
TOWARD A THEORY OF TEACHER EDUCATION FOR JUSTICE-ORIENTED STEM

BETH SONDEL

North Carolina State University

JOANNA GREER KOCH

North Carolina State University

SARAH CARRIER

North Carolina State University

TEMPLE A. WALKOWIAK

North Carolina State University

Abstract

Among the multiple perspectives as to the focus of education policy, there has been much recent attention paid to both STEM and social justice education. While these approaches are often seen in opposition with each other, in this paper we explore the possibility of combining these two aims as we begin to develop a theory of teacher education for justice-oriented STEM education.

Introduction

In our nation's current debate about education and equity, there has been much attention to both STEM and social justice education. While these approaches may be seen in opposition with each other, in this paper we explore the possibility and importance of combining these two aims as we begin to develop a theory of teacher education for justice-oriented STEM education.

Each of us work as faculty in an undergraduate elementary teacher education program at North Carolina State University (NCSU) with the dual mission to prepare elementary teachers with deep content and methods knowledge in the STEM fields as well as the commitment and capacities to teach towards social justice. The path by which our teacher candidates develop knowledge within each of the STEM disciplines has been well established. In their freshman and sophomore years, candidates take 27 credit hours of mathematics, science, and engineering design content courses, including calculus and physics courses designed specifically for elementary teachers. Once the candidates enter our program in their junior year, they take two mathematics courses, two science courses, and one engineering methods course. Technology is infused across the program through computer presentation software, video and audio recording, science probeware, and student online interactions.

Our teacher candidates' trajectory in their development as social justice educators is, to date, less established. Because of the number of STEM-related courses we fit into our program, there is no official Foundations or School and Society course, and the bulk of justice-related content and concepts are addressed in a two-credit seminar students take in their junior year, officially titled "Connections: Identity, Social Justice, and Diverse Learners." In addition, and to varying degrees, members of faculty incorporate justice-oriented concepts and content in literacy, social studies, and STEM-related methods courses. We have recently begun to assess this incorporation, systematically, as a program. In order to meet our dual mission, we believe it is necessary to take seriously the task of more intentionally incorporating the components for the development of social justice educators into our STEM courses.

In what follows, we use Marilyn Cochran-Smith's (2009) theory of teacher education for social justice as a launching point and draw on our own experiences when possible, to explore the multiple ways in which the aims of STEM and social justice education can serve each other. In doing so, we present a new model for aligning the undergirding missions and assumptions of these two, often-divergent fields.

The Divergent Assumptions of STEM and Social Justice Education

STEM is conceptualized in a variety of ways, yet is anchored by the notion that global competition requires a workforce prepared in science, technology, engineering, and mathematics (e.g., National Academy of Sciences, 1995, 2007, 2010). In the interest of global competitiveness, there has been increasing governmental emphasis on national progress in STEM fields. This includes a series of reports and studies on the preparation of students for STEM careers across the U.S. and in comparison to other countries (e.g., Kuenzi, 2008; Martin, Mullis, Foy, & Stanco, 2012; OECD, 2014). In 2010, for example, the "Rising Above the Gathering Storm" report (2007) claimed that jobs of the future will be STEM driven and further, that the foundational STEM knowledge gleaned from K-12 education will have direct links to the prosperity of the U.S. Subsequently, we have seen growing attention to the development and monetary support of STEM education in K- post graduate education.

Relatedly, the widely held view that prosperity and education are directly connected has brought increased attention to educational inequality, especially along lines of race and socio-

economic status. While research links the majority of variations in student achievement to out-of-school factors such as poverty and lack of access to resources (e.g. early childhood education and health care) (Berliner, 2013; Rothstein, 2007), public discourse reflects a general consensus that schools and teachers must be held accountable for the alleviation of inequities (Berliner & Glass, 2014). This recent attention has brought emphasis to programs that attempt to alleviate inequalities and those that identify as social justice in nature. Subsequently, the term “social justice” has been used to promote a multitude of concepts and programs (North, 2006). The theoretical foundation of this field, however, is anchored by the notion that the purpose of education is in service of human enlightenment and human liberation (Ayers, Quinn, & Stovall, 2009). As such, social justice educators are committed to promoting and protecting the recognition of people’s intersectional identities (Leonardo, 2009; Stovall, 2006), interrupting the reproduction of social inequalities, and preparing “justice-oriented citizens” (Westheimer & Kahne, 2004) who have the capacities and consciousness to understand and actively respond to the root causes of systemic inequities (Adams, Bell, & Griffin, 2007; Freire, 1971; Kumashiro, 2015; North, 2006).

