International Journal *of* Designs for Learning
2018 | Volume 9, Issue 1 | Pages 14-33

ADVANCING CULTURALLY RESPONSIVE SCIENCE EDUCATION IN SECONDARY CLASSROOMS THROUGH AN INDUCTION COURSE

Julie C. Brown[1], Elizabeth A. Ring-Whalen[2], Gillian H. Roehrig[1], & Joshua Ellis[3]
[1]*University of Minnesota Twin Cities;* [2]*St. Catherine University;* [3]*Michigan Technological University*

Culturally responsive science teaching has been associated with several positive academic outcomes for students of color, including improved science achievement, attitudes, and identities. Given the chronic science performance gap between students of color and white peers, culturally responsive teaching seems ideal for mitigating this disparity. Traditional teacher preparation programs, however, neither emphasize nor require multicultural science education coursework. Unfortunately, many science teachers exit preparation programs without critically examining their beliefs about culturally diverse students or increasing their confidence in working with them. In response to this concern, we designed a theoretically- and contextually-grounded induction course to support culturally responsive secondary science teacher development. The purpose of this four-week course was to engage beginning secondary science teachers (1-5 years of teaching experience) in activities, discussions, and reflections raising awareness of the importance of attending to attitudes about culturally diverse students, as well as abilities to incorporate students' backgrounds into science instruction.

Course goals included improving teachers': understanding of culturally responsive pedagogy (CRP); sociopolitical awareness and knowledge of their cultural identities; knowledge of and attitudes toward culturally diverse students, their families, and communities; critical reflection on classroom practices; and abilities to design culturally responsive science curriculum units integrating families' funds of knowledge and/or sociopolitical ties. In this paper, we share our design and implementation experiences, as well as teacher outcomes. Continued conversations between researchers, teacher educators, and others involved in advancing culturally responsive science teaching are crucial to the academic success of culturally diverse student populations.

Julie C. Brown is an Associate Professor of STEM Education in the Department of Curriculum and Instruction at the University of Minnesota, Twin Cities. Her research focuses on the development of culturally responsive science teachers in pre- and in-service contexts. She employs design-based research methods to construct, test, and revise empirically-grounded supports to foster teacher development.

Elizabeth A. Ring-Whalen is an Assistant Professor of Science Education in the Education Department at St. Catherine University in Saint Paul, MN. Her research explores teachers' beliefs of integrated STEM and how these beliefs influence teachers' practices and student achievement in the classroom, including the attitudes and beliefs teachers hold about cultural diversity and teaching culturally diverse students

Gillian H. Roehrig is a Professor of STEM Education in the Department of Curriculum and Instruction at the University of Minnesota, Twin Cities. Her research focuses on the transformative professional development to improve teaching and learning in K-12 classrooms, including mentoring and induction supports for beginning teachers and integrated STEM instruction.

Joshua Ellis is an Assistant Professor of STEM Education in the Department of Cognitive and Learning Sciences at Michigan Technological University. His research focuses on supporting pre-service and beginning in-service teachers through mentoring and induction supports. He designs online learning environments that provide these supports to teachers regardless of geographic location.

https://doi.org/10.14434/ijdl.v9i1.23297

INTRODUCTION

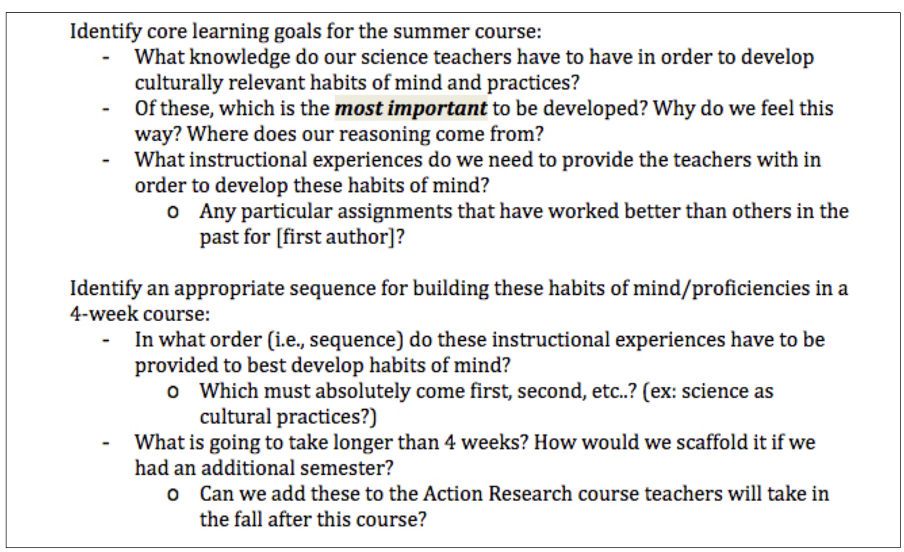
Science teacher educators face a significant challenge: preparing the next generation of teachers to enact reform-based science with an increasingly diverse student body in an era of accountability. Culturally responsive teaching, which uses "the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (Gay, 2010, p. 31), has been associated with several positive academic outcomes for culturally, racially, and linguistically diverse students, including improved science achievement, attitudes, and identities (Lee & Buxton, 2010). Given the chronic science achievement gap between students of color and their white peers, culturally responsive teaching seems an ideal tactic for mitigating this disparity. However, many prospective and beginning science teachers have had relatively little prior experience with ethnically and linguistically diverse people (George, 2013). As a result, though unfortunate, it is not surprising that many prospective science teachers exit preparation programs without fundamentally altering their beliefs about the abilities of culturally diverse students or improving their confidence in teaching them.

There is, however, a growing body of research that provides guidance on how to effectively prepare culturally responsive science teachers, be it through having teachers critically reflect on their own practices (Mensah, 2013a), actively participating as learners in culturally relevant science exemplars (Lee, 2004), or being supported through the curriculum design process (Brown & Crippen, 2016a). Despite this knowledge, similar to Hernandez, Morales, and Shroyer (2013), our team "struggled to find a unifying approach in teacher education to guide the preparation and assessment of culturally responsive science teaching" (p. 806). Examples from the literature are disproportionately situated in professional development programs offering more instructional flexibility and longer durations (e.g., Brown & Crippen, 2017; Johnson, 2011; Zozakiewicz & Rodriguez, 2007). Traditional teacher preparation programs neither emphasize nor require multicultural science education coursework (Ferguson, 2008). Moreover, most existing multicultural education courses deal only with pragmatic skills, not developing core elements in teachers such as sociopolitical consciousness and abilities to foster students' cultural competence (Gorski, 2009). In response to concerns of being underprepared to effectively teach science to culturally diverse students and a paucity of multicultural science education courses to draw from, our team designed and implemented a theoretically- and contextually-grounded induction course for beginning secondary science teachers (within 1-5 years of professional experience). This innovative course contained essential experiences for culturally responsive science teacher development not previously found together in the literature and sequenced them in accordance with theory on how teachers learn. In this paper, we report on our course design and implementation experiences, as well as science teacher outcomes. We now detail the larger context for the course and its enrolled teachers.

CONTEXT

Program

PREPScI (**P**romoting **R**eflective and **E**quitable **P**ractice through **S**cience **I**nduction) is a series of three, 3-credit graduate courses completed by secondary (grades 6-12) science teachers in their first years of teaching following completion of a 12-month post-baccalaureate teacher licensure program. The post-baccalaureate nature of the program ensures that candidates have a bachelor's degree in the content area in which licensure is sought. Admission requirements include content coursework equivalent to an undergraduate major, as well as a required science research experience. The entire post-baccalaureate program includes two components: the 12-month initial licensure component and the completion of a M.Ed. degree (i.e., the PREPScI course series). Students enter the 12-month initial licensure program as a cohort, completing coursework including a three-course science methods sequence with extensive, supervised practicum and student teaching experiences in addition to coursework in the history and philosophy of science, technology integration, and cultural context of teaching and


Identify core learning goals for the summer course:
- What knowledge do our science teachers have to have in order to develop culturally relevant habits of mind and practices?
- Of these, which is the ***most important*** to be developed? Why do we feel this way? Where does our reasoning come from?
- What instructional experiences do we need to provide the teachers with in order to develop these habits of mind?
    - Any particular assignments that have worked better than others in the past for [first author]?

