

Developing a Community-Based, Environmental Justice-Oriented Curriculum for STEM Learning

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On Community-Based, Environmental Justice-Oriented Curriculum for STEM Learning

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Introduction

Challenges of the 21st century are interrelated: global environmental threats, binary thinking, polarizing discourse, and the erosion of caring for our places and others [1], [2], [3]. With intersectional challenges, it is essential to rethink how science, technology, engineering, and math (STEM) education connects with the community and how the community is integrated into the classroom. Traditional pedagogical methods for STEM education focus on developing students' science knowledge and technical skills, reflecting the historical foundations of STEM and STEM education in the United States [4].

Published in 2005 [5] was a U.S. congressional-requested report that raised employer consciousness on the call to educate scientists, engineers, and mathematicians to maintain the nation's global position as a leader in research and technological innovation. Even now, federal STEM education initiatives state that their primary goal is to develop the STEM workforce. The U.S. government has argued that focusing on STEM is "critical to the prosperity, security, and health of our Nation—our history is filled with examples of how America's ability to attract global talent has spurred path-breaking innovation" [6]. This narrative of STEM lacks the broader social, economic, or ecological problems that STEM careers and adjacent interdisciplinary practices deal with daily [7].

While there is a recognition of the importance of interdisciplinary content integration through real-world problem-solving in STEM curricula [8], [9], [10], [11], [12], these methods are not typical components of STEM education curricula. Standardized testing, mandated curricular requirements, class schedules, and other school structures often result in content areas being taught in silos. Technical skills are decontextualized [13]. Even when there is a focus on real-world problem-solving in STEM education practices, what is often missing is the space to ground knowledge from the culture of a related community, the place of the problem, or the people who seek to solve it [7]. The authors of this study aim to understand and reflect on these notions central to community-based learning (CBL) practices within a STEM classroom.

This case study was part of a broader educational project developed to integrate CBL as a learning context for STEM or STEM-adjacent classrooms, leveraging the contexts of local environmental injustices and community infrastructure inequities. To authentically engage in real-world problem-solving, students, professionals, and all who are engaged must understand the context of the problem. Contextual understanding is rooted within disciplines of the social sciences such as history, geography, civics, and more. Dually important is how the engaged problem-solvers relate to the context as a sense of place or their relation to community. The needs of our communities guide real-world problem-solving. The increasingly urgent environmental, ethical, and social justice exigencies require a critical rethinking of education, particularly STEM education. This opens educational opportunities for situating learners in

critical, agentive roles and supporting their tackling of challenges and controversies using real-world tools in authentic sociotechnical contexts [7], [14], [15]. This paper explores how the integration of CBL shaped two case study teachers' perspectives on STEM education, curriculum design, and their classroom environments. The following research questions guided this study:

1. How do case study teachers integrate community-based learning in applied STEM classrooms?
2. How does the integration of community-based learning impact case study teachers' perspectives on STEM education and curriculum design?

More than ever, the aspects of CBL that highlight the intersection of students' learning with real-world problems and the social dimension of STEM problem-solving are of heightened value to students and the most impacted communities of the issues of concern.

Rethinking STEM education

Researchers have sought to understand and address inequities in STEM education to improve the STEM workforce "pipeline" [16], [17]. An unanticipated result of this line of research was the formation of deficit narratives within STEM education, ranging from studies highlighting skills gaps, school failure, and deficits of minority students, particularly among Black, Indigenous, and people of color (BIPOC) [18]. This was followed by counter-research narratives on BIPOC students' participation, experiences, and resilience in STEM [19], [20], [21]. Counter-research has contributed to BIPOC students' access to positive STEM experiences and a nuanced understanding of the challenges involved in traditional STEM education. Even as researchers and education practitioners continue to broaden participation in STEM, gaps in gender, racial, and ethnic diversity participation still characterize the STEM environment, particularly in computing and engineering [22], [23].

A way to rethink and reconceptualize traditional STEM education is to center community as a way of learning and knowing [3]. Educators must first recognize and acknowledge that there is validity to "non-traditional" modes of understanding the world and learning, including the lived experiences of populations that are underrepresented in STEM. This is imperative for diversifying the perspectives and experiences needed for 21st-century problem-solving, critical thinking, and ethos for global sustainability [24].