Scholars and the public have also begun to address and attempt to alleviate the challenged access to STEM education and careers among women and people of color as an issue of access and equity (Brown et al., 2015; Diekman, Weisgram, & Belanger, 2015; Wilson, Bates, Scott, Painter, & Shaffer, 2015). To that end, there are clear overlaps across the fields of STEM and social justice education, namely in their intention to create equitable opportunities for all students. There are, however, also glaring discrepancies, namely that STEM approaches to equity are primarily concerned with the creation of pathways by which individuals can gain access to the economy and experience social mobility. Alternatively, social justice education is concerned with preparing citizens with the capacities and commitments to interrogate and rearrange the very structures that maintain a stratified society in service of the common good.

Critical mathematics and science education scholars have pointed out that it is possible to teach towards social justice in and through mathematics and science education (i.e. Barton, 1998; Bianchini, Akerson, Barton, Lee, & Rodriguez, 2012; Dimick, 2011; Felton & Koestler, 2015; Gutstein, 2006; Leonard, Brooks, Barnes-Johnson, & Berry, 2010, Rodriguez, 1998). For example, the study of mathematics, according to Gutstein (2003), provides opportunities for students to understand relations of power, resource inequalities, and disparate opportunities between different social groups and “examine these various phenomenon both in one’s immediate life and in the broader social world” (p. 45). Yet, teachers are too often likely to complete credentialing programs without knowledge or experience with this approach (Blanchett, 2006) and in-service teachers rarely receive professional development specifically on how to develop culturally relevant pedagogy in their mathematics classes (Leonard, Brooks, Barnes-Johnson, & Berry, 2010). School districts and teacher education programs too often assume that the achievement gap in STEM fields results entirely from teachers’ lack of disciplinary knowledge. Instead, this gap could be caused by teachers’ deficit perspectives and internalized racism and bias (Delpit, 2012) or their lack of cultural competence and ability to make curriculum relevant to students’ lived experiences (Ladson-Billings, 2009). In addition to an equity orientation, Gutierrez (2013) claims that teachers’ efforts to provide equitable opportunities in math are stymied by their socio-political contexts:

What is lacking in these approaches is a model of teacher development that includes giving teachers the skills to form a deep connection to students and

political knowledge: negotiating the world of high stakes testing and standardization, connecting with and explaining that mathematics to community members and district officials, and buffering themselves, reinventing, or subverting the system to be an advocate for their students (p. 37).

To that end, Cochran-Smith's (2009) theory of teacher education for social justice serves as a framework as we attempt to envision how to prepare teachers for the arduous task of justice-oriented STEM.

Towards a Theory of Teacher Education for Justice-Oriented STEM

In her theory of teacher education for social justice, Cochran-Smith (2009) begins with an articulation of justice that goes beyond simple notions of "non discrimination and equal opportunity to participate" (p. 450). Instead, she argues, we must define justice through terms that are democratic, anti-oppressive, multi-perspectival, and rooted in critical theory. Drawing primarily on the work of critical, feminist theorist Nancy Fraser (Fraser & Honneth, 2003), Cochran-Smith argues that justice is only possible at the intersection between equitable distribution of resources and the recognition of individuals and social groups based on culture, race, gender, religion, nationality, language, sexual orientation, and ability/disability. In Fraser's other work (1997), she similarly claims that remedies to inequality must pay attention to how *both* "economic disadvantage impedes equal participation in the making of culture, in public spheres and in everyday life" and "[c]ultural norms that are unfairly biased against some are institutionalized in the state and the economy" (p. 15). In simple terms, and as related to schooling, scholars of social justice education (North, 2006) have taken up this theory to assert that the curriculum must provide students with pathways to access economic resources without expecting them to sacrifice their identities. Further, Cochran-Smith continues, schools must prepare students to recognize inequalities and identify ways in which they can participate in and contribute to recreating a more just and democratic society.