Identify an appropriate sequence for building these habits of mind/proficiencies in a 4-week course:
- In what order (i.e., sequence) do these instructional experiences have to be provided to best develop habits of mind?
    - Which must absolutely come first, second, etc..? (ex: science as cultural practices?)
- What is going to take longer than 4 weeks? How would we scaffold it if we had an additional semester?
    - Can we add these to the Action Research course teachers will take in the fall after this course?

FIGURE 1. Screen capture of the *Design Decisions Report* where major course design ideas were kept.

schools. To complete the M.Ed. degree, teachers enroll in the PREPScI series post-licensure to earn the additional required 9-credits.

The PREPScI course series starts with a yearlong, online induction program, the Teacher Induction Network (TIN). According to Ellis, McFadden, Anwar, and Roehrig (2015), induction programs "support beginning teachers over time through professional development, mentoring, and collaboration" (p. 405). Through our design-based research approach, we have continually modified TIN to best support teachers' professional growth and develop reflective, reform-based practices. TIN incorporates the following primary components: individual reflective journals, small group Vexation-Venture activities (Johnston & Settlage, 2008), Professional Development Inquiries (Danielson, 2007), and video clubs. These components arise from an effort to provide teachers multiple affordances for developing their reflective and reform-based practices in an online learning environment (McFadden, Ellis, Anwar, & Roehrig, 2014; Roehrig, Donna, Billington, & Hoelscher, 2015). Notably, missing from TIN was a focus on equitable and culturally responsive science teaching. Thus, we added two courses with this important focus—the first is the four-week, face-to-face summer course that is the focus of this paper, followed by a 3-credit blended action research course that facilitates beginning secondary science teachers' investigations of their developing culturally responsive practices.

The four-week equity-focused PREPScI induction course took place during the Summer 2016 semester at a research-intensive university located in a large metropolitan area in the Midwestern United States. The first two authors engaged in course design, with the first author leading its design and the second author assisting the process. As a former secondary science teacher and a teacher educator with 9 years of experience developing equitable science teachers, the first author was the instructor of record for the course. The second author was the course teaching assistant. As a former secondary science teacher, she provided a perspective that grounded theory in the realities of classroom teachers. They met biweekly for three months prior to course implementation to discuss literature on culturally responsive science teacher preparation, consider specific experiences for the course that were literature-based but also sensitive to the needs of the teachers in the PREPScI course series, and to identify essential classroom artifacts teachers would need for the course. Course design ideas were recorded in an ongoing *Design Decisions Report* (DDR) kept by the first author. Figure 1 is a screen capture of questions and goals guiding our initial meetings.

Teachers and Their Professional Settings

Eighteen secondary science teachers participated in this course, all of who were licensed by the state and had been teaching full-time between 1-5 years at the time of enrollment (see Table 1). As undergraduates, all of the teachers majored in a science or engineering discipline, including Biology (50%), Physics (26%), Chemistry (8%), Biomedical Engineering (8%), and Mechanical Engineering (8%). Given their strong content backgrounds, teachers were qualified to teach in multiple science subject areas. Although their schools were located across multiple contexts, most taught in urban environments where they served students whose racial and linguistic backgrounds frequently differed from their own.

CHARACTERISTIC	% (N=18)
RACE	
Asian	5%
Biracial	5%
White	90%
GENDER	
Female	67%
Male	33%
YEARS OF TEACHING EXPERIENCE	
0 - 1	17%
2 - 3	58%
4 - 5	25%
GRADE BANDS TAUGHT	
6 - 8	50%
9 - 12	50%
CONTENT AREAS TAUGHT	
Biology/Life Science	33%
Chemistry	42%
Earth/Space Science	33%
Physics/Physical Science	92%
PROFESSIONAL SETTING	
Suburban school	22%
Rural school	11%
Urban school	67%

TABLE 1. Teacher demographics. *teachers taught multiple subject areas.

COURSE DESIGN PROCESS

Theoretical Grounding

Course experiences were founded on the following conjectures about the knowledge and practices of culturally responsive science teachers:

- Culturally responsive science teachers have asset-based views of students from culturally, linguistically, and ethnically diverse backgrounds (Villegas & Lucas, 2002).
- Culturally responsive science teachers understand the influence of culture on teaching and learning (Howard, 2010; Nasir, Rosebery, Warren, & Lee, 2009).
- Culturally responsive science teachers affirm students' and families' funds of knowledge in instruction (Gay, 2010; González, Moll & Amanti, 2005).
- Culturally responsive science teachers use instruction to advance sociopolitical consciousness in students (Furman & Calabrese Barton, 2006; Mensah, 2011,2013b).

As indicated by the first conjecture, the course contained an overarching theme of developing affirming attitudes in teachers toward culturally and linguistically diverse students (Gay & Kirkland, 2003; Villegas & Lucas, 2002), as Brown (2014) has found that science teachers who successfully enact culturally responsive instruction may still hold deficit views of their students' families and/or communities.

To promote asset-based attitudes toward culturally-based ways of communicating, interacting, and thinking about science, we knew from existing research that it would be important to first help teachers understand how cultural backgrounds influence student learning (Howard, 2010). Self-reflection and the development of critical consciousness regarding race, culture, and language are also advocated as activities for science teachers to regularly engage in (Gay & Kirkland, 2003). However, science methods courses typically lack opportunities for self-examination of this nature (Ferguson, 2008). Thus, building in opportunities for teachers to be critically reflexive was key when designing the course.

From our own research (Brown & Crippen, 2016b) and research from other science educators (Laughter & Adams, 2012; Patchen & Cox-Petersen, 2008), we expected that our science teachers might struggle with enacting culturally responsive science instruction beyond promoting caring classroom environments and be disinclined to include sociopolitical connections in their instruction. In his survey of multicultural education courses across U.S. higher education institutions, Gorski (2009) found that 70% did not address such fundamental aspects of culturally responsive teaching. Thus, these were additional areas targeted during course design. We planned a variety of activities, including time to read and discuss theoretical foundations of core culturally responsive pedagogy (CRP) topics and to experience and critique sociopolitically-tied science lessons.

Science teachers often report having little cultural knowledge about their students (George, 2013). Common techniques for learning about students' communities include home visits (Johnson, 2011) and service learning projects (Calabrese Barton, 2000). However, in-service science teachers have reported feeling uncomfortable with such practices, and found them to be intrusive to families and inconsiderate of their other professional demands (Brown, 2014). To provide relevant cultural and community knowledge while addressing teachers' concerns, we worked with the university library specialist to compile Group-Level Repositories for the predominant ethnic, cultural, and racial communities that teachers would likely teach in their settings. These Group-Level Repositories are a unique approach to improving cultural knowledge. Each Repository contained written and audiovisual (AV) resources about a specific ethnic, cultural, or racial group that teachers were educating but confessed to knowing little about. For instance, the metropolitan areas of our state are densely populated with individuals from Hmong and East African origins. Hmong people are immigrants to the U.S. from Southeast Asia, many of who fled their homeland after the war between Vietnam and the U.S.


HMONG TIMES

Volume XV, Edition 06 "The Newspaper of the Hmong Community" March 21, 2012

Bus: (651) 224-9395 www.hmongtimes.com Fax: (651) 228-9049

SoLaHmo: Building on Cultural Strengths for Safe, Healthy & Strong Families and Communties

From Mikow Hang, Mai See Thao, Mai Bao Xiong, and Charles Vang

"The most important thing comes from parents, the mom and dad in the house knowing how to love each other. If they know how to love each other, they give a great example to their children and there are no worries in the family." (Focus Group Participant)

Somali, Latino and Hmong Partnership for Health and Wellness: Caafimad-Salud-Kev Nyob Zoo (SoLaHmo), is a program of West Side Community Health Services founded on engaged community-professional partnerships working together to decrease health disparities in the immigrant and refugee communities of St. Paul, MN. Members of Somali, Latino, and Hmong communities work together with health care providers and University of Minnesota researchers to promote health and wellness through research, education and policy. As a community based participatory action research team, SoLaHmo is dedicated to the recognition that Somali, Latino, and Hmong communities have the knowledge, skills and power to participate as equal partners with researchers and health care professionals to maximize community health and wellness.

In 2011, SoLaHmo completed a project called *Cultural Asset Assessment of Somali, Latino and Hmong Communities*. With funding from Blue Cross Blue Shield Foundation of Minnesota, SoLaHmo utilized Community Based Participatory Action Research (CBPAR) to identify cultural strengths and assets as defined by Somali, Latino, and Hmong communities. CBPAR is an approach where community members participate in mutual partnerships alongside academic/professional partners to generate research that is informed by community member knowledge and experiences. In doing so, CBPAR provides members a voice in addressing issues that matter to them and their ethnic communities. SoLaHmo's findings on cultural strengths will be utilized to identify and develop culturally appropriate programs, clinic practices and interventions to achieve healthy families and communities.

Artwork by Xee Reiter

Hmong, Latino and Somali ethnic community members partook in conducting research within their own ethnic group, analyzed the data, and identified the cultural strengths and assets of their community. These strengths and assets were synthesized into a model, presented as a tree. The tree's roots are the shared community values throughout Somali, Latino, and Hmong ethnic groups; the trunk represents the strongest over-arching asset: social connectedness with family, community, and society; the branches represent six core assets: language, religion, knowledge, cultural arts, cultural traditions, and work ethic; and finally the leaves and fruits represent safe healthy strong families and communities. Recognizing and building on the ethnic communities' strengths and assets, health and clinic interventions will be able to address the concerns of each population and work together to build better and more sustainable programming to maximize health.

SoLaHmo is currently conducting two CBPAR projects that are informed by the Cultural Asset Assessment Project. These projects are 1) *Development of a Multicultural School-Based Approach to Substance Use Prevention and Resiliency Promotion for Somali, Latino, and Hmong Youth* and 2) *Healthy Kids – Healthy Lives*. The goal of the first project is to better understand how teachers serving Somali, Latino, and Hmong youth can best promote youth resiliency among

SoLaHmo
continued on page 4

FIGURE 2. Group-Level Repository article read by science teachers focusing on Hmong populations. Source: Hang, M., Thao, M.S., Xiong, M.B., & Vang, C. (2012, Mar 21). SoLaHmo: Building on cultural strengths for safe, healthy, & strong families and communities. Hmong Times.

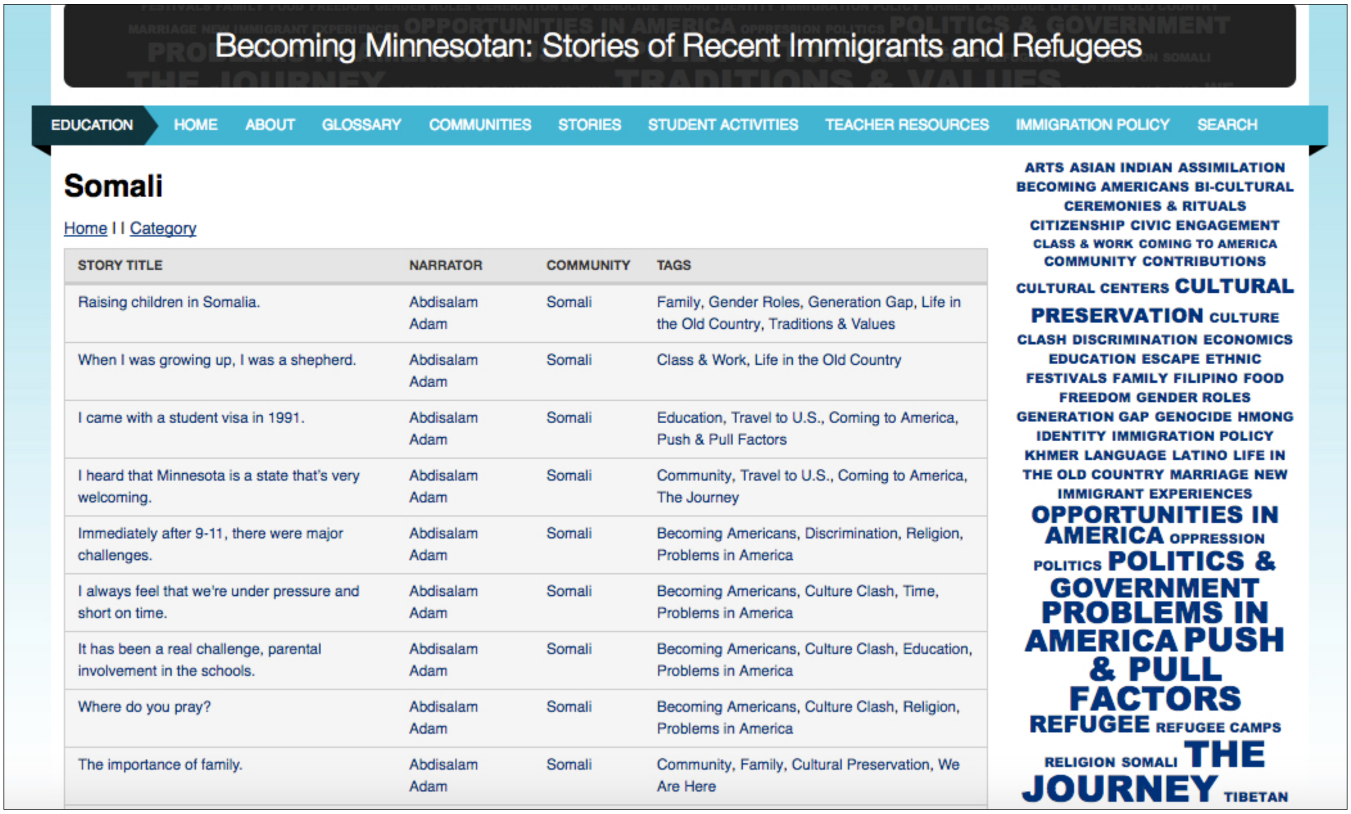


FIGURE 3. Group-Level Repository resource, Somali: Becoming Minnesotan, containing oral histories of Somali immigrants. On the right are hyperlinks for oral histories compiled by key terms found across multiple ethnic and cultural groups. Source: Minnesota Historical Society (2017): *Becoming Minnesotan: Stories of Recent Immigrants and Refugees.*

(Upadhyay, 2009). At times, the Repository also contained class-wide resources not tied to a particular ethnic group but were germane to the week's topic. For example, during Week 1, science teachers watched Chimimanda Adichie's TED talk, *The Danger of a Single Story*. All Group-Level Repository sources were vetted beforehand by the first author and the university library specialist to ensure they portrayed asset-based views and, when possible, were created by members of the particular group they were about. Figure 2 is an example Group-Level Repository article read by science teachers who chose to focus on Hmong populations. Figure 3 depicts a page from the website *Becoming Minnesotan* containing oral history audio files shared by recent Somali immigrants.

Lastly, our team's previous research indicated that science teachers are more likely to enact rich and appropriate culturally responsive instruction when they have had opportunities to examine their own classroom- and student-level data (Brown & Crippen, 2016a). Structured reflection on their practice and the systematic study of student learning enables teachers to tailor instruction directly to their students' needs and strengths, a core aspect of culturally responsive pedagogy. We incorporated a series of protocols —the *Growing Awareness Inventory* (GAIn; Brown & Crippen, 2016b)—to facilitate teachers' examination of context-appropriateness for specific culturally responsive connections.

Contextual Grounding

While the literature provided theoretical grounding for specific course experiences and their suggested sequence, our team also wanted to ensure that the course was context-appropriate. Because a large percentage of teachers who take the course are typically enrolled in the PREPScI course series, we had certain expectations about them and their settings prior to course implementation. This included their prior knowledge. The third and fourth authors have both previously served as instructors for the yearlong online induction course and, thus had intimate knowledge about what science teachers were likely to know and do as a result of the online course.

To contextually ground the course for beginning secondary science teachers' needs, we also performed a field-based assessment with a select group (n=9) of enrolled teachers the entire academic year before the course was taught. These teachers were participants in our larger, grant-funded project examining the development of reflective and equitable science teachers that all authors were a part of. During this time, the first and second authors visited the classrooms of each teacher two or three times, conducting observations and post-lesson debrief interviews. These observations gave us a sense of reform-based and equitable science practices being implemented, as well as practices that teachers struggled with or did not use. They also allowed us to gather student demographic information, which was used to compile the Group-Level Repositories. In the debrief interviews, we asked teachers to comment on the aspects of their lessons that they were most pleased with and those that they would change, if any. Additionally, we asked them to share their thoughts about culturally relevant instruction and where, if at all, they felt such instruction was present in the observed lesson. The first and second author discussed these contextualized findings in our biweekly course design meetings.

This information provided valuable insights around which course experiences were later designed. Primarily, these included the culturally relevant examples we provided, the specific practices we modeled, opportunities for us to highlight culturally responsive practices that teachers were already doing well, and material for the construction of the Group-Level Repositories. For example, teachers' self-assessments and classroom observations indicated that they felt most comfortable holding high expectations of their students and providing respectful classroom spaces, but made neither family nor sociopolitical connections a regular part of their science instruction. As a result, both were made explicit during our course. The first author compiled these responsive design elements in her ongoing *Design Decisions Report* (DDR) to keep track of all possible connections. Below, we share two excerpts from the DDR. The first highlights our emphasis on science and engineering *practices*—as opposed to specific science *content*—when providing culturally responsive examples, and the second demonstrates how we explicitly drew upon teachers' practices when introducing culturally relevant leverage points:

> *...the lessons will likely be heavy on science and engineering practices, but light on the specific content of a discipline. This is because we want to make it accessible to everyone and we want them to think through the content area connections and extensions, just like we want them to think through and look for student experience-based connections and extensions based on their students' artifacts. The course needs to have time built in to do both…*
>
> *...we can provide everyday situations that can be applied to CRP as they learn: For example, for group work and students constructing products together, I can build off my notes from [teacher's] 4/20/16 observation (heat vs temperature) as a way to move from "telling information" [to students] to information—generating on students' parts… Additionally, several teachers involve their kids in solving word problems (in particular the physical sciences - look at [teacher's] classroom and all the equations permanently listed on the board: Fg=mg, PEg=mgh, Ft=Δmv, etc.). [We can] show how this can be done in more group- and individually-accountable ways that also allows teachers to have consistent check-ins from groups at each point (ask them to describe how often they have kids solve problems, what they as teachers tend to do during that time, what the content of kids' questions are during that time, what they'd like to improve, etc.)*

In addition to its theoretical foundations, this contextual grounding allowed our team to further ensure that the science teachers would be engaged in responsive, authentic activities during the induction course, an important element of facilitating learning (Putnam & Borko, 2000).

THE COURSE: CULTURALLY RESPONSIVE SCIENCE TEACHING

Conjecture-Driven Course Experiences

We sequenced specific activities in accordance with a situated cognition perspective on how teachers learn. As "fundamental orientations" for culturally responsive teaching (Villegas & Lucas, 2002), teachers' sociocultural awareness and affirming attitudes toward culturally diverse students were first targeted. We then built in opportunities to evaluate culturally responsive science lesson examples from there. We used the *Culturally Responsive Instruction Observation Protocol* (CRIOP, Powell & Rightmyer, 2011) to facilitate teachers' critique of the example lessons, while also asking them to comment on appropriateness for their specific contexts. The CRIOP is a validated observation protocol that operationalizes seven aspects of culturally responsive instruction: Classroom Relationships; Family Collaboration; Assessment; Curriculum/Planned Experiences; Instruction/ Pedagogy; Discourse/Instructional Conversation; and Sociopolitical Consciousness (Powell, Cantrell, Malo-Juvera, & Correll, 2016). The lesson critique approach is consistent with recommendations for preparing culturally responsive science teachers (Ferguson, 2008; Hernandez et al., 2013). Because of the comprehensive nature of the CRIOP, when teachers evaluated lessons using it they also gained awareness that culturally responsive science teaching is more than explicit curriculum changes.

The first three weeks of the course centered on a specific topic each week (see Table 2). Each week's topic was explored using the following format: Day 1 - readings, discussions, and personal connections to the week's topic; Day 2 - experience and critique culturally responsive pedagogy in science (CRP Science) exemplars; Day 3 - classroom-based analysis for context appropriateness. The first and second authors created this structure specifically because it allowed the teachers to first grapple with content according to their own experiences before seeing what it might look like

TOPIC	READINGS/DISCUSSIONS/ PERSONAL CONNECTIONS TO TOPIC	EXPERIENCE & CRITIQUE EXEMPLARS	CLASSROOM BASED-ANALYSIS FOR CONTEXT-APPROPRIATENESS
	DAY 1	DAY 2	DAY 3
Week 1: Culture and Learning, Developing Affirming Views (Conjecture 1)	Card Sort Activity *Success in Science* Activity Culturally Responsive Teaching Continuum	*Nature of Science* Activity *Personal Identity/Culture Mosaic	*Student Identity Profile* analysis Growing Awareness Inventory (GAIn) 1
Week 2: Funds of Knowledge (Conjecture 3)	*Finding CRP in STEM* Activity Reading Reflections Discuss readings on Funds of Knowledge	*Multiculturalism and Culturally Relevant Pedagogy interactive lesson with guest speaker Dr. Felicia Mensah	Student-Video Analysis through GAIn 2 *Group-Level Repository
Week 3: Critical Consciousness (Conjecture 4)	*Privilege Walk* activity Reading Reflections *Space Traders* discussion	Cell Cycle and Genetics of Cancer * *Cancer Risks and Environmental Justice* activity	*Analyze Student - Interview Audio Recordings through *GAIn 3 Group-Level Repository
Week 4: Curriculum Writing (Conjecture 2)	Curriculum Design *CRP Science Points to Ponder guide CRP Science Unit Template Reading Reflections	Card Sort Activity Curriculum Design *CRP Science Points to Ponder guide CRP Science Unit Template	Curriculum Design *CRP Science Points to Ponder guide CRP Science Unit Template Final Reflections and Next Steps...

TABLE 2. Course activities according to daily schedule. *course activities detailed in narrative.

when applied to a science classroom. We also felt it was of utmost importance that teachers engaged in active learning experiences around the weekly themes when they experienced exemplars, rather than just read about them or listen to a lecture.

Because we wanted to ensure that teachers had opportunities to adapt any relevant materials to their contexts, the first and second author structured Day 3 so that it involved teachers in first analyzing their practices through video-recorded lessons taught during the school year and then examining their students' artifacts. Teachers spent the remaining class time working in teams as they learned about their students' ethnic and cultural backgrounds in the Group-Level Repositories. We asked them to process this information as a team and think through how their instruction could be modified based on specific student needs. The final week of the course focused solely on curriculum design and teachers' incorporation of CRP Science into their curricula. In this section, we detail main activities according to their respective weeks in the course. These activities are denoted by an asterisk.

Week 1: The Influence of Culture on Learning

Before teachers started our course, the first author inventoried their initial ideas about two things: (a) their own success in science and (b) the science success of culturally, racially, and linguistically diverse students. Based on the literature and our own previous experiences, we expected a range of ideas to surface. Knowing these initial perspectives allowed us to target subsequent learning experiences, as it is often difficult to get teachers to explicitly profess deficit-based thinking about students of color. When comparing the ways they speak about themselves compared to "underrepresented students," however, this disparity becomes more evident. To gather this information, teachers were required to complete an activity, *Success in Science*, before the first day of class. Two versions of this assignment were provided. Both versions contained identical tasks, with the exception

Educators, politicians, and families all have theories about the factors that contribute to a child's science achievement in school. Here is a list of factors (in no particular order) that have been suggested as contributing to achievement:

- **Individual** factors: Abilities, talents, disabilities, physical appearance, effort and motivation to achieve, past history of achievement, etc.
- **Family** factors: Marital status of parents, educational background of family members, science background of family members, number of siblings, family resources, etc.
- **Teacher** factors: Teacher professional background, teacher years of experience, teacher passion and commitment
- **School** factors: School leadership, school resources, teacher stability or turnover
- **Community and Societal** factors: Kind of neighborhood, access to health care (mental health, dental health, etc.), access to after school programs and summer programs

Directions:

1. In the space below list any of the above factors that you believe are important to the science achievement of underrepresented students/students of color. Briefly describe why you chose these particular factors. If any influential factors are missing, please add them in **red text**.
2. Construct a pie graph to show how each factor set has contributed to the **school achievement of a child from a historically underrepresented group or living in poverty**. Label each section of your pie and write the number to suggest what percentage of achievement is explained by each factor set (e.g. if the factor sets contribute equally then each part of the pie would be labeled 20%)
3. Based on the influential factors you identified above, describe one or two major recommendations you would make to teachers and schools for enhancing the science achievement of all students.

FIGURE 4. Screen capture of "Others' Success in Science" activity from Week 1.

that one half of the class was required to comment on their *own* experiences (the "My Success in Science" version), while the other half was tasked with commenting on *others'* experiences (the "Others' Success in Science" version). The assignment asked them to: (a) identify factors contributing to either "my" science success *or* the science success of "underrepresented students/students of color" and describe their choices; (b) construct a pie chart depicting the strength of influence of each factor; and, (c) pose recommendations for equitable science based on their answers to (a) and (b). Figure 4 presents directions for the "Others' Success in Science" version.

On the first day of class, the first and second author provided teachers with direct quotes and pie charts from their completed assignments, organized by either *My* or *Others'* success in science. We asked them to work in groups to analyze the data (i.e., their quotes and charts) and make claims about how they viewed their own science success and the success of culturally diverse students. This experience set the tone for how teachers were expected to participate in class: critically reflective and using direct evidence to make claims, be it about students, themselves, or science content.

Once initial ideas were surfaced, we wanted science teachers to understand that culture impacts *what* people learn and *how* they learn it (Nasir et al., 2009). Thus, we also devoted time in this first week to building their understanding that science as it is commonly taught has its own specific culture. These defining cultural features are known as the nature of science (NOS) (NRC, 2012), which includes specific ways of interacting with the world (e.g., posing questions about natural phenomena that can be directly tested, obtaining empirical evidence that can be quantified and described) and determining "legitimate" or "valid" knowledge in science (information that is substantiated by direct evidence, claims that are reasoned through this evidence). The Nature of Science activity required groups of teachers to select and read through two lessons from a preselected bank of lesson plans on the "History of Science" created by Dr. Robert A. Hatch at the University of Florida. These lessons were selected because they made explicit several key features of the Nature of Science. As they read, teachers answered a series of questions:

- How is knowledge gained and when is knowledge considered accurate/valid in this lesson?
- What actions/activities are students expected to engage in during this lesson?
- What thought processes are students encouraged to use and what types of thinking are valued in this lesson?
- How are students expected to communicate and talk about the knowledge they gathered?

We posed these particular questions because they targeted observable elements of "culture," including the shared knowledge, practices, and communication of a community. Groups were then asked to define the Nature of Science using their responses to questions. A large group share-out and discussion followed and allowed teachers time for processing and reflecting after the activity.

We also took this time to help teachers acknowledge that their previous experiences and identities as science learners come through in their own physical classroom environments. In addition to inventorying their classroom settings, we had each teacher construct their own Personal Identity/Cultural Mosaic, using cutouts from popular magazines (see Figure 5). The purpose of this activity was to help teachers recognize their own culturally-based identities. After a brief data analysis exercise where teachers used their mosaics as data sources (e.g., we posed questions such as "How many mosaics contained religious connections?" and "What was the most frequent identity facet displayed in the mosaics?") and communicated results, they discussed how their classroom environments can communicate certain messages about who is welcome and what is valued, intentionally or implicitly.

We then introduced tenets of cultural difference theory (Gay, 2010), which states that students whose home cultures and ways of communicating and interacting are different

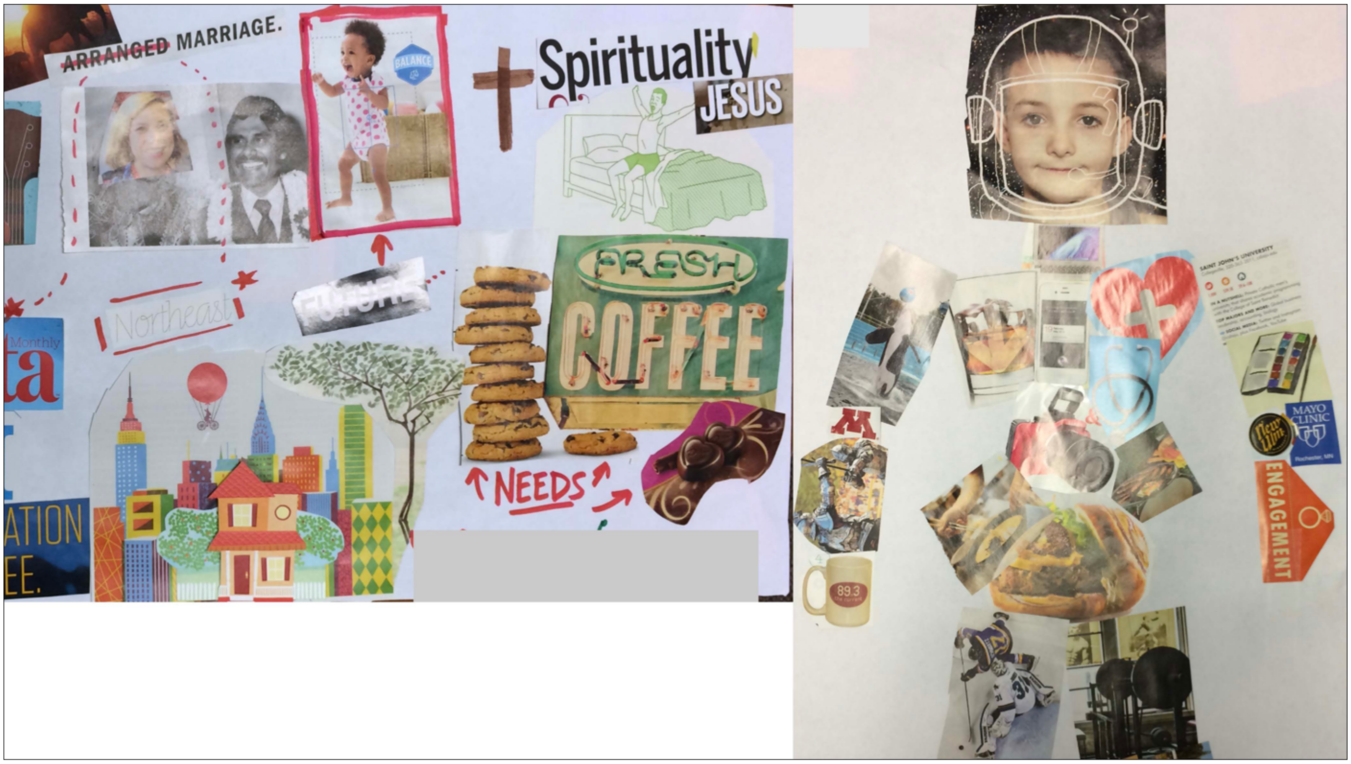


FIGURE 5. Personal Identity/Cultural Mosaics created by two secondary science teachers enrolled in the course.

from those valued by science (i.e., NOS) will likely face challenges when experiencing traditional science teaching and learning. One way to lessen this difficulty is by affirming students' identities in the classroom (Lee & Buxton, 2010). On Day 3, we asked teachers to examine two classroom-based artifacts: (a) *Identity Profiles* completed by their students just prior to the course (from National School Reform Faculty Paseo Protocol)—and (b) video recordings of their classroom teaching. Using these artifacts, teachers were asked to determine the degree to which (a) their own identities and (b) their students' identities were present in the recording, if at all. This led to a discussion about possible ways to cultivate more inclusive, respectful learning environments and also introduced teachers to the idea that the study of their instruction can be a useful tool for understanding equitable science instruction.

Week 2: Funds of Knowledge in the Science Classroom

Culturally responsive pedagogy advocates a learning environment that is community-based, affirms diversity, and uses students' funds of knowledge in instruction (i.e., community, home, and family skills and knowledge; González et al., 2005) to ease differences between home culture and the typical science classroom culture. However, science teachers struggle with constructing culturally relevant experiences for their students. While the reasons for this struggle vary, it is often simply due to a lack of sufficient cultural knowledge about their students (George, 2013). Thus, Week 2 activities focused on including funds of knowledge in science instruction while also providing actual funds of knowledge-based resources from which teachers could draw.

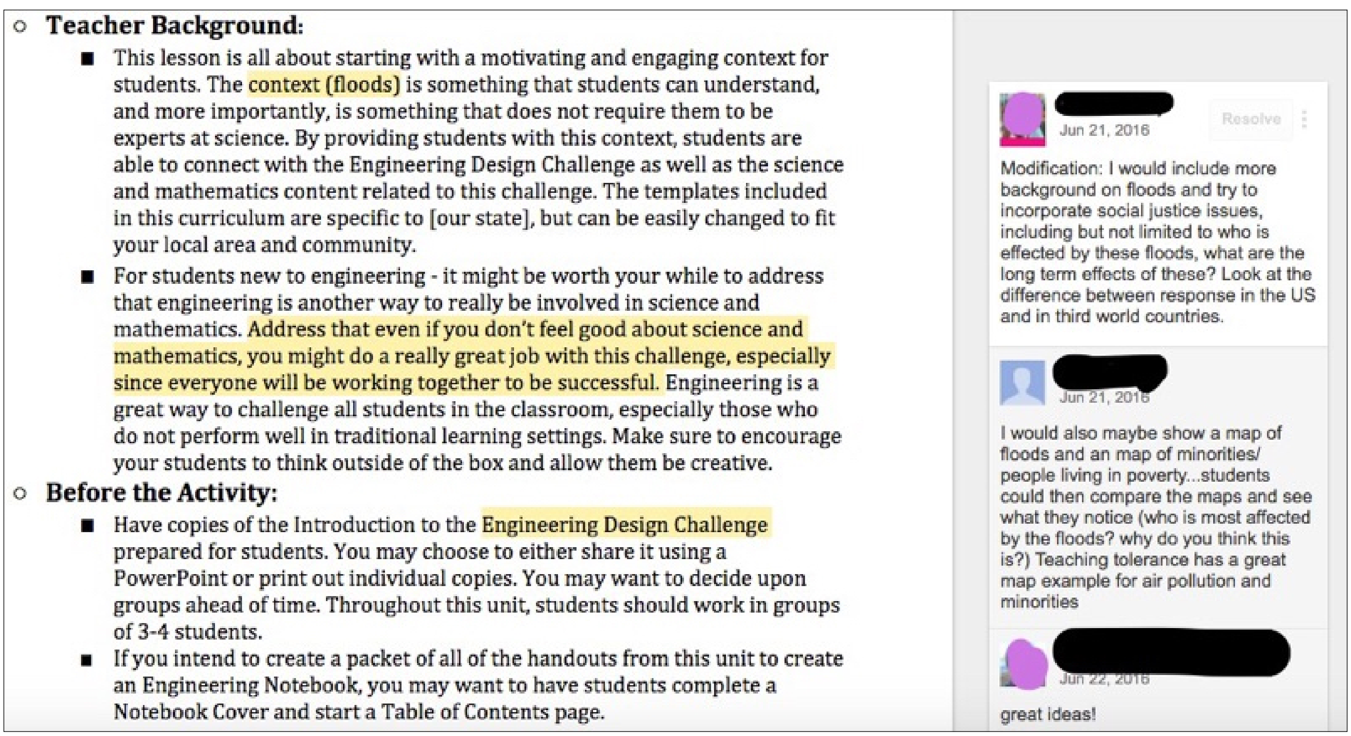
Working in small groups, teachers began the week with structured readings discussions. These were selected by the first author to highlight the importance of eliciting student and family knowledge, as well as multiple perspectives on what counts as intelligence and "legitimate knowledge" to diverse communities. The teachers responded to specific questions about their readings, such as:

- In "Who are the Bright Children?" Sternberg (2004) discusses the intelligence of others as being judged through an individual's implicit definition for intelligence. In what ways have you experienced an implicit definition for intelligence being used to judge the intelligence of others and, reflecting on those experiences, how would you analyze them after reading Sternberg? How would you define intelligence?
- Should all teaching be "a daily search for the child's point of view" (Paley, 1986, p. 123)? What might be accomplished from this? What might be forfeited?
- Thinking about the many issues that urban school teachers face today and any challenges you face in your own classroom, what helpful information did you find in Upadhyay (2006) about collecting information on students' funds of knowledge and creating a classroom that integrates teacher and student lived experiences into science learning?

The discussion gave teachers a chance to process the readings together and speculate on how they might be applied to their own contexts. Afterward, the second author engaged them in an innovative investigation with science, technology, engineering, and mathematics (STEM) connections. This activity allowed teachers to experience an engaging content-focused investigation with plenty of opportunities for incorporating students' funds of knowledge. In this activity, *Finding CRP in STEM,* teacher teams were first presented with a scenario—the local National Guard branch must respond to flood conditions and rescue any affected citizens in the most efficient and effective way. Each team was challenged to construct a watercraft prototype and calculate the maximum occupancy it could hold when scaled-up. Teams first created and labeled a diagram of their prototype. They then constructed it using available materials and tested it in a simulation container. Finally, they calculated mass of the watercraft and the volume and mass held by it, all of which were presented in a force diagram illustrating the watercraft's maximum capacity. After teachers participated as students would during the activity, teacher teams were asked to consider how, if at all, an engaging STEM lesson could be modified to integrate their students' and communities' funds of knowledge. To do this, the teams were given the original lesson plan and asked to draw from their readings, *Student Identity Profiles*, and their own experiences when making suggestions. They then modified the lesson plan together and wrote a summary stating the changes made and their justification for these changes.

Figure 6 illustrates modifications suggested by one group of teachers to improve cultural relevance for their students in the "Front Matter" of the lesson (*Teacher Background* and *Before the Activity* sections). In this example, teachers' suggestions center on social justice connections. One teacher proposes examining different long-term effects of flood disasters based on how developed a country is, while the other speculates on using science practices—such as obtaining, analyzing, and interpreting data—to explore possible demographic disparities in flood-afflicted areas.

In the second day of this week, we collaborated with Dr. Felicia Mensah—Professor of Science Education at Teachers College, Columbia University, and leading scholar on preparing culturally relevant science teachers—to engage the teachers in an interactive lesson on multicultural and culturally relevant science education. In this lesson, teachers were asked to describe characteristics of culturally relevant science teaching, provided with examples of CRP in science-specific contexts that had funds of knowledge ties, and asked to evaluate one of those examples according to Banks's (2015) typologies of multicultural curricular reform, paying particular attention to any funds of knowledge connections. Banks's typologies were used for this activity because they categorize different levels at which multicultural content can be integrated into instruction. In the lowest typology levels, multicultural content is simply "added" to instruction and leads to superficial integration (e.g., celebrating Cinco de Mayo). Higher typology levels indicate more meaningful multicultural content integration and opportunities for social action. By examining funds of knowledge connections this



- **Teacher Background:**
  - This lesson is all about starting with a motivating and engaging context for students. The context (floods) is something that students can understand, and more importantly, is something that does not require them to be experts at science. By providing students with this context, students are able to connect with the Engineering Design Challenge as well as the science and mathematics content related to this challenge. The templates included in this curriculum are specific to [our state], but can be easily changed to fit your local area and community.
  - For students new to engineering - it might be worth your while to address that engineering is another way to really be involved in science and mathematics. Address that even if you don't feel good about science and mathematics, you might do a really great job with this challenge, especially since everyone will be working together to be successful. Engineering is a great way to challenge all students in the classroom, especially those who do not perform well in traditional learning settings. Make sure to encourage your students to think outside of the box and allow them be creative.
- **Before the Activity:**
  - Have copies of the Introduction to the Engineering Design Challenge prepared for students. You may choose to either share it using a PowerPoint or print out individual copies. You may want to decide upon groups ahead of time. Throughout this unit, students should work in groups of 3-4 students.
  - If you intend to create a packet of all of the handouts from this unit to create an Engineering Notebook, you may want to have students complete a Notebook Cover and start a Table of Contents page.

[redacted]
Jun 21, 2016
Resolve
Modification: I would include more background on floods and try to incorporate social justice issues, including but not limited to who is effected by these floods, what are the long term effects of these? Look at the difference between response in the US and in third world countries.

[redacted]
Jun 21, 2016
I would also maybe show a map of floods and an map of minorities/ people living in poverty...students could then compare the maps and see what they notice (who is most affected by the floods? why do you think this is?) Teaching tolerance has a great map example for air pollution and minorities

[redacted]
Jun 22, 2016
great ideas!

FIGURE 6. Modifications suggested by teachers for an engaging STEM lesson to make it more culturally responsive.

way, teachers were able to consider the different ways in which meaningful integration can occur. They were then asked to reflect upon the ways in which funds of knowledge can be effectively integrated into science classrooms.

During this week, teachers were also introduced to the Group-Level Repositories. The goals of the Repositories were to help teachers (a) identify common practices, events, community issues, cultural norms, and ways of communicating for the ethnic group that they chose to focus on and (b) connect these findings to possible topics for their Culturally Responsive Pedagogy in Science (CRP Science) curriculum unit. We began by asking them to select an ethnic or racial group that they wanted to learn more about. They then formed teams according to those choices. In teams, teachers were asked to read the sources and look for possible topics for their CRP Science units. They kept their ongoing ideas in a shared Google Document that the first and second authors also had access to.

Week 3: Using Science to Raise Critical Consciousness in Students

Because it aims to empower learners who are traditionally disenfranchised in the U.S. educational system, at its core, CRP is emancipatory (Ladson-Billings, 1995; Gay, 2010). To achieve this aim, culturally responsive teachers invite students to identify oppressive practices, examine and challenge them when studying their content area, and construct action plans to remedy oppressive practices when possible. However, these critical consciousness-raising experiences are consistently absent from K-12 classrooms, particularly in science (Ferguson, 2008; Morrison, Robbins, & Rose, 2008).

To allow teachers to experience the need for critical consciousness in a very personal way, the first author began Week 3 with a *Privilege Walk* activity, which she adapted from the Diversity Education Task Force by selecting fewer statements than originally listed based on their relevance to our particular context. The remaining parts were the same as the original *Privilege Walk* activity. This activity was selected because it has been advocated by Villegas and Lucas (2002) as an important tool to use when preparing culturally responsive teachers. This is because the *Privilege Walk* helps teachers identify and begin to understand the myriad privileges they possess by virtue of their racial and socioeconomic backgrounds. Developing awareness of their position in the world is fundamental to being able to understand larger structural systems and how they operate to privilege some and oppress others, intentionally or not. When completing the *Privilege Walk*, teachers all began at the same position on a straight, imaginary "start line." The first author then read statements aloud, including, "If you studied the culture or the history of your ancestors in school take one step forward," and, "If you were ever uncomfortable about a joke or a statement you overheard because of your race, ethnicity, gender, appearance, or sexual orientation but felt unsafe to confront it, take one step backward." After all statements were read, and depending upon their responses, teachers ended up at different distances from the start line. Those closer to the "front" of the group represented individuals with greater privilege and better positioning in life.

We used this activity to segue into our discussion of *Space Traders*, a story written by Derrick Bell (1992), who is considered to be the founder of critical race theory. The story presents a proposal made by the Space Traders—an alien community from a distant star—to the people of the United States at a time when the environmental and financial future of the U.S. is dire: "*In exchange for all the African Americans in the United States that will be taken back to our home star,*" the Space Traders proposed, "*we will ensure the health, financial, and environmental prosperity of those left remaining in the country*" (p. 160). The story then presents perspectives from multiple individuals on this offer, some of whom viewed it as a travesty and others who welcomed it as a much-needed opportunity. The first author chose *Space Traders* to expose and help teachers wrestle with institutionalized racism. She

- Sweet! Aliens are coming! What kinds of scientific knowledge do they have that we can learn from?
- What the hell? Why would they want to take the African Americans back home?
- They seem like altruistic people, at least from the first half of their offer, perhaps they want to save black Americans from injustice.
- I find it interesting that this was my first inclination about the aliens offer, rather than the imprisonment of their captives. I'm glad the story pointed out the positive attitudes that white people had toward the aliens and the initial negative attitudes that black people had. I'm white, for sure.
- Either way, the offer is unacceptable. No one could possibly justify accepting their offer. Though I haven't fully formulated rationale for this impossibility, I am comfortable leaving it simply as an impossible offer that must be dismissed out of hand.
- The "American racial experiment"? I have operated under the assumption that the diversity in America is the source of our ingenuity and strength. Certainly, it is a tumultuous source of strength, but useful nonetheless. Can it continue to be a benefit to America rather than a burden? Are the people of America willing to engage headlong in a difficult conversation that will be uncomfortable and ultimately beneficial?
- Am I supposed to appreciate that Golightly has positioned himself in a place of power to now impact the decision making or disparage him for support policies that engender inequity? I feel conflicted about Golightly. Predominantly, I think he has done a great deal of damage to poor people of color in America.
- This cabinet conversation is super gendered. The patriotism described is a powerful representation of traditional masculinity; women and children are portrayed as powerless in determining their own fate. Indeed, the predominantly male cabinet has little perspective on the potential role women will play in the future of America.
- "We will give [Golightly's perspective] weight in our consideration" (170). The president has clearly cut the only person of color out of the decision making process. He spent a few minutes allowing Golightly to speak, but the president did not actually listen to what Golightly had to say. This trade deal will happen, if it is up to the president and his cabinet.

FIGURE 7. Screen capture of a teacher's thinking while interacting with the story, *Space Traders*, by Derrick Bell.

1. Describe for me a typical day or weekend at your home.
2. What are some of your favorite things to do in your free time?
3. What are you really good at?
4. Is there a place outside of school that is important to you? Why is this place important?
5. What does it mean to be "successful in science?"
   - Who are some of the people in our class that are successful in science (you can include yourself, too, if you feel this)?
   - What qualities do they/you have that makes them/you successful?
6. Read this passage (below) from Upadhyay (2009) aloud to the students. Tell them that this passage is about how a teacher and her students tried to make science learning more meaningful by bringing in their backgrounds and experiences:

> "Bringing Hmong students' gardening experiences into the science classrooms is one way to value non-mainstream American students' ideas, concepts, and experiences. Hmong students in Lee's [the teacher] class felt that their experiences, culture, and Hmong identity were valued as a part of learning science. Two of the students interviewed noted:
>
> S10 [male]: For us [Hmongs], garden relates to our lives, and science in Lee's class is about gardening.
>
> S14 [female]: I'm happy to *learn* science is like gardening. I can learn about science doing garden things.
>
> Hmong parents made similar encouraging comments about the relationship between gardening and learning science that happened in Lee's class:
>
> We [Hmong parents] believe gardening is important part of Hmong life . . . Lee uses gardening [experiences] to teach science, this will positively encourage Hmong students to like science and learn science and see connection between home and science that Lee teaches."

Then, after reading this passage to your students, ask them:

a. What are some important cultural practices at your house or in your community? For example, gardening, church/mosque, activities that you and/or your family are regularly involved in.
b. Let's look at some of these topics together (these will come from the three units you identified above). What are possible ways that we could make these more interesting than they were this year? What possible topics could we include?
c. Is there anything else that you wish I asked about you that I didn't ask? If so, what is it?

FIGURE 8. Focus group interview questions posed to students by their science teachers before the course.

structured this experience in two ways: first with having teachers record their individual thoughts as they read the story, which counted as part of their reading reflection for the week; and, second, through a structured group-wide discussion that emanated from their reading reflections. Teachers were asked to come to the discussion prepared with a question to ask of the whole group, and these became the foundation for our conversation. Figure 7 displays one teacher's thoughts as he read *Space Traders*.

In this excerpt, the teacher displays a range of emotions and thoughts as he interacted with and tried to make sense of Bell's story. Initially, he was excited by the prospect of alien contact, which quickly changed once he understood the purpose for their visit. He kept an open mind at first, hoping that there might be some altruistic motive behind the aliens' proposition. But, his rejection of their idea was soon cemented, at which point he positioned himself squarely counter to this. His reflection also demonstrates critical reflexivity, particularly when discussing the cabinet conversation and his own thoughts about racial diversity in the U.S.

After experiencing critical consciousness tenets from a personal standpoint on Day 1, on the second day the first author engaged teachers in an activity on *Cancer Risks and Environmental Justice* (Brown, 2012). This activity began with a lesson on the cell cycle and the genetics of cancer. Teachers then worked in teams as they identified Environmental Protection Agency-designated Superfund locations throughout the state, examined the presence of carcinogens at these sites, and then compared U.S. Census data on the income and race/ethnicity demographics of these areas to non-Superfund site locations in the same county. Each team reported their findings to the class. An evidence-based discussion of whether or not a correlation existed between Superfund site locations and income and/or race/ethnicity was held. The activity concluded with teacher teams evaluating the *Cancer Risks and Environmental Justice* lesson for its cultural responsiveness according to the CRIOP. Through this activity, teachers were able to envision how sensitive topics can be embedded into rigorous, inquiry-based science learning experiences.

On Day 3, teacher teams continued working on their Group-Level Repositories. Teachers also worked individually to examine more student artifacts, this time using audio recordings of student interviews to identify additional possible culturally responsive connections for their CRP Science curriculum units. To assist teachers with this task, the third in a series of GAIn protocols was used (Brown & Crippen, 2016b). GAIn is a set of structured observation and reflection protocols that guide science teachers in critically examining their classroom environment and identifying ways to incorporate students' experiences into science instruction. In the third protocol, teachers are asked to "hold a conversation with your focus group students to learn about aspects of their life outside of school [and] incorporate information from your conversation into upcoming science lessons." To guide the conversation, teachers were given a set of questions and prompts to ask students that was adapted from Villegas and Lucas (2002), Carlone, Haun-Frank, and Webb (2011), and Upadhyay (2009) (see Figure 8).

Week 4: Culturally Relevant Science Curriculum Design

The final week of the course was a dedicated time for the teachers to design their Culturally Responsive Pedagogy in Science (CRP Science) curriculum units. Teachers were required to include at least four science lessons in their units, contain all materials (e.g., handouts, lecture notes) necessary to prepare the lessons, and demonstrate explicit and meaningful culturally responsive connections for the students and communities they serve. Teachers could choose to make these connections from a funds-of-knowledge approach, a sociopolitical-consciousness approach, or a combination of both.

Two structures were provided to support teachers during the curriculum design process: a *CRP Science Unit Points to Ponder* guide created by the first author and a unit planning template, adapted from Wiggins and McTighe's (2005) *Understanding by Design* model. These structures focused teachers' attention to both Western and culturally responsive science content and practices. Whereas teachers used preexisting units, state science standards, and textbooks to address Western science components of their curriculum units, to incorporate contextually-appropriate and culturally relevant science elements, they applied findings from GAIn protocols (i.e., classroom-based analyses) and Group-Level Repositories.

We were available to teachers at all times during this week, consulting with them as needed. Moreover, teachers were encouraged to collaborate with one another, in either Group-Level Repository teams or science discipline-specific teams. To set the tone for collaboration, the week began with two brainstorming sessions. In the first session—in which teachers were grouped by content area—teachers generated possible culturally responsive topics and strategies based on specific, related science standards. In the second session, teachers met with their Group-Level Repository teams to brainstorm relevant curriculum connection for their specific ethnic and cultural groups.

At the end of each curriculum-writing day, teachers uploaded their working unit planning templates to our course management system (e.g., Moodle). They also were required to write a daily progress report, which concluded with an articulation of their design plans for the following day. This allowed us to monitor teachers' ongoing progress and help them chart out next steps. Once teachers completed their CRP Science units they were asked to explicate how GAIn and Group-Level Repository findings were applied to the lessons. Responses were recorded at the end of their CRP Science units, with the intent that it would be immediately accessible to the teachers as they prepared to enact the unit. Figure 9 presents a summary of one teacher's modifications to a momentum and impulse unit. By reflecting on self-, classroom-, (i.e., GAIn connections), and community-based (i.e., Group-Level Repository) findings, this teacher's revised physics unit included culturally relevant topics (cell phones) and responsive instructional strategies (collaboration in groups).

ASSESSMENT

The first and second authors designed a variety of assessments to align with course experiences and guiding conjectures (see Table 3). Both authors also graded the assignments. In this section, we detail these assignments as they were introduced to teachers in the course syllabus.

Summary and Reflection

My biggest GAIn findings were that my classroom was very teacher centered and that, in my questioning, I did not hold the students up to a high standard. Most of my questions from my video excerpt were level one questions and, while this was challenging to some students, there was a classroom culture of "the teacher will answer/explain it eventually, so there is no reason for me to try very hard". I have set these lessons up to really challenge the students, and indirectly my questioning techniques, to keep the classroom student-centered and concept based. The students will be required to make connections together and individually while I only guide directions. Likewise, within a period of seven days, I have two hands-on activities that have the students exploring and applying science concepts in small groups. Ultimately, I want to set up a classroom wherein I can challenge students with a high level questions and they will have the tools and confidence to attempt an answer or be able to figure out an answer on their own.

Many students expressed interest in family and friends in their identity profiles. Most of my lessons have small group work (both labs, final project, turn and talks, and whiteboard share out) that allow ample time to "hang" or "chill" (also in the identity profiles) with friends. Likewise, during the cell phone drop lab the students are required to get family input on their ideas and designs. Some students identified as contemplative, and I have tried to provide time to process and/or talk before responding. And finally, I have tried to make this lesson relevant and bring out science connections with the students' lives/interests – whether that be sports or creative outlets. Sports are relevant in the safety equipment research possibility and there is a creative/artistic outlet in the final project for students identifying with that.

From our group's Repository, [I learned that] African Americans do seem to feel displaced by traditional learning and culture. By viewing the students as scientists and making them perform/discuss science concepts in their own way, they make the science their own and put it in their own words. In other words, they make it theirs and are no longer displaced. Likewise, both allowing choice in assessment/communication and allowing discourse to proceed in their own vernacular, the