Reasoning
Centering on Communities	MEETS: Community initiated and led the study.
Capacity Building	MEETS/EXCEEDS: Community adapted and expanded program without academic partner. The community members were trained to conduct research independently such that a follow up study was conducted without the academic partner. Student researchers were not members of the community.

Element	Apparent Level and Reasoning
Action Oriented Outcome	MEETS: Results were provided to participants to motivate behavioral changes that would result in improved IAQ. Overall study results were summarized to better understand priority areas for future work. The project included implementation of a household hazardous chemicals reduction program although there was no assessment of the outcomes for this part of the program.
Equitable Valuing of CER Scholarship	BELOW: The work was presented at the 2015 Association of Environmental Engineering and Science Professors conference with the community lead as a co-author. This presentation was shared with the community but was valued more highly by the academic partner.
Shared Leadership	MEETS/EXCEEDS: The methods and overall program was developed via shared leadership between the community and academic partner. Exit survey feedback was obtained from the project participants to improve the program.
Shared Funding	MEETS/EXCEEDS: Funding was direct to the community with a subcontract to the academic partner.
Shared Data	BELOW: The academic partner developed a dashboard for easy access to the project data. However, the data was stored in a server owned by the academic partner. The academic partner provided all data analysis. Ideally, the data would be stored at both locations with necessary IRB protections intact.
Culturally Specific Communication & Dissemination	MEETS: The community wrote or reviewed all communication with student participants, including the IRB consent form, IAQ information and mitigation strategies, and survey instruments. The community requested that the academic partner conduct the IRB and decided not to provide their own IRB approval. The community partner provided recruitment and some of the educational materials in the native language, but decided that there was not a need to translate the consent form, diary and other materials to the native language for the specific participants of the program.
Culturally Specific Assessment	BELOW: While summary data were assessed and exit surveys were collected and reviewed, there was no dissemination plan for the integrated study results. Only individual reports were provided to the community members, No framework for administering equity, No focus on social equity frameworks.

Summary and Conclusions

Community engagement work can bring communities and academia (as well as government) together to achieve a variety of goals. Some projects will generate scholarly outcomes, while others will meet community needs and provide educational gains for participants. These are not mutually exclusive goals and a well-designed and executed project could yield all of these outcomes concurrently. Historically, academics have perhaps been too focused on academic metrics of success (e.g., student education, research publications in scholarly venues) rather than sharing power and reaching optimal outcomes for community partners. These shortcomings may be reflective of the lack of diversity in academic settings where such oversights are not easily challenged by members of marginalized communities, who are often the focus of these efforts. A current effort is underway to characterize high quality community engaged research (CER) activities in environmental engineering. The principles of high-quality community engagement have been proposed before, including via CBPR and PAR; however, some of this literature may be unfamiliar to engineers. The draft EnvES CER rubric presented here is being refined through stakeholder input. The usefulness of the draft rubric in CE focused on education (e.g., service-learning, learning through service) was explored in this paper. The majority of the rubric criteria are well-suited to educationally-focused collaborations, provided appropriate attention to

respectful engagement is given. Applying the rubric to the case study of improving a municipal wastewater treatment plant found that a number of the categories were uncertain but potentially fulfilled by the non-profit group that served as a facilitator between the community and the academic partner. Applying the rubric to the first case study from the beginning could have broadened and strengthened the partnership. Applying the rubric to the second case study, improving residential indoor air quality, found that a strong partnership up front resulted in most of the categories either meeting or exceeding the criteria. However, three of the rubric categories had not been considered by either partner when developing the project. Using the rubric when first considering community partnerships can start these activities off on solid footing, ensuring that the stakeholders have transparency and clear communication around expectations and their needs.

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