If the ultimate aim is education for justice, then Cochran-Smith contends, teacher education programs must first diversify the teaching force and recruit teachers whose "beliefs, experiences, and values are consistent with social justice goals" (p. 459) and provide candidates with opportunities to work alongside and learn from mentors, parents, and community members who are committed to justice. In addition, Cochran-Smith argues that course work should serve to help candidates (re)conceptualize teaching as the amalgam of the following: 1) content **knowledge related to equity and justice** as well as the ability to critically analyze the construction of said knowledge; 2) a mindset, or **interpretive frames**, that support a justice-oriented practice; 3) the teaching **methods, strategies, and skills** to engage *all* students in meaningful learning; and 4) a sense of **advocacy** and alliance with students, parents, colleagues, and communities (p. 454).

Even as some may believe that the work of preparing teachers for a social justice practice does not belong in the STEM fields, others have provided argument and evidence that both mathematics (Gutstein, 2003; 2006) and science education (Basu & Barton, 2007; Meyer & Crawford, 2011) provide opportunities to develop students' critical capacities and skills of justice-oriented citizenship. To that end, we contend that preparing teachers for a justice-oriented practice is not only possible, but also essential, in STEM methods coursework. In what follows, we will draw on Cochran-Smith's framework to envision methods courses in a teacher preparation program with **justice-oriented STEM** as the aim. To do this, we will discuss how to

facilitate teaching candidates as they cultivate the **knowledge; interpretive frames; methods, strategies, and skills**; and sense of **advocacy** necessary for a justice-oriented STEM practice.

Knowledge

In terms of knowledge development, Cochran-Smith contends, candidates must be prepared with the body of *knowledge* generally agreed upon in the field to teach students in meaningful ways (i.e. Darling-Hammond & Bransford, 2005). In addition, they must develop the capacity to “critique the very idea of a knowledge base and understand its limitations” (p. 455) and draw on the “the knowledge traditions and lived experiences of marginalized and oppressed groups” in order to challenge the status quo (p. 451). STEM methods courses have the potential to provide ample opportunities to prepare candidates to develop and practice these skills by asking questions from the field of critical pedagogy (McLaren, 2009) including: ‘What kind of knowledge is valued?’ ‘Who decides?’ ‘Who benefits and who is marginalized?’ and ‘What other approaches could we take?’ Further, STEM methods courses provide opportunities to prepare candidates to teach their students to grapple with similar questions.

First and foremost, the STEM fields inherently foster the critical and analytical skills necessary to problematize and interrogate the construction of knowledge. Scientific practices (NGSS, 2013), for example, lend themselves to the exploration of how knowledge is cultivated, what counts as evidence, and who decides. Additionally, there is an opportunity here to compare this process of knowledge development with socially constructed “knowledge” including stereotypes and biases. For example, students in our diversity seminar watch sections from the PBS special “Race: The Power of an Illusion,” to look at the lack of scientific evidence for our socially constructed concept of race to help them understand the ways in which scientific practices and knowledge, like all knowledge, are constructed within a socio-cultural context.

Mathematical computation also lends itself to exploring different ways of approaching problems and provides a structure for young learners to learn multiple perspectives and solution paths (Koestler, 2012). This fosters opportunities to interrogate how knowledge is valued differently by individuals and groups. For example, in their mathematics methods course, our candidates examine what the “traditional” algorithms are in various cultures around the world. Candidates are typically surprised to learn that the traditional algorithm in the United States for division, for example, is not the predominant algorithm in all countries. Activities and discussions such as these serve as a launching point for further interrogation of the cultural relativity of knowledge.

A focus on STEM also provides opportunities to explore how access to knowledge is differentially distributed, and how this access manifests as economic inequality. As mentioned, there is already much documentation of differential access to STEM education and representation in STEM careers (Brown et al., 2015; Diekman et al., 2015). By looking directly at contemporary research on this topic and situating this opportunity gap in historical contexts (Mohr-Schroeder, Cavalcanti, & Blyman, 2015), candidates can develop understanding of systemic racism and the ways in which inequitable educational access continues to reproduce racial and economic inequalities (Kozol, 2005; 2012). Further, this analysis will help candidates understand the necessity for making STEM fields accessible, especially to those students who have been historically marginalized.

