

Activating Resources for Incorporating Culturally Relevant Teaching in STEM Curricula

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Abstract: Studies reveal that significant instructional challenges persist when teachers integrate culturally relevant teaching (CRT) in science classrooms, often due to insufficient structural support and available resources. Additionally, teaching of STEM requires teachers to have access beyond material resources, such as lesson plans that they acquire in professional development. We present a case study of one experienced science teacher implementing an innovative STEM curriculum that integrates bioinformatics, data literacy, and mobile learning. We use a resource activation framework to examine constraints occurring when implementing the curriculum that was specifically designed for CRT. We analyzed the teacher's daily reflection posts, classroom observation notes, and a post-implementation interview. We found that symbolic resources (i.e., perceived institutional social values that are ascribed to different forms of instruction) impacted the teacher's instructional choices. Our findings suggest that successful implementation of STEM curricula is dependent on teacher's activation of different forms of resources often simultaneously.

Introduction

Studies on equitable science teaching in urban schools stress the need to design inquiry-based curricula that involve culturally relevant teaching (CRT) (Brown, 2017). Traditionally underrepresented groups, such as people of color, enter and are retained in STEM fields at lesser degrees (NSF, 2018). CRT can lessen the educational debt experienced by students who have been historically underrepresented in STEM disciplines (Ladson-Billings, 2006). CRT is a pedagogy of empowerment (Ladson-Billings, 1995), linking learning and culture in ways that aim to improve academic success, foster critical consciousness, and support cultural competence in the classroom, which give students opportunities to relate themselves to science in and out of school. Common barriers for enacting CRT in STEM include lack of structure and resources for preparing teachers, such as professional development (PD) training opportunities, model teachers who can positively demonstrate CRT instruction, and curricula of CRT that align with the standards (Barron et al., 2021). These limitations are amplified when teaching with innovative STEM curricula which focused on emerging disciplines, such as bioinformatics, computational thinking, machine learning, and data science. This is because in-depth conversations of CRT have not quite yet emerged (Brown, 2017).

Literature on implementing STEM curricula indicates that their successful implementation in classrooms depends on external resources beyond individual experiences and resources that teachers can acquire in PD (Brand, 2020). These resources, among others, can take the form of cultural resources, such as teachers' pedagogical skills, or symbolic resources, such as the importance that STEM ideas have in the standard curriculum (Rivera Maulucci, 2010). Yet how teachers understand and activate essential resources to successfully implement innovative STEM curricula is still not well understood (Wang et al., 2020). Moreover, research on STEM education typically focuses on two forms of resources that are material, such as teaching supplies or curricula, and cultural resources, such as students' prior knowledge (Brand, 2020). The demands of teaching dictate that teachers should utilize multiple resources simultaneously, and supporting teachers requires a more robust understanding of the complex nature of the resources that teachers draw upon (Rich, 2021). Rivera Maulucci (2010) proposed a resource activation framework that aims to systematically explore the ways that teachers utilize diverse resources concurrently. For STEM curricula to be incorporated with CRT, we used a resource activation lens to analyze an in-service teacher's experience in adapting and teaching a bioinformatics problem-based learning unit in which students collect, analyze, and visualize air quality data collected through mobile apps and sensors. This study is guided by the following questions: (1) What resources did the expert science teacher activate to implement the bioinformatics curriculum? and (2) how did the interrelationships between the resources impact the activation?

Theoretical framework

This work is guided by the resource activation framework (Rivera Maulucci, 2010). According to Rivera Maulucci (2010), "activation" refers to an intentional use and adaptation of knowledge and commitments to improve pedagogical strategies and support teaching practices. In her resource activation framework, resources for teaching