In this study, efforts to center community learning resulted in an emphasis on place-based connection with community partners, fostering teachers' understanding and agency in the context of local community issues. The purpose is to overcome deficit narratives that erase community voices relevant to the context of real-world problems. This paper demonstrates how two case study teachers applied CBL and how their perspectives on STEM education were influenced by the integration of the community.

Community-based learning in and for STEM education

Prior to integrating community-based learning in a classroom, it is key to be aware of the range of ways of knowing and learning, and which groups are excluded as primary knowledge bearers in 'traditional' STEM contexts. This study's use of CBL reflects [3]'s philosophy as the learning

framework, which calls for authentic collaborations with the communities in which the work takes place [25]. Such collaborations require the building of meaningful connections with community partners and their lived experience as knowledge of the problem's context [26]. Community-based problem-solving is about elevating the knowledge of the people most impacted by the problem being examined. The teachers in this study leveraged a community-based learning context that looked towards neighborhood organizations facing environmental hazards, whose credentials did not come from academic spaces. Even so, as the most impacted had the greatest experience with living adjacent to the environmental hazards, the residents of the community were experts on the issues. CBL requires a critical, interdisciplinary approach to problem-solving, where a range of content areas and ways of knowing are exposed and valued [25], [27].

Methodology and methods

Theoretical framework

Given the focus on examining the integration of community learning contributing to teachers' understanding and practices in applied STEM education, this analysis used sociocultural theory (SCT) [28] and critical social theory [29], [30] as the theoretical framing to understand the interconnection between education, community, and culture. SCT theorizes that school knowledge is cultural, learning is social, and teaching is assisting—that teachers are central to mediating learning and the social relationship of learners. Critical social theory [30] addresses the role of identity and the use of agency in learning and in broader contexts of society as a means to address inequities resulting from standardized practice [31]. Researchers have posited the need for another dimension of knowledge in teaching focused on racial and cultural knowledge. Racial and cultural knowledge would help teachers understand and connect with students from diverse backgrounds to mitigate the marginalization of culturally diverse students in classrooms [32], [33]. The study draws from both critical social theory and SCT. Together, they provide an interpretative framework to critically understand how the researchers can analyze the relationships within education, teachers, community partners, and the learning process. Using a multiple case study design to investigate teachers' perspectives on the integration of community-based learning in the classroom, two primary questions guided this study:

1. How do case study teachers integrate community-based learning in applied STEM classrooms?
2. How does the integration of community-based learning impact case study teachers' perspectives on STEM education and curriculum design?

Participants and context

Two former public high school teachers from an urban school district were identified as participants in this study. Participant selection was convenient but purposeful, formed of teachers connected to the researcher through a network of educators who were interested in testing new ways of learning in their STEM-adjacent classrooms, specifically career and technical education courses in urban planning and architecture. The teachers co-developed and integrated a community-based learning project focused on local neighborhood contexts into existing curricula

over a year. Neighborhoods of focus included those identified as infrastructure deserts in the existing literature. Both teachers identified as women and were second-career teachers. They had transitioned into teaching from different professions and obtained teaching certifications when employed as classroom teachers. Both teachers departed public school teaching and transitioned into advancing their studies as education researchers after they finished implementing a CBL curriculum. In this study, the authors present case studies of two experienced teachers who have integrated project-based learning and other innovative ways of learning in a classroom. Analysis of the teachers' perspectives and experiences in a community-based learning classroom was sought.

Laura

Laura was a professional architect and a second-career teacher. Originally from Mexico, she studied and practiced architecture in Mexico before moving to Texas to work in an architecture firm. She showed great enthusiasm when speaking about mentoring colleagues and interns at the architecture firm, which she described as what propelled her to go through a teacher certification program while teaching architecture at a public high school. She described how her identity as a Latina woman has impacted her commitment to teaching, connecting, and being a role model for students who "may never have had a teacher who looks like, sounds, or speaks like themselves." Since then, she has taught architecture at the high school and university level for over five years. The study's interviews and discussions with Laura occurred after her last year teaching at a public high school.