Yet to develop a justice orientation, the very focus on STEM itself needs to be problematized and candidates should grapple with the ways in which knowledge is “historically and socially

rooted and interest bound” (McLaren, 2009, p. 63). Even as students are learning the importance of making STEM content accessible, there is also room to interrogate the focus on STEM and problematize the ways in which technocratic and quantifiable skills continue to be valued over the humanities in our current reform context (Apple, 2004; Hursh, 2000). As Lisa Delpit has argued (1995), especially those students from marginalized communities must be explicitly taught about the “culture of power,” or the tools (knowledge, beliefs, and skills) valued by those in the dominant majority such as STEM in this case. At the same time, they must be given opportunities to critique these tools and recognize that they are not better, but rather necessary because they are valued by those in the dominant majority. In simpler terms, teacher candidates, and subsequently their students, would understand that STEM content knowledge is essential, not necessarily because this knowledge is superior to the humanities, but because it is valued more in society.

Finally, in any justice-oriented STEM program, students should learn about the ways in which perceived scientific knowledge has and continues to be used to perpetuate systems of oppression. Learning the history of the eugenics movement (Gould, 1996), for example, or about the ways in which technological developments (Bigelow & Peterson, 2002) contribute to the wealth gap and the diminishing middle class, could provide students with an opportunity to critically answer questions such as, ‘whose interests are served by particular forms of knowledge?’

Interpretive Frames

In addition to knowledge, Cochran-Smith discusses *interpretive frames*, or the “filters through which teachers make decisions, form relationships, and support learning, [which] are the powerful mediators of practice and thus of students’ opportunities and experiences” (p. 456). Candidates, she contends, must develop an **assets-based view** of their students and the communities from which they come, a **sense of inquiry** about themselves and others, and the **understanding that teaching is deeply entrenched in a socio-political context**. STEM methods courses are perhaps ideal places to shape candidates’ interpretive frames. For example, and as we will describe here, the development of each of these interpretive frames is easily abetted through analysis of the common practice of ability grouping, or tracking, in mathematics classes.

To teach for social justice, it is essential for candidates to challenge any deficit-based thinking and instead develop **assets-based perspectives**, with the ability to recognize and draw on students’ prior knowledge and past experiences (Leonard, 2008; González, Andrade, Civil, & Moll, 2001; Oyler, 2011). Investigating tracking in mathematics classes can contribute to candidates’ development in this area through an exploration of the tangible and differential outcomes of assets-based and deficit perspectives. In our current mathematics methods courses, for example, we attend to and problematize the language often heard in schools to talk about students and their performance in mathematics (i.e., “low” and “high”) that typically determines their placement into groups. We explore research that articulates how this cultivates a “fixed mindset,” or notion that people are born smart, or either as a “math person” or not a “math person” (Boaler, 2016; Dweck, 2006). Candidates also learn how tracking results in disparities in educational experiences as students in “lower” tracks often receive lower-quality instruction (Gamoran & Carbonaro, 2002), which can result in students giving less effort to their academic work in comparison to students in “higher” tracks (Carbonaro, 2005). Further, research has suggested that students have very little chance of moving to a different track throughout their K-

12 schooling (Dixon, 2002). All of this, candidates understand, has significant implications for students' long-term academic outcomes (Hoffer, 1992), as well as their levels of anxiety and confidence (Butler, 2008). Alternatively, candidates learn, that when students are not placed into tracks and heterogeneous grouping is utilized, assumptions about student ability and expected performance are less prevalent. Hence, students are more likely to have a growth mindset (Dweck, 2006) about their ability to do mathematics (Boaler, 2016), perhaps explaining why the use of heterogeneous grouping has been positively linked to academic achievement and the probability of completing advanced mathematics courses (Burriss, Heubert, & Levin, 2006). Through learning about this research on the use (or not) of tracking, the realities of deficit-based thinking become clear to teacher candidates. Then, by discussing the ways in which deficit perspectives differentially and negatively influence students from marginalized communities, as tracking practices tend to segregate by race and class (Oakes, 1990) even when we control for assessment data (Stiff, Johnson, & Akos, 2011; Faulkner, Stiff, Marshall, Nietfeld, & Crossland, 2014), candidates become more aware of systemic racism and the tangible effects of deficit versus assets-based thinking.