science can be categorized as material, cultural, social, and symbolic resources. Available *material resources* include learning supplies, such as textbooks, data collection devices, computers, and consumable equipment. Material resources can result from the context in which teachers work. Activating material resources could look like a teacher finding a short news clip that reports inaccurate data representation which could easily mislead the audience, and using it to facilitate students' discussion about the application and ethical use of data in the real world. *Cultural resources* are "knowledge, skills, education, and experiences within particular contexts" (Maulucci, 2010, p. 824). In an educational setting, cultural resources include the understanding of students and the teaching context; teachers' knowledge and conceptual understanding of data literacy (e.g., context, variability, aggregate, visualization, and inference); teachers' pedagogical and instructional strategies to foster critical data literacy and/or school's preferred instructional approach (e.g., problem-based learning, inquiry-driven learning, mobile learning, culturally relevant pedagogy); students' knowledge, experience, language, and academic abilities; and the culture of the school. *Symbolic resources* refer to value or prestige a community ascribes to an activity or goal. In an educational setting, symbolic resources refer to the perceived status or importance of teaching and learning. Symbolic resources highlight the institutional social value that is ascribed to different forms of instruction. For example, in our study, whether and how data literacy in STEM domains is prioritized, and recognition of teachers' efforts to integrate data literacy into their existing curricula. A teacher's symbolic resources might be activated when a principal recognizes the teacher for their efforts to bring cutting-edge knowledge into her science classroom or when the teacher is afforded some autonomy to design lessons using new pedagogy.

Methodology

Context

This study is part of a larger NSF-funded project that aims at constructing an innovative STEM curriculum in the context of bioinformatics that integrates culturally relevant pedagogy into the high school science classroom (Yoon et al., 2022). The curriculum is grounded in real-world problem solving that engages students with the community issue of asthma and air quality to explore data literacy as it pertains to biology. This issue was chosen because it is a problem that is highly relevant in the city, especially among students of color (Bryant-Stephens et al., 2012). A three-week summer PD workshop was designed to help teachers teach this curriculum. We ran the PD for 75 hours in July 2019. During the PD, six teachers learned the bioinformatics content and were introduced to pedagogical concepts such as student-centered, community-centered, and culturally relevant approaches. Teachers were asked to reflect on their learning after morning and afternoon sessions in a Google Classroom site that was created for sharing and storing of PD resources.

Participants

We used a case study method which requires researchers to purposefully select information-rich cases, as they will allow researchers an in-depth understanding of relevant and critical issues under investigation (Yin, 2017). To gain such insight, we chose to investigate Tracy, one of the teachers who participated in the PD, who implemented the curriculum in her environmental science class at a public high school in the Northeast U.S. She had been nominated as an expert teacher by the director of science in the school district. She identified herself as African American and was in her 5th year of teaching, with previous experience teaching biology, environmental science, and AP environmental science, all at the high school level. On the pre-PD survey, she indicated her passion toward teaching science. She responded, "I love Biology, I love to get students just as excited as I am in the subject(s)," and "I hope that I complete the PD with more knowledge, with something I can take back to my student in the classroom. Something that is real life, relatable to my students, and hands-on." These comments highlight her strong interest in providing authentic and meaningful learning experiences to her class.

Data source and analysis

We collected three data sources: daily reflection posts, classroom observation notes, and a post-implementation interview. The daily reflection posts were gathered to learn about how her perception of CRT changed as a result of PD participation. These posts were based on prompts given by the PD instructors, were submitted to Google Classroom throughout the PD. The prompts included, "1) What do you think about this content in terms of how you already teach? 2) What issues or challenges do you foresee in teaching this content to your students?" A total of 15 reflections were collected. The observation notes included descriptions of the classroom conditions, the teacher's instructional practices, and the activities and interactions among students taking place. Tracy's class was observed 9 times out of the 14 classes devoted to this project, which totaled 16 hours of instruction. Observation ranged in length from 33 minutes to 55 minutes with an average length of 46 minutes. The semi-structured post-

implementation interview, which lasted 67 minutes, was conducted to probe the teacher's specific practices, beliefs, and understanding of implementing the new curricula, as well as the teacher's experience of preparing the class and participating in the project. Authors deductively coded data to identify instances that demonstrated the teacher activating resources in four categories of material, cultural, social, and symbolic resources. For example, the teacher's interview response, "[The principal] is very supportive over new [curriculum ideas] and if it supports the students' learning, then he will try his best to support it," was coded as symbolic because the teacher had symbolic support from the principal to pursue a more innovative approach to science teaching. Any discrepancies that occurred were negotiated until consensus on the codes was reached.

Findings

Shift in symbolic resources to navigate cultural and material resources

During the PD, Tracy did not appear to have enough symbolic resources for her to navigate cultural resources and turn them into material resources. In the PD, the teacher was asked to post a reflection after each morning and afternoon session. One of her posts captured how she initially felt about CRT in her instructional practices.