Janet

Janet was a homemaker and a second-career teacher. She explained that she grew up in Massachusetts and studied international relations at a university in her home state before becoming a homemaker. Although Janet identified herself as Caucasian, she described how "society" transitioned to viewing her as a Muslim woman, visibly dressed in a hijab, after she converted to Islam despite having grown up with privileges not afforded to Muslim populations in the U.S. She began teaching at a private school about a decade after receiving her degree and has since taught for two decades in various grade levels at both public and private institutions. Her main teaching areas of focus were in social studies, such as world history, human geography, and urban planning. She describes her greatest desire for teaching as "leaving students with something that has broadened their perspective and mindset." The study's interviews with Janet took place after her last year teaching at a public high school and examined her and Laura's co-developed CBL curriculum from their final year.

Data collection

To develop a more comprehensive understanding of teachers' perspectives and practices after leveraging CBL, multiple data sources were collected including teacher interviews and teacher work artifacts, such as the community-based curriculum document, lesson plans, and presentation slides shared in the classes. Multiple data collection methods (i.e., interviews and document review) allowed for the collection of richer, nuanced accounts of teacher practices and perspectives [34] and data triangulation to mitigate potential issues of construct validity in the

study [35]. Case study teachers were interviewed after they finished integrating the CBL curriculum into their classrooms. The interviews were relatively unstructured but guided by four themes using Charmez's [36] method of leveraging a few broad, open-ended, and non-judgemental questions to encourage rich narratives to emerge. Themes acted as starting points to capture elements and stories of their everyday practices. This included (1) participants' backgrounds, education, and important influences as a person, (2) career histories, (3) important professional influences, and (4) their practices fostering community learning in the classroom. Through follow-up questions, the interviews allowed for issues participants viewed as important in their work to take space and time. A common follow-up question would be: "What is an everyday example of this in your teaching?" After giving an example, a subsequent question could be, "Why is this important to you?" or "How has that impacted you?" Interviews focused on bringing forward teachers' stories of practice [37] and practical arguments on ways of teaching [38]. The interviews lasted approximately an hour. Interviews were recorded and transcribed for data analysis.

Interviews were conducted by the first author, who is an Asian American woman. While it cannot be fully known how the researcher's race and gender influenced the study's data or outcomes, I was warmly welcomed to interview the teachers, having established rapport as an advisor during the development of the community-based learning curriculum, lesson planning, and integration of software tools used in STEM careers. It is possible that my status as a woman of color, member of academia, and background in grassroots community organizing aided this, allowing these women educators to view me as a social ally, comfortable sharing their perspectives.

Data analysis

A multiple case study approach [36] was used to capture variation related to teachers' backgrounds or contexts and commonalities visible across both cases. To generate case study descriptions and analyses, interviews were transcribed, along with documentation of the developed curriculum and presentation materials, and were reread several times to become familiar with the full range of data. An initial coding cycle was done by reading and memoing emergent ideas on the digital interview transcripts [39], [40]. A second round of open coding was completed manually on Microsoft Excel. The primary goal of the second cycle of coding was to develop a thematic organization from the array of the first codes. Quotes from interviews and classroom observations were analyzed and coded for patterns using descriptive codes. A codebook was developed based on the analyses that involved data aggregation and the sense-making process of themes that emerged from interviews.

Documents were analyzed using a similar procedure to that of interviews. Analysis was an iterative process that combined elements of thematic analysis, to identify meaningful passages and patterns, and content analysis, organizing collected data into categories relevant to the research questions [41], [42]. Since document analysis was supplemental to interview data, predefined codes from interview transcripts were applied to data from documents. This enabled the integration of data gathered via different methods.

Themes were constructed from qualitative analyses of participants' stories of practices aimed at integrating community-based learning methods in their classrooms. Thematic analysis was then completed using the codebook, establishing three themes from the existing categorical aggregates [39], [40]. The primary aspects that came into focus through teacher responses and documentation centered around integrating community having influenced teachers' curriculum design and thought through viewing (1) city as a place for classroom learning, (2) classroom as a place for community, and (3) authentic human connection for community.