We have some evidence to suggest that teacher candidates' experiences in our program push them to develop a more assets-based perspective of elementary children. As a part of large, longitudinal, evaluative study of our program, we have systematically collected data on our teacher candidates' evolving perspectives on why children living in poverty tend to do less well in school than children from middle or upper class backgrounds. By asking this question to a subset of our candidates during interviews at three time points of the program, the resulting data indicates that they may move away from deficit perspectives of children living in poverty. For example, at the beginning of the program, the candidates tend to focus on what the students do not have, often placing the blame on the parents:

I think it has a lot to do with the parents. I think lower income generally the parents aren't as involved because for one they're usually working more because they don't have as much income.... Also, there's probably a lot of low-income people who didn't go to college and didn't grow up valuing education, so they can't pass that onto their child.

As they progress through the program, their perspective tends to shift to blaming either societal structures or teacher biases for why children in poverty tend to do less well in school. For example, one teacher candidate, near completion of the program, focused on the inequity of the structure of funding and resources when she said, "I think that a lot has to do with resources, the kind of the schools that typically are in that area and who, what kind of teachers they attract." Another candidate's rationale centered around teachers' expectations: "I think the biggest [reason] is the stereotypical expectations that teachers apply....to children who come in with less money." This candidate, among others, emphasized that teachers tend to have biases that naturally impact their expectations of academic performance of students living in poverty.

Looking at tracking through this socioeconomic and racial lens can also be leveraged as a tool to motivate teacher candidates to take an **inquiry stance** toward their biases and stereotypes. First, teacher candidates can examine their own experiences with tracking in school and analyze whether they were privileged or neglected by these practices and how this reflects the research on the ways in which race and class are manifested in tracking practices. From there, teacher candidates must be encouraged to critically analyze their own assumptions, biases, and misconceptions about who is "good" at mathematics and explore further where they developed

stereotypes and biases and how this influences their relationships with students and their families.

A discussion of tracking also provides an opportunity to explore the **socio-political context** of teaching and schooling. A critical analysis of the ways in which tracking translates individual bias into systemic inequality provides a framework through which to look at the myriad of ways in which schools have the potential to perpetuate (i.e., unequal funding, segregation, ethnocentric curriculum) or interrupt cycles of inequality (i.e. culturally relevant pedagogy, multicultural curriculum, integration programs). Further, an exploration of tracking in mathematics provides an example of the degree to which teachers have agency in their classrooms. Even as our candidates learn about the negative outcomes of ability tracking, they too often complete their student teaching in schools where tracking occurs, given the pervasiveness of these practices. If we are to assume that teachers are neither evil nor ignorant, investigating why teachers continue to track (e.g., it is easier, it is required by the school, it makes parents happier), we can address the multiple pressures put on teachers' time and practice. As teacher candidates come to understand the socio-political nature of teaching, approach the work with an inquiry stance toward themselves, and view their students with an assets-based perspective, there are simultaneous efforts to develop their methods, strategies, and skills to have a justice-oriented approach to education in the STEM disciplines.

Methods, Strategies, and Skills

Cochran-Smith (2009) explains that teaching *methods, strategies, and skills* that support social justice are anchored in *guiding principles* rather than specific techniques or best practices, including the ability to: **develop caring relationships** with students (Witherell & Noddings, 1991), provide **culturally relevant content and pedagogy** (Ladson Billings, 2009) for all students, include English language learners and students labeled "at risk" (Oakes, Rogers, & Lipton, 2006), and make the development of students' **critical consciousness** an explicit part of the curriculum. Science methods courses provide multiple opportunities for preparing candidates to educate *all* students in science, emphasizing the relationship between science education and public engagement in science.

In order for candidates to learn to connect science with all students, they must first learn to **develop caring relationships**. Again, learning to teach science can support this process. Our candidates spend time in multiple classrooms in partner schools that have been intentionally selected to offer candidates, among other things, experiences with a diversity of student populations. During science methods courses, candidates explore issues related to science and make connections with how current events related to science impact children's lives. In addition, candidates interview children about their everyday science content understandings. The interview allows candidates to examine cultural influences that children bring to the classroom and to connect both personally and academically with children. Such experiences emphasize candidates' and children's shared interactions through science engagement. During data collection in the aforementioned longitudinal, evaluative study of our program, one candidate explained a student's enthusiasm about sharing his learning in science using drawings; "He was so excited to share and you could see how special that was to him." This candidate's realization of the process students go through in learning science, instigated within her an emotional understanding of, and connection to her student. She explained her realizations, "Kids are so curious...they want to know how things work, they want to know the science behind things." She

acknowledged that as she learns more about science education, she and her students will begin to discover science together.