It is a topic that I don't cover unless students bring it up. I stick strictly to the curriculum. However, I think I'm sensitive to the student racial/social needs just because I'm an African American woman who also grew up in [City] ... but I shouldn't use that as an excuse. I will try to educate myself on implementing social and environmental awareness into my curriculum; especially in AP [Environmental Science]. The only issue I foresee is educating myself and trying not to impose my personal feelings on the issues discussed.

In this post, Tracy explained that CRT was not part of her core instructional approach prior to the PD, but expressed an interest in incorporating it more. She also mentioned in her post-implementation interview, "we have to [be] making sure that what we're teaching, it's aligned to the standards, and that we just don't have the standard and [are] teaching whatever we want." She pointed out the lack of recognition from the school district for bringing CRT to science class while taking standards into account. These examples illustrate that there were not enough symbolic resources for her to navigate culturally relevant approaches (cultural resource) and incorporate them into activities in science class (material resource).

To overcome symbolic resource constraints, through the PD, Tracy was able to connect her shared identity to teaching goals which extended access to symbolic resources. For example, in the second half of her reflection post above, Tracy expressed an affirming attitude toward incorporating CRT in her science class. Her perceived importance of CRT indicates that her view of science teaching has shifted (symbolic resource) and that she admitted to using her positional identity as a source of strength in pursuing her interest in incorporating CRT in her implementation. In other words, symbolically, her positionality and PD experiences amplified her perceived value of CRT in science, as well as its perceived importance by others at the school.

Activating symbolic resources to make space for racial and cultural connections

During the school-year implementation, activating symbolic resources were salient in Tracy's class implementation and it drove the energies and focus to engage in choosing authentic and real-world examples. In other words, Tracy adapted the curricula acquired from PD in ways that reflected her students' interests and context. Tracy used symbolic resources in several ways to activate cultural and material resources simultaneously.

She actively sought to incorporate personally relevant and real-world examples to students, such as lead levels in children's blood in the city. For example, in the observation note on the lesson introducing data visualization, the researcher detailed that Tracy used a picture of [City] that included information about the incidence of children with high blood lead levels. Then, the class discussed what could be the cause of high lead levels in children's blood and looked at the correlation between environmental variables and health. In her interview, she explained the reason for this adjustment and said, "I felt like that was really good for the kids because they're from [City]. They can see the area that they live in. They can analyze that." Tracy clearly intended to bring CRT for science into the classroom to help students engage with and learn science. In another example, she discussed an oil refinery fire and explosion incident in [City] which happened six months prior to the lesson. As she used this example, many of the students actually remembered the incident and started to talk about it. Tracy extended the conversation by asking, "What do you think that did to the air quality for people who lived in that area? How did that affect them? And what type of people live in that area?" In her interview, she articulated a clear goal for students to be able to personally connect with the community issues and solve them in science as she tried to "bring in that real-world information and trying to take something that doesn't seem realistic and

making it realistic because they already know that it happened. Maybe so many kids even actually live near [near the incident].” These examples reveal that Tracy connected science to issues that concerned students’ communities (cultural resource) and used examples that students were familiar with (material resource) as she considered them valuable to science instruction (symbolic resource).

Discussion

This study advances the current literature on STEM implementation by providing empirical evidence of how a teacher activated different types of resources in order to successfully implement new curricula. These findings indicate that the teacher relied on diverse resources in addition to the material resources that she acquired in the PD (Maulucci, 2010). While other studies have shown that CRT is not limited to curricular practices perceived as important for teacher enactment (Barron et al., 2021), this study’s outcome extends this conversation in terms of how symbolic resources are activated by teachers to implement CRT. In this paper, the teacher’s view of social and community issues and the decision chosen to navigate her belief motivated her to identify and activate multiple resources for CRT. Still, a focus on symbolic resources may begin to excavate some of the initial structural barriers that might derail implementation of STEM education. We argue that developing teachers’ resource activation is an important instructional practice for teaching STEM curricula that incorporate CRT. Finally, it is important to note that teacher PD should provide more opportunities for teachers to identify available resources and ways to activate different types of resources in various situations.

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