1. How do case study teachers integrate community-based learning in applied STEM classrooms?
2. How does the integration of community-based learning impact case study teachers' perspectives on STEM education and curriculum design?

Findings

Integrating community-based learning in the classrooms influenced the case teachers' ways of knowing and learning practices valued in STEM education. Both teachers designed the CBL STEM curriculum so that learning was driven by building a connection to place and developing awareness of one's sense of place. This led both educators to develop an awareness of their sense of place in relation to the community-based problem-solving process.

Using the neighborhood and city as classrooms

As both case studies were second-career teachers with industry experience in architecture (Laura) or international relations (Janet), leveraging the city as a classroom for learning was a natural and practical flow to their lesson planning. Prior to their development of the CBL STEM curriculum, both teachers described having partnered with design firms and planners who worked with city government as their way of using the city as their classroom and letting students experience the city. Arguably, that was a very different method of leveraging the city as a classroom than was more recently done, and this was reflected on by Laura.

Laura described this as, "Whether the field wants to come to terms not, we [architects] really just work for the one percent that can afford to commission us. I wasn't a part of the projects that were pro bono, you know like free of charge, but then again it was rarely talked about and we never really had any...I worked in the industry for decades."

The CBL curriculum instead utilized the community as a learning environment in which the students, teachers, neighborhood groups, and representatives from other sectors participated in the learning experience.

Janet: "I was not familiar with the [hyper]local environmental justice issues that were happening in our city, so when you connected us with [omitted neighborhood organization], I really learned a lot about our city along with the students...having a framework to look at infrastructure inequity and justice was helpful for me to teach the class...I was familiar with environmental justice and justice because of my international relations studies, but they were about these issues not happening in the U.S., and this was happening right here."

By integrating ongoing issues flagged by local neighborhood groups as educational "case studies" for the context of their STEM-related classes' community-based problem-solving project, there was a pattern of centering the importance of respecting place and community

members' needs. Janet described a learning experience in which a community leader of a neighborhood group was featured as a guest speaker in her class as having been a meaningful time for the students. She elaborated that some students lived or had relatives who lived in the neighborhood in which the guest speaker came to speak on, particularly the ongoing neighborhood equity advocacy she was leading. Secondly, she continued that the students could relate to "someone who they could see themselves as." Both teachers described the purposeful guest featuring of community members who worked within contexts of their neighborhood's place-based issues as having influenced their sense of place and gained a greater understanding of the undeniable regional patterns of inequity that were part of the city.

The teachers both highlighted their beliefs about the importance of hands-on, experiential learning to understand the community, which translated to students conducting site visits and infrastructure quality studies within the public spaces of the guest speakers' neighborhoods. Laura: "I was shocked at how well the students took to CBL and the interest they showed. Sometimes, ideas we think will be well received by students but aren't. But most of my classes asked lots of questions to understand these neighborhood areas, what was going on, and why. This was so great because I wanted to talk about this."

Using the classroom as a community

During the interview, Laura claimed, "These students really look after one another. They really seem to care if their classmates are well or not. They're different." When asked whether she thought curricular designs or community learning played a role, she responded that it may have been a "mix" of things, including the development of trusting student-teacher, almost mentorlike, relationships. She continued explaining that such relationships were as important as any other concept, technical skill, or career preparation skill she taught. She mentioned when the classroom is a safe and comfortable space, students can readily engage with learning, be curious and thoughtful.

Janet articulated her social relationship with students differently, saying, "The students know that if they had a bad interaction with me the previous day, the next is always a fresh start with me. And I think that's really important for all of us... we don't hold grudges because otherwise, how do we maintain a sense that we're here for learning, not drama?" Although both teachers describe handling social classroom environments differently, both were methods case study teachers employed within their comfortability and skillset to maintain classrooms they claim were conducive for learning. Janet gave an example in which, "When students had questions about community case studies, sometimes other students would answer, and they'd have back and forth conversations." In turn, one could suggest that an active, interactive classroom could become its own learning community.