Some candidates enter their teacher preparation programs with an admitted aversion to science and mathematics. These aversions may stem from past personal experiences with science instruction or cultural/family disconnections with science, yet science methods classes are fertile pathways for sharing the **cultural relevance of science content and pedagogies**. By creating a safe space for candidates to share their aversions and describe personal pathways toward connecting with science content, such relationship building helps candidates envision the importance of presenting culturally relevant science content in order to see themselves and their future students engaging in science.

Throughout our program, candidates are asked to reflect on the degree to which science was made relevant to them as students. Often a lack of relevance can be connected to commonly held stereotypes of scientists as White males. To counteract these stereotypes, candidates consider the contributions of scientists of various ethnicities and genders such as environmentalist Rachel Carson, botanist George Washington Carver, and physicist Shirley Ann Jackson, modeling practices for empowering children to build personal connections to scientists from shared ethnic or racial backgrounds. Additional course readings ask candidates to examine how students in low-income urban areas use and identify with science (Basu & Calabrese Barton, 2007; Tan & Calabrese Barton, 2010), thus expanding candidates' vision of science beyond a focus on careers in science. Moving away from science education as solely preparing students for the "pipeline" to careers in science, Feinstein, Allen, and Jenkins (2013) emphasize the role of science education for arming "competent outsiders" (p. 314) with the skills to navigate issues for everyday engagement in science.

In addition to exposing candidates to diverse populations of scientists and the plethora of science that surrounds us, Cochran-Smith (2009), Ladson-Billings (1995; 2009), Reich (2002), and many others recommend teaching practices that foster the development of critical consciousness, or the creation of safe spaces to identify and openly discuss topics of equity/inequity and respect/disrespect for individuals and social groups. Science methods courses, for example, can help build teacher candidates' **critical consciousness** and understanding of the "social function" of knowledge (McLaren, 2009, p. 63), or how knowledge can and must be used to interrupt systems of inequality (Freire, 1971). More importantly, they can develop the skills to incorporate opportunities for their future students' critical consciousness into their curriculum and practice. Candidates in our science methods courses, for example, discuss the civic purpose of scientific inquiry and the contributions of science literacy to inform voting practices. Societal issues such as the public water crisis in Flint, Michigan illustrates how understanding of science issues informs public decision-making. Science methods courses are also an ideal space for candidates to learn the ways in which knowledge, including rigorous scientific inquiry, can be used to understand and address systemic inequality. Environmental justice issues such as the absence of grocery stores in communities experiencing poverty or the propensity of landfills near high-poverty communities inhabited by racial minority populations illustrate the connections of social issues with areas of science such as chemistry, ecology, climatology, and geology (Bigelow & Swinehart, 2014; Dimick, 2012). Further, by learning about social entrepreneurship or "eco-justice" in the STEM fields, or about the ways in which advances in the sciences or technology have provided solutions for social ills, candidates can imagine how to help their future students apply their STEM knowledge to issues of inequity and navigate issues connected to their lives.

Engineering design also lends itself well to simulation activities that help young learners explore contemporary issues. In their current social studies methods course, for example, candidates participate in an engineering simulation to interrogate the effects of economic inequality. Adapted from a lesson written by Bill Bigelow (2002), students work in groups with differential amounts of materials with which they must build the tallest tower. While participants struggle with limited materials or excel with excess materials, the professor presents the rhetoric of meritocracy; “If you work hard you can win,” and “Your success is entirely up to you.” In the debrief, candidates reflect on how their experience mirrored the reality of the current socio-economic context. Moving from identifying the ways in which science and engineering can serve the development of critical consciousness, we begin to empower candidates toward envisioning how STEM knowledge can support analysis, action, and advocacy.

