

MARIA S. RIVERA MAULUCCI AND KASSIDY T. FANN

6. TEACHING FOR SOCIAL JUSTICE IN SCIENCE EDUCATION

Helping a New Teacher Develop a Social Justice Identity

INTRODUCTION

In January 2013, I wrote following response to Karen's schooling autobiography.

Dear Karen,

What I love about stories like yours is that they make me so hopeful, that we do know how to create good schools that get results. However, results schools obtain are not due solely to schools, but also to the range of supports available in the home and the community. The challenge becomes how we transfer what we already know to places where the challenges are greater, and the supports are fewer. Nevertheless, I am hopeful. I am so thankful for your enthusiasm for teaching, and I look forward to working with you on this part of your journey of becoming a teacher! The challenges are many, but I know you are equal to them!

PR [Prof. Rivera]

Karen is a White, Female, Physics major, and a product of excellent public schools. In her schooling autobiography, she writes about the opportunities she had to learn science and to excel in schools that served culturally diverse, but affluent students and, at the time, 95% of the students in her elementary, middle, and high schools achieved proficiency on the state English Language Arts and Mathematics exams. Karen enjoyed supportive teachers in school and numerous community-based activities, including Girl Scouts, soccer, swimming, dance, horseback riding, musical theatre, and diving after school. Her K-12 success positioned her to complete a major in Physics and her degree requirements with a better than 4.0 grade-point-average in three years. During the fall semester of her junior year, Karen enrolled in Science in the City, a science content and pedagogical methods course. At the time, Karen planned to graduate early and was taking the course as an elective. Her decision to enrol in the course marked the beginning of her journey of becoming a science teacher and taking on the identity of a social justice educator.

TEACHING FOR SOCIAL JUSTICE IN SCIENCE EDUCATION

I have defined socially just teaching as an ongoing struggle for more caring, equitable, and agentic schooling at the classroom, school, and community levels (Rivera Maulucci, 2013). Thus, teaching for social justice involves being able to evaluate teaching and learning situations, to imagine how they could be better (more caring, more equitable, more agentic), to develop and implement new plans, and to reflect on the relative success of those initiatives. At the same time, Western science has traditionally excluded many groups, such as women and students of color, and traditional ecological knowledge. Thus, from a justice perspective, teachers must also explore the nature of science and how to mitigate existing barriers to students' engagement and achievement in science. In this chapter, we explore Karen's development as a social justice-oriented teacher during three field/seminar experiences: Science in the City in the fall of her Junior year, Seminar in Multicultural Pedagogy and Urban School Practicum in Spring of her Junior year, and Student Teaching during the Fall of her Senior year. In describing her identity development, we primarily focus on the notion of a role identity since we mainly explore how Karen takes on the role of a social justice teacher, rather than her sense of belonging to a group of social justice educators. According to Stets and Burke (2000), "Although it is important to examine how a person categorizes herself or himself as a member of a group, it is also important to observe the role that the person enacts while a member of the group" (p. 228). Furthermore, as a preservice teacher, it is more accurate to focus on Karen's process of *becoming* a social-justice oriented teacher, rather than her *being* a social-justice teacher. This process included learning about the importance of being a social-justice oriented teacher and accepting those ideals as vital parts of her professional identity. In addition, becoming a social-justice oriented teacher involved gaining an appreciation for how students need opportunities to discover and to develop as agents of change in their community even in the seemingly right/wrong, correct/incorrect world of science.

Interrogating Science

In the Science in the City seminar, we begin with an activity, "What is Science?" I ask the preservice and inservice teachers to draw or write about what they think of when they hear the word, science, a high point or low point in learning science, or where they see science in their communities. The purpose of the activity is to help participants excavate their notions of what science is in light of what other students and teachers in the class have to say about science. Then, they go home and read about the nature of science from a variety of perspectives (Bell, 2007; Costa, 1995; Barba, 1997) and write an essay that reflects upon what they drew, what it means, and how the readings are shaping their views of science.

For Karen, the essay became a space to share that her views of science education were radically shaped by a family member's traumatic brain injury that left no

memories of the family or the world. Like a child, her family member had to relearn the names for everyone and everything, as well as the why of everything. To Karen, “Children are natural scientists, asking questions and wondering about the world around them.” (What is Science?) Karen argued,

We too often forget that every science question a child asks at one time did not have an automatic answer among collective society. The answers that adults pass on to their children as facts are a result of many years of scientific discovery, investigation, and debate. (What is Science?)

Karen explained that it was important to recreate those discoveries so that children can see science as more than just a body of knowledge but as “an array of processes, assumptions, and values” (Bell, p. 14). Other points from the readings that resonated with her were the importance of changing the ways that “[science classes] allow less room for creativity and self-expression and seem less personally relevant” (Costa, 1995, p. 321) compared to other subjects, and how “[the Eurocentric] view of the history of science excludes the contributions of many culturally diverse individuals and groups and deprives children of vitally needed role models” (Barba, 1997, p. 56).

Interrogating Science Pedagogy

As part of the seminar, Karen collaborated with an inservice teacher, Etta, and another preservice teacher, Raul for her fieldwork. Etta, a Black, progressive teacher, had been a science specialist at the school, but this year, she was teaching a mixed-grade, third-fourth grade class. Raul, a Latino, male, music major, from the Midwest, was planning to obtain his elementary teaching certification. The school served a predominantly Black and Latino/a student population (75%), 61% of students were eligible for free or reduced lunch, and about a third of the students had Individualized educational plans. The school had an A rating on its School Progress Report since it scored better on measures of preparing “students for college and careers, school organization and management, and quality of the learning environment” than 94% of other elementary schools (NYCDOE, 2013). The Quality Review Report commended the school’s implementation of a “well-differentiated curriculum aligned with project-based learning [that] gives the students the opportunity to undertake research and be highly active learners” (NYCDOE, 2013).

Karen observed and participated in mathematics and science instruction two periods a week at the school. At this stage, her sense of justice was primarily concerned with what students should know and be able to do in these subject areas. Her early journal entries highlighted the exploratory, open-ended nature of the activities that the teachers designed to build students’ observational skills and incorporate student-driven investigations. For example, in one investigation the students were exploring shadows using a board with a clay structure in the middle and a flashlight. The students had to discover how they could make the shadow bigger or smaller or

change the shape of the shadow. In another science lesson, students went outside several times during the day and drew shadow plots to document how the shadow of their object changed over time as the position of the Sun shifted. In class, students measured their shadow plots and had to determine what time of day had the longest and shortest shadows. In a follow-up activity, they challenged the students to use a flashlight to recreate the shadows formed by the shadow plots. Karen noted:

I probably would have modified this time a bit and made it a bit more structured. The students have already explored with flashlights and the movement of shadows, and I would have liked them to figure out how to: 1. Rotate the shadow; and 2. Lengthen or shorten the shadow. I think several students figured out these concepts on their own which is great, but I noticed a good number of students were still using guess and check methods and moving the flashlight in any number of ways before the shadow lined up. This was also clear in the discussion time when they could not explain how they made their shadow line up. (Practicum Journal, 10/23/12)

Karen also noted that the activity could support a common student misconception about the Sun and shadows. She explained, “One problem with this investigation is that because we were still using flashlights, the light source moved. In reality, the sun does not move and instead the earth is the one rotating” (PJ, 10/23).

In a later assessment lesson, the students received drawings with the Sun and an object, and they had to draw the shadow that would form. Karen noted,

One of the main things I noticed was the shadows being upside down... I interpret this as a lack of detail-oriented observation or rushing through something. We are trying to incorporate a lot of observation into their science experiences and maybe we should try to focus a bit more on details and careful observation. (Practicum Journal, 11/13/12)

By the end of the seminar, rather than graduating early, Karen decided to stay in college for an additional year to enrol in our teacher education program and prepare to become a high school Physics teacher. In reflecting on her learning in the course, she wrote:

One of the major changes to my understanding was recognizing the severe Western influences on current science curricula and how detrimental that is to a program. By feeding the students facts that are currently accepted in the modern Western culture, we have concealed all the history, challenges, and questions that go along with that scientific concept. After working with the students in the classroom, I see the importance of student interest and student-driven learning. (Final Reflection, 12/5/12)

At this point in her journey of becoming a teacher, Karen did not yet realize how many people self-identified as “non-scientists.” She also thought that almost all science classrooms started with student-driven questions because this was the only

TEACHING FOR SOCIAL JUSTICE IN SCIENCE EDUCATION

science teaching she had known. However, by observing in the elementary classroom, she saw different kinds of lessons and she noticed how student engagement could change drastically depending on the style of the lesson, not just the content. At the same time, Karen wondered how this approach would translate to a “more structured high school Physics curriculum where there are right and wrong answers” (Final Reflection, 12/5/12). She wrote:

I hope to keep an open mind and work on my ability to make the information accessible to a variety of students with different learning styles. I also hope to show my students that science is always in flux. Our understanding is always incomplete, and improvements can and should always be made because those discoveries will hopefully improve the quality of life for generations to come. (Final Reflection, 12/5/12)

The science methods course provided an opportunity for Karen to begin reflecting on her understandings of the nature of science, how students can and should learn science, and to begin to apply her developing ideas to her goals of becoming a high school Physics teacher. She begins to discuss some of the trade-offs that she expects will happen when she exchanges the relative freedom of an elementary science classroom, in which the focus could be on students’ interests and student-driven learning, for the more rigid structure of a high school science curriculum. Nevertheless, she articulates a clear desire to avoid teaching science as a body of knowledge, in favour of teaching science as a set of processes and a body of knowledge that are in flux. In the following section, we explore her development during the pre-student teaching methods and practicum courses.

GROWING IN SOCIOCULTURAL AWARENESS

In spring 2013, Karen enrolled in the Secondary Multicultural Pedagogy and Urban School Practicum courses. In these co-requisite courses, we focus on specific pedagogical approaches designed to meet the needs of all learners. Five key domains structure the learning process: learning about self, students, content standards, constructivist and culturally responsive pedagogy, and the urban school context. Preservice teachers continue to excavate how their schooling experiences frame their vision and philosophy of teaching and learning. They learn about the needs, interests, cultures, and capacities of urban students through field observations at a local public school for 6 hours a week and course readings and discussions. They review and critique content area standards, highlighting what aspects of the standards align with their vision and philosophy of teaching, what goals they have for students that go beyond the standards, and how they might use the standards as a tool for promoting equity and social justice. They explore constructivist and multicultural approaches to teaching and learning and design and teach lessons to their peers drawing on these approaches. Finally, they examine the array of constraints and possibilities afforded by urban school contexts.

We title this section, “Growing in Sociocultural Awareness,” because much of the work requires preservice teachers to engage in an open exploration of the ways in which their experiences in and out of school and their worldviews are not universal, but are shaped by their unique life experiences (Villegas & Lucas, 2002). Preservice teachers who have been successful in mainstream schools may have difficulty understanding why students in high-need schools do not seem to value education as they did. They may hold deficit notions of students related to race and class biases (Valencia, 1997), grounded in beliefs that the United States is a meritocracy and that student success relies solely on individual talent and effort (Alon & Tienda, 2007). A sociocultural perspective begins to unpack these myths and explore the ways in which schools and their approaches to content and pedagogy may function to reproduce social inequality (Valenzuela, 2002; Villegas & Lucas, 2002). As preservice teachers gain awareness of the opportunity gap, or the ways in which differential access to opportunities to learn creates the achievement gap (Rendón, 1997), they also must grapple with what their role can and should be in transforming students’ opportunities to learn. Villegas and Lucas (2002) refer to this process as taking on a view of “teacher as agent-of-change.”

As part of the Urban School Practicum, preservice teachers complete a minimum of 60 hours of fieldwork in a local public school. During their observations, they keep a journal in which they document their experiences and record data from interviews with students, teachers, and administrators in the school. The field notes are used to prepare formal journal assignments in which they examine and evaluate evidence of implementation of the Common Core Standards, culturally responsive pedagogy, and how the school and teachers meet the needs of students learning English and students with special needs. Karen was assigned to a Grades 6–12, high-performing, STEM-focused school for her observations, and she primarily observed the ninth grade Physics class.

During the practicum, preservice teachers primarily serve as observers, and most of their reflections on life in the classroom revolve around what they would or would not do as teachers. For Karen, her reflections spanned how she would engage or promote student interest, how she would have students explore and develop content and process knowledge, and how she would have students work through problem sets in a high school Physics classroom. For example, across her early weeks of observations, Karen identified several strengths in Mr. Gordon’s practice that resonated with her beliefs about teaching, including how he led by example and modelled the behaviour and methods that he expected from students.” She explained:

Mr. Gordon also collects his own data and analyses it on the smart board as a model for how the students are supposed to manipulate and think about their own data. He is careful not to do everything out for the students and he is constantly eliciting student involvement by asking many questions and having the students draft their own central questions and steps to solve problems.

One instance that particularly impressed Karen was when Mr. Gordon was having difficulty keeping the students focused. He told the students, “As the teacher and classroom manager, it is my responsibility to make sure you learn this information and I would like some suggestions from you all on how we can make this work better.” According to Karen, by stopping the lesson and calling students attention to the ways in which they needed to be part of the solution, he gave the students “a chance to be aware of their actions and do something about it.”

Often, issues of context arose, such as how Mr. Gordon handled the New York State High School Regents exam, the impact of Common Core Standards, or issues of school culture. For example, Karen explained:

This is Mr. Gordon’s second year teaching Physics at CSS-MSE and he says that this year he is focusing more on the curriculum material that goes with the state standardized tests because his students did not do as well as he was expecting last year on the Regents. He describes his classroom last year as being a place of discussion and conversation about Physics but this year it is more lectures, worksheets, and problem – solving based. Professor Gordon is a bit disappointed by this shift because he has students that ask some very deep and creative questions about Physics. In order to not get behind schedule, he must cut some of these questions and conversations short and continue with his planned lesson but he worries what that does to the students’ creativity and interest in the subject (Portrait of an Urban Classroom).

These issues of context are important for understanding how school policies or practices might function to reproduce or transform social inequalities. In this case, Karen notices how the pressures of the high-stakes standardized test have changed Mr. Gordon’s approach to teaching and learning at the expense of student creativity and interest.

Karen’s reflection on culturally responsive pedagogy demonstrated her growing sociocultural awareness. She began her reflection with a description of the Chemistry lab, which unlike the other labs in the school, was a “real” lab:

...this classroom is in the basement of the building and has all the sights, smells, sounds, and feels of a real Chemistry Laboratory. There are glassware racks on the wall, a fume hood, sinks and faucets for water and gas, and even an emergency safety shower. When a student walks into this room, it feels fundamentally different from the rest of the school. When I first walked into the Chemistry lab/classroom, I even felt compelled to check if I had on closed toed shoes. (Description of a Lesson: Culturally Responsive Pedagogy Reflection, 5/2/13)

Karen’s description conveys her familiarity with the physical and cultural norms of a real Chemistry lab. At the same time, she recognized the ways in which as comfortable as she was in this setting, it could have positive or negative effects on students. She wrote:

Students may feel more motivated and ready for science in this setting, but other students may be intimidated by science and especially if they have developed a non-scientific identity, this classroom is not a place where they will think they can succeed. (Description of a Lesson: Culturally Responsive Pedagogy Reflection, 5/2/13)

Later, she reflected that despite a well-structured lesson, the student with special needs that she was shadowing for the day was, for the most part, disengaged. Karen noted,

Martin is mainstreamed and because of this, there are high expectations, and the work is challenging. This is a great thing if there are supports in place to allow him to face and conquer the challenge, but it seems to me that Martin more often feels stupid or unable to face the challenge. (Portrait of a Student with Special Needs, 4/13/13)

By shadowing Martin, talking to him about his family background, and helping him complete a writing assignment, Karen became convinced that his teachers were unaware of his strengths and the types of curricular adaptations and supports that would help him achieve. She explained:

He very much needs to talk out his response before he begins writing, but it is also a balance of how much to say before he writes something down. For the first question, I gave him the strategy of writing out a few bullet points of what he wanted to include in the answer so he could go one by one when he was writing. This helped him, and I was really excited when on the last question he used this technique without me saying anything. (Portrait of a Student with Special Needs, 4/13/13)

She also noted that some of his difficulties seemed to be related to language proficiency. The insights she developed about Martin's difficulties in school are important because they show that rather than holding deficit views about Martin due to his lack of engagement and participation in class, she was able to take a resource perspective and note how teachers were failing to tap into his resources and provide the types of supports that might actually help him achieve. Most of the students in Martin's school are high-performing students. In 2012, 92% of students performed at levels 3 (meets standards) or 4 (exceeds standards) in English Language Arts exams and 97% of students performed at levels 3 or 4 in mathematics. However, Martin, a Latino male, was left out of this pattern of achievement. We purposely have preservice teachers shadow a student learning English and a student with special needs to help them construct productive, nondeficit ways of thinking about the problems of practice that particular students may present to teachers and schools. An expanded sociocultural awareness allowed Karen to see the broader contextual factors that contributed to Martin's disengagement and underachievement in school.

CONSTRUCTING AND ENACTING A PRELIMINARY SOCIAL JUSTICE
VISION OF SCIENCE TEACHING AND LEARNING

As students work out problems of practice in their field placements, they also have opportunities to engage in lesson planning and to teach two mini-lessons to their peers. The mini-lessons provide preservice teachers with opportunities to synthesize their learning about critical (Freire, 1977) and multicultural pedagogy (Banks, 2008), constructivist teaching (Brooks & Brooks, 2007), meeting the needs of students learning English (Echevarria, Vogt, & Short, 2010) and meeting the needs of students with special needs (Rose, Meyer, Strangman, & Rappolt, 2002). By enacting their developing visions of teaching and learning, preservice teachers can develop stronger linkages between theory and practice, and through peer feedback, self-reflection, and instructor feedback; they can analyze their performance and set goals for improvement.

Karen's mini-lessons highlighted constructivist approaches to teaching Physics and an awareness of some of the common misconceptions students might have:

This lesson is an opportunity for students to bring their prior knowledge and see some of their conceptions (and misconceptions) of the world play out. Most people do not bring very much attention to the concept of falling objects. Everyone can predict that an object is going to move down when they let go (and not float upwards) but most students are not able to articulate a clear reason. I wanted students to explore these questions in groups and practice some basic experimental and data collection procedures. (Multicultural Reflection, Falling Objects Lesson Plan)

Karen envisioned this lesson as one that would occur towards the beginning of the year and she was using it to convey that the study of Physics in her class would include an exploration of everyday phenomena and that students would be developing knowledge through collaborative inquiry, data collection, and analysis. The lesson titled, "Falling Objects," began with direct instruction followed by a structured discovery lab. During the direct instruction part of the lesson, Karen asked students to define distance, time, and speed, to explain how they were measured, and to consider how distance, time, and speed might relate to each other. Then, she asked students how they could calculate average speed using a story problem. Although she described this part of the lesson as direct instruction, she did not lecture. Instead, she asked a series of questions and used students' responses to co-construct the definitions of each term and to solve the story problem.

Throughout the lesson, Karen's teaching decisions were designed to make Physics accessible to her students and to address common gaps and misunderstandings that might hinder student achievement. For example, she noted, "It is important that the students are comfortable with identifying these variables and connecting the problem information to the mathematical equation." Furthermore, she explained her emphasis on algebraic manipulations as follows, "Algebraically manipulating

equations is not a direct objective of Physics according to the New York State standards, but it will be very difficult for students to succeed if they are not comfortable with algebraically manipulating equations.” For the lab activity, she gave the following instructions:

In your lab groups of 3–4 students, you will be dropping three different balls of different masses. For each trial, one person will drop the ball, and two or three people will time. Because it will be fast, your data will be more accurate if multiple people time the drop, and then you average the results. You should have three trials for each ball. (Falling Objects Lesson Plan)

As each of the lab groups began working on the activity, what she did not tell them is that the groups would have a different assortment of balls to drop and different tools with either metric or standard units to measure the height of the drop. She explained her rationale as follows:

Units are a vital part of any scientific research. When the units do not line up, you are not able to compare the data. There have been several examples in history of mixed up units causing large and expensive disasters. When the data is in proper form, students should be able to identify patterns in the results and understand what the results mean. (Falling Objects Lesson Plan)

Although she was teaching this lesson to her peers, the lesson plan still had to include selected interventions for students learning English and students with special needs. In this area, Karen showed an ability to plan appropriate adaptations, but also to note how they might work differently with real students. For her lesson, one of her classmates, Bobby, volunteered to be a student learning English. Karen wrote,

I wanted the students to work in pairs so everyone could participate, and Andrea volunteered to work with Bobby, the ELL student. Andrea can speak Spanish, so they worked well together, and Bobby was able to communicate and participate fully. I know that ELL students need more scaffolding than simply putting other students who can act as translators with them, but this was helpful on Bobby’s “first day” in my classroom.

Other interventions that she included were choosing a couple of central keywords to focus on in the lesson and providing a guided notes worksheet. However, in reflecting on her lesson she noted that she could have provided more targeted supports,

In the next lesson...I would provide them with a glossary of terms and translations as well as guided notes that already have certain main ideas typed out. I plan on providing extra time and support when necessary to students when they need it, so they do not feel excluded or stupid.

Growth in sociocultural awareness must accompany growth in knowledge of pedagogical strategies that align with the problems of practice that preservice teachers encounter in schools. Karen notes,

TEACHING FOR SOCIAL JUSTICE IN SCIENCE EDUCATION

One of my main goals for learning more about teaching is learning how much to put into a lesson and how to build effectively on prior knowledge. One of my biggest challenges with microteaching was figuring out what to teach because my students had never actually been in my “classroom.” I did not know what they remembered, and I did not know what terms I could use. Although I feel that the activity went very well, I feel that my lesson this time was a bit thin and went slowly ...I want the learning to be student-driven, but students are not always the most engaged, especially at the beginning. I want to develop more skills and strategies to bring the students in and increase alertness so I can pick up the pace without leaving anyone behind. (Mediathread Reflection, Falling Objects Lesson)

A social justice orientation towards teaching requires preservice teachers to think deeply about what it means to help all students learn, what it means to hold all students to high expectations for learning, but also what it means to honour students’ ideas, prior knowledge, and goals. As Karen notes, this can be difficult when you are not planning for real students in the context of your own classroom. At the same time, taking on a social justice identity can be overwhelming. In her teaching philosophy statement written at the end of the semester, Karen wrote, “I have to believe that I can and will make a change in my classroom. I have to believe that I can learn from and teach the students and other teachers in my school” (4/26/13). Karen clearly articulates the goal of teaching for change, not just for the students in her classroom, but also for the other teachers in her school. She notes, “Although this positive attitude is going to be very hard to hold on to at times, it is the only way I will not crumble under the pressure of everything (and more) that we have discussed this semester.” In the context of Physics, a course that tends to exclude more than it includes, Karen especially hoped to motivate her students to learn. She wrote, “I hope that I will learn to somehow motivate my students to learn for the sake of learning. I want them to be motivated by their own thoughts and self-worth.” Nevertheless, at this point, she still genuinely thought that the most important thing she was teaching as a Physics teacher was the Physics. She was learning and accepting that other aspects of teaching needed to be there, but she still mainly focused on her subject.

REFINING A VISION OF SOCIAL JUSTICE TEACHING IN SCIENCE DURING STUDENT TEACHING

The student teaching semester provides preservice teachers with direct classroom experience in which to practice teaching with real high school students and the support of a cooperating teacher. Karen was assigned to an A-rated urban high school that served a predominantly Latino/a (65%) and Black (26%) student population, of which 79% were eligible for free or reduced lunch. Sixteen percent of students had Individualized Education Plans, and 4% were students learning English. During student teaching, she had the opportunity to observe in an 11–12th grade, Regents

Physics class with one teacher, and to student teach in a 12th grade AP Physics class with another more experienced teacher. In her letter to her cooperating teacher at the beginning of the semester, she wrote,

I do recognize that this process is not all about me. I will be responsible for real high school students and their education. Yes, there is a Physics curriculum, and I love solving Physics problems, but the real reason I am committed to teaching is because of the children.

Karen saw this semester as an opportunity to “go from a pretty good tutor and a decent stand-alone lesson planner to a real teacher.” She has experienced success with one-on-one tutoring and with lesson planning, but now she would be teaching real students.

As part of student teaching, students are required to keep a journal in which they record reflections on their experiences. Karen’s reflections often juxtaposed the challenges of the 11–12th grade class with the opportunities of the 12th-grade class. In the 11–12th grade classroom, students were just arriving in high school and still learning the ropes, whereas the 12th graders in Honours Physics had already demonstrated academic success to be placed in the class. In the third week of student teaching, Karen wrote,

It is interesting to go back and forth between the Regents Physics class and the honours Physics class because it is a different population of students, and the two classes are traveling at very different paces. I wonder if the Regents Physics class is so different because they actually need it to be that way or if we have too low expectations for those students. I wonder if putting a bit more pressure on the students and moving at a faster pace would encourage them to be more active participants in their learning compared to just getting by without putting forth much effort. (Student Teaching Journal, 9/23/13)

In Regents Physics, the teacher tended to simplify the concepts and teach tricks and gimmicks for solving Physics problems. In part, she relied on these measures because she was certified to teach Chemistry and was teaching Physics outside of her license. Thus, her understanding of the content did not have the depth that Karen brought to the class as a Physics major. At the same time, the Regents Exam that students had to take at the end of the year fostered a more “plug and chug” approach rather than teaching for understanding. On the other hand, the students in Honours Physics were preparing to take the AP Physics C, Mechanics exam; however, the students were not required to take this exam and not all students were planning to take it.

Across the semester, the justice issues that framed Karen’s experiences related to tensions regarding the goals and purposes of learning Physics. Karen wanted *all* students to learn, and she wanted them to learn *deeply*. Furthermore, she wanted the motivation to learn to shift from extrinsic pressures, such as grades or high-stakes exams, toward *intrinsic* desires to learn how Physics applies to everyday life.

She still had the belief that the Physics content was the most important thing to teach, rather than how to problem-solve or to explore historic scientific shifts in understanding. For example, in her sixth week, the 11–12th grade Regents students were learning about free fall. Karen wrote:

[The teacher] gave the lesson, and it was basically the same smart board file from last year's class. When I made my lesson, I saw this file and was not very impressed. There was nothing wrong with it, but I thought it was boring and lacked complexity. That is why I changed mine so much when I taught my free fall lesson...I know that these students are not as strong science or math students, but I think they still deserve the interesting historical application and modern day application that I am trying to build into my honours curriculum

Karen articulates a several critiques. First, she is concerned about the wholesale adoption of curriculum materials without any modifications based on the needs, interests, or cultures of the students. The 11–12th-grade students needed to be motivated to learn. The simple approaches to content lacked complexity and fostered boredom. Second, Karen had already taught her lesson on free fall. For this lesson, she had prepared a smart board file that included the historical context for the development of ideas about free fall (Lesson Plan, Observation 1, 10/8/13). She began with more naïve ideas held during Aristotle's time and then explained how later on, Galileo conducted experiments to test his ideas, and that he was regarded as the world's first scientist. Third, beyond her views about the efficacy of this approach to teaching, Karen also believed that students had a right to learn this more complex knowledge about the historical development of Physics and its modern applications. During the lesson, I witnessed how powerful this approach could be. In my review of her lesson, I wrote:

The historical context was great and helped establish the importance of the topic. You circled back to the historical context at the end of the lesson by noting that the final problem included extra information about mass, but mass never matters in free-fall problems, and that is what Galileo found out. (Collaborative Assessment of Observed Lesson, 10/8/13)

Karen's desire to help students see the everyday relevance of Physics was not lost on her students. During her third observed lesson, a student knocked a binder from the windowsill, and it made a loud noise. Another student called out, "Miss, was that work?" The whole class laughed. She then asked the student follow-up questions that led her to answer her question. I saw this as a great example of students seeing the relevance of Physics, but also feeling comfortable to ask questions, even if they interrupted the flow of the lesson. She handled it beautifully.

An important problem of practice that Karen grappled with was the role of science labs and their connection to the curriculum. The school had a single laboratory that had to be set up for labs across the curriculum and thus requests for materials had to be made in advance. The timing of the lab could not always align directly with the

curriculum and teachers did not have the flexibility to improvise by changing the available methods or materials. Despite these challenges, Karen experimented with a variety of approaches to Physics labs. Across her attempts, she noted, “The students have grown up with cookbook style labs and are often uncomfortable when I ask them to play and explore outside of their comfort zone.” She also stated, “I hesitate to say that a successful lab has every student on task the entire time because lab is all about discovery and discovery sometimes looks messy and a bit chaotic.” Finally, she changed her thinking regarding formal lab reports. She wrote,

I would rather challenge my students to think about their lab and answer thoughtful reflection questions where they have to extend their lab experience to something else we have been learning or connect it to something else in the real world. I do see value in having students write a formal lab write up when it is appropriate, but I also see value in being flexible and open to other formats of lab assessments and picking the one that best fits with the discovery that happens that week. (Final Reflection, 12/16/13)

According to Karen, using a variety of methods to assess labs would “also allow a variety of learners to appreciate lab and will not alienate certain students who struggle with completing and organizing a formal lab write up” (Final Reflection, 12/16/13). At the same time, Karen was gaining an appreciation for the distinction between real laboratory exercises and hands-on activities. She found that especially in Physics, students rarely do full-scale labs. Instead, they do activities that verify something and rarely discover something new. Nevertheless, she felt it was her job to have students practice genuine lab skills (writing a hypothesis, collecting data, analysing data, discussing error, and drawing specific conclusions) in these activities.

Another aspect of teaching for social justice involves a sense of urgency around issues of time. In general, teachers are always concerned about time and time management. However, when you work with students who have been traditionally marginalized in your subject and you deeply desire to resist this pattern; your sense of urgency around time may be heightened. During her 9th week of student teaching, there were two days in which most of the students in her honours Physics class were away on a senior retreat, so only the juniors were present. Rather than teaching a topic that she would have to re-teach when the seniors returned, she mostly played games with the remaining students or let them complete work for other classes. Although as a student teacher, she felt some peer pressure from teachers who were showing movies and not doing anything with their students, in her reflection at the end of the week, Karen reminisced about how her high school Physics teacher never gave them a day off from learning. Instead, he would plan a lesson related to the subject but not directly part of the curriculum. She wrote,

I remember one day, all the seniors were missing and he did a lesson on relativity and strange things that happen as you approach the speed of light...I remember sketching out the pictures and listening to his explanation of this

very high-level concept to intro Physics students. It was one of the lessons early in my Physics career that inspired me to become a Physics major...I thought back to that lesson on relativity and felt sorry that I had not put more effort into teaching an amazing lesson about something in Physics that could have inspired my students. (Student Teaching Journal, Week 9, 11/4/13)

In reflecting back on that moment, Karen sees it as one of her big, “missed moments” regrets that she has tried to learn from as a teacher. Thus, desiring all students to learn and the extent to which teachers achieve this goal also creates tensions for social justice-oriented teachers. Karen deeply regretted the outcomes for one student in the 11–12th grade Regents class. The student had managed to pass during the first marking period, but then she started slipping. She failed her quizzes and did not turn in her lab reports. After failing the second marking period, she was “100% disengaged.” Karen wrote,

She is in class every day, but she spends the whole period with her head down on the desk. She does not take any notes, and she does not try any of the classwork or homework. During lab, she sits with her lab group but does not contribute anything... School should not be a place of torture or wasted time but that is all this class is for her right now. (Student Teaching Journal, Week 12, 12/2/13)

Although this student was not in the class that she was student teaching, Karen still identified this problem of practice as one that she deeply wanted to solve. She wrote,

I don't really know what went wrong with this student, and I don't really know what to do now that it has gone so wrong. I would like some help on this topic because I want to try to avoid this when I have my own classroom. (Student Teaching Journal, Week 12, 12/2/13)

In my response to her journal, I talked about how it is important for teachers to recognize the early warning signs and to intervene before the student actually fails, and that it is important to discern the cause of disengagement, whether it stems from difficulty with the material or personal issues that affect the students motivation.

In her 12th grade class, Karen struggled to provide an adequate level of support and challenge for students with such varied prior preparation. She noted:

One of my biggest challenges this semester was learning how to read my students and gauge their understanding. My class was very diverse in their prior knowledge and experience with Physics. Some students have already taken Physics, and some students have already taken Calculus. Some students had no experience in Physics and Calculus...I have learned a lot about adapting lesson plans and teaching the whole group of students but I need to continue to learn more about my students as individuals and specifically design all my lessons with my students in mind. (Final Reflection, 12/16/13)

At the same time that she wanted to develop strategies to differentiate the curriculum, she also recognized the need for consistency. According to Karen,

Coming across as fair and consistent in your expectations and teaching will promote a positive learning environment in your classroom and foster respectful relationships between all members of the classroom. (Final Reflection, 12/16/13)

Two important dimensions of consistency that she identified were consistency over time and consistency between students in terms of behavioural expectations and grading. Thus, part of her social justice approach meant to attend to the ways in which students might evaluate the fairness of her approach and how their evaluations might contribute to, or detract from, the overall classroom climate.

By the end of the semester, Karen looked back on her experiences and was able to see how much she had changed. She wrote, “I realize looking back that...I have changed a lot and while nothing will ever fully prepare me for teaching my own class, I value this experience and feel that I can and will make a difference in my students’ lives” (Final Reflection, 12/16/13). Whereas at the end of methods and practicum, she wrote, “I have to believe that I can and will make a change in my classroom,” now, instead of needing to convince herself, she *feels that she can and will make a difference in her students’ lives*. The emphasis has shifted from changing her classroom to changing her students’ lives. Nevertheless, she still recognized the contingent and contextual nature of her positioning as a social justice teacher. She wrote,

There are many challenges for a first-year teacher, and I know that when I am teaching it will be difficult to remember everything I have learned this semester. Hopefully, I will be well equipped to make good decisions and, hopefully, I will be in a school where I am surrounded by a team of other teachers and administrators who will support me and help me continue to grow into a great teacher. (Final Reflection, 12/16/13)

Furthermore, by the end of student teaching, Karen began to realize that the Physics content was not as important as how students see themselves and how they think about the world. As a Physics teacher, she was certainly teaching them Physics, but more importantly, she was teaching them how to think critically and how to problem-solve. It just so happened, that she was using the context of Physics to do this.

TEACHING FOR SOCIAL JUSTICE IN SCIENCE EDUCATION

Across Karen’s journey, we see evidence of growth in sociocultural awareness across five domains of knowledge: self, students, science, pedagogy, and school contexts. With respect to self, Karen learned that her worldview, including her beliefs about school, science, and Physics, were not universal, but shaped by her particular life experiences. With respect to students, her opportunity to observe Martin, a student

learning English, provided a powerful example of how differences in social location across race/ethnicity, social class, native language, gender, or sexual orientation are not neutral. Also, she saw how schools might fail to respond to a student's particular needs for support, and thus exacerbate differences. Furthermore, she learned that science content and practices are not neutral. Instead, science is part of a culture of power that has traditionally marginalized girls and students of colour. Western science can have the effect of concealing important social and historical issues and circumstances that framed the development of scientific knowledge. Also, science teaching methods are not neutral but convey notions about what constitutes knowledge, how such knowledge should be taught, and the expectations for student learning. Lab exercises that focus on hands-on activities can obscure authentic scientific practices, such as asking questions, constructing hypotheses, planning and carrying out investigations, analysing and interpreting data, and drawing conclusions (NGSS Lead States, 2013). Finally, she observed how the school organization, availability of resources, policies, and procedures might function to reproduce or transform social inequalities. For example, the Regents exam was one contextual factor that deeply constrained her partner teacher's approach to teaching. Other aspects of school culture, such as what to do when some students are absent can convey messages about what is valued for students and their learning. This growth in sociocultural awareness was crucial to developing and refining a social justice orientation to teaching because it provided Karen with a rationale for why and how teaching for social justice mattered for her and for her students. In addition, growing in sociocultural awareness provided new meanings that she could attach to her teaching role identity. Science teacher education programs should attend to the ways in which they might help prospective teachers expand their sociocultural awareness across the five domains: self, students, science, pedagogy, and school contexts.

A NOTE ABOUT METHODS

The data for this study were gathered as part of an IRB-approved study to explore the impacts of our teacher education program on our preservice teachers' preparation for teaching. As part of the study, upon consent, copies of all student work in my courses were collected at the end of each semester after grades were submitted. For this chapter, we selected Karen as a case study because we had a complete case record for her from Science in the City through Student Teaching. A case study approach is particularly suited to answering questions about how or why (Yin, 2009) a preservice teacher might take on a social justice identity. There was only one other Science candidate in her cohort; however, she did not take Science in the City, and Maria did not supervise her during Student Teaching. According to Yin (2009), a case study, "investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13).

Data for this study included all Karen's coursework across the three semesters, observations of two lessons taught in the Secondary Multicultural Pedagogy Seminar,

and observations of three lessons taught during Student Teaching in Urban Schools. The data were compiled into a database, and analytical methods involved querying the database with the following questions: What are the key elements of Karen's developing social justice identity? How do these elements stay the same or change over time? What are the problems of practice that tend to frame the social justice issues that Karen notices in the field? How does Karen reflect on those problems of practice? How are the various learning contexts and activities supporting Karen's development as a social justice science teacher? Vignettes were coded, sorted, and used to develop the final report. This report was shared with Karen, and she had the opportunity to review the accuracy of the report and approve the final version.

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Maria S. Rivera Maulucci
Education Program
Barnard College, Columbia University

Kassidy T. Fann
Physics Teacher
Bedford High School