We are all in the community

The integration of CBL offered opportunities to alter the learning experience in important ways that allow for a broader vision of what it means to be in STEM (e.g., using science to protect air quality) while also expanding what ways of knowing are valued in the process of problem-solving. Laura: "I think the only way we can move forward with all the problems in the

world is by truly caring about one another and that starts by understanding and connecting with people.” When prompted to elaborate on the meaning of connecting with people, she responded with a vision for STEM education and education in general to “...just see and recognize the fact students, teachers are first of all human” and to be able to fill in the social interactions that are key to supporting student content learning. Engaging in these experiences, within neighborhood case contexts, and within classrooms, enabled the teachers to establish rich connections to the community. The experience of integrating the knowledge of neighborhood groups was an opportunity to explore and understand that there are a range of ways of knowing that are required to solve real-world problems in our communities meaningfully.

Part of what Janet described as key to impactful CBL design was the presentation of student work at the end of the project. Students displayed their projects in the form of a gallery walk at the first author’s university. “You don’t even know how happy those kids were after the gallery walk. I think it was really important for the students to feel and know their ideas and projects were heard [by university students and faculty].” The sense of belonging and importance of each student’s work for the greater community while in a classroom community was touted by both case teachers as necessary when designing CBL.

Discussion

The findings illustrate two teachers’ teaching practices to integrate community-based learning in STEM-adjacent classrooms and the impact of their perspectives of STEM education upon centering community in the curriculum. The results of the previous section do not aim to evidence ‘what works’ but instead inform education practitioners’ judgment of unique cases of learning to deepen understanding of complex educational practices. Similar to findings in CBL STEM literature, this study demonstrates pathways for engaging in learning experiences [43] and how integrating community in a classroom can allow for richer meaning to content learning. Thus resulting in impacts beyond improved test scores [27]. As the field continues to rethink STEM education and the ways of knowing and learning methods, it is important to understand the foundations and histories that drive STEM education to overcome the deficit narratives that marginalize community voices relevant to the context of real-world and next-generation issues.

As described by both case study teachers, community-based, local contexts were pivotal in deeply connecting and understanding real-world issues of inequity due to the proximity and relevance of how STEM and STEM education can leverage the contextual understanding of place and people to “problem-solve.” The centering of community in the classroom afforded opportunities for authentic connection to understanding their city. Discussion of local issues in relation to classroom learning encouraged dynamic dialogue, and even amongst the teachers themselves. During the interview, in which STEM education and community were central in questioning, the act of teachers articulating and processing their experiences in real-time appeared to bolster their understanding of what community can look and feel like. For example, areas described as infrastructure deserts are home to community groups formed by residents to address local issues. A community can be fostered within the classroom when collaborating to “problem-solve” a shared issue, as observed by case teachers. Existing literature on Communities of Practice (CoP) supports this finding. The process of “thinking together” is key to forming CoPs, where people guide one another through their understanding of a shared problem in an

area of mutual interest and share tacit knowledge [44]. The integration of community-based contexts for STEM learning reflects an essential purpose of broadening methods for teaching in STEM to broaden the participation of diverse groups of learners.

While these findings emerged from and are grounded in the data, the study has limitations that should be considered. First, the study leveraged convenient, purposeful sampling to select two teachers who developed a CBL curriculum focused on local environmental justice issues for an applied STEM course. Document analyses of the teachers' lesson plans helped triangulate information about curriculum design and implementation. Even so, it is possible that Janet and Laura share an unobserved or unaccounted-for characteristic that differentiates them from teachers working in similar applied STEM classrooms. Second, the scope of this study was small and did not include frequent observations during their classroom teaching, which may have supported firmer conclusions about the teachers' changes in perspective on STEM education when actively implementing CBL. Although the sample number of two teachers does limit the authors' ability to make broader statements or conclusions, the small number of participants allowed an in-depth exploration of teachers' perspectives on STEM education after integrating CBL practices. Future studies should further examine these relationships between CBL and teacher perspectives with a larger sample of participants and in other academic disciplines.

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