Advocacy

Finally, Cochran-Smith (2009) explains, candidates should develop a sense that it is within their scope of responsibility and in their best interest to conceptualize themselves as *advocates* and work alongside their students and community in order to contribute to systemic change in education and society. Again, STEM courses can support this process. As candidates learn about inequities, they can simultaneously use their burgeoning expertise to engage in the creation of solutions. Currently, one of our faculty members facilitates a tutorial support service within the Latino/Latina community in which our candidates are trained to serve as literacy tutors for children who attend an afterschool program. It could be a powerful addition to provide tutorial services in STEM fields in centers such as this in communities where STEM is not being adequately addressed in schools. In doing so, it would not only provide a service of increasing access to resources, but also give candidates the experience of working towards change in collaboration with communities.

Candidates must also learn that social justice advocacy goes beyond providing charitable services (Westheimer & Kahne, 2004), and includes working alongside members of the community to advocate for more equitable policies. Again, by analyzing tracking and the socio-political context within which this happens, candidates are provided further opportunities for advocacy. Specifically, after discussing how the school, local, and national context contribute to the practice of ability grouping, candidates could and should discuss what it would look like to influence systemic change beyond their classrooms. In our current program, candidates learn directly from a teacher who has successfully advocated for a school-wide policy for the end of tracking and the start of heterogeneous grouping. Candidates further learn directly from a local teacher who has collectively developed a social justice caucus (Organize2020) of the state teachers’ union to enact the Schools Our Students Deserve campaign to challenge privatization, segregation, and the defunding of public education.

In addition, in the diversity seminar, candidates begin to imagine themselves as advocates through discussions of how to shift the school, district, state, and federal practices and cultural norms that perpetuate tracking, segregation, and systemic racism. For example, we discuss the possibility of writing OpEds, speaking at school board meetings, working alongside students and parents to lobby for policy change, and pulling in the media to positively represent what is happening in their classrooms especially when they are teaching in schools serving students from marginalized communities.

Further, in their analysis of how to use STEM fields to develop students’ critical consciousness, as described above, candidates are provided with another opportunity to explore

means by which they can work alongside communities to initiate systemic change. Through an investigation of environmental injustice, for example, candidates can explore what communities are already doing to address these inequities and explore ways in which to further collaborate and work collectively in the pursuit of justice.

Looking Forward

Having both a STEM and social justice mission can be a complicated task. If both of these goals are to be taken seriously, they cannot be treated separately. Yet, as we hope we have begun to illustrate, through a reframing towards justice-oriented STEM, there is room to use the individual disciplines and integrated STEM for the purpose of developing much of the content and capacities necessary for social justice education. In doing this, however, there must be a fundamental shift in the purpose of STEM from preparing individuals for competition in a global market to preparing citizens who understand and are capable of using their STEM skills towards the alleviation of inequity in service of the common good. Without this shift, STEM education will, at best, provide individual students with potential access to an unequal labor economy without fully preparing them to transform the structural inequalities that plague our society.

There are, of course, many challenges in developing a justice-oriented STEM program. A primary limitation, we have noticed, is that our candidates enter our program with a lack of awareness of issues related to systemic inequity and injustice. This is exacerbated by the nature of teaching in North Carolina, where teachers are not highly compensated and subsequently, it is difficult to recruit students of color who potentially bring a level of cultural awareness and justice orientation (Cochran-Smith, 2009). In addition, given the decreasing support for teacher education programs and the rise in alternative credentials (Kretchmar, Sondel, & Ferrare, 2016; Zeichner & Pena-Sandoval, 2016), to remain competitive, it would be difficult to expand the length of our program. To that end, it would help justice-oriented STEM programs to require students to take courses related to sociology, public policy, and anthropology as a part of their general education requirements.

In addition, even as there are many highly competent teachers in our county, it is difficult to identify mentors with whom our students can observe and participate in both high-quality STEM and social justice education. To that end, for a justice-oriented STEM program, supervision of field placements should incorporate opportunities for candidates to engage in deep reflection on their classroom observations and include attempts to incorporate justice-oriented STEM experiences alongside university personnel (Zeichner, 2009).

As a department, we are not yet fully engaged in justice-oriented STEM teacher education; however, we remain hopeful given that our department is committed to these aims. Our next step in continuing to move towards this approach is in using this article, along with the Cochran-Smith's vision from which we draw, to create a systematic evaluation of and re-imagining of our program. We hope that other departments with similar aims will be inspired to do the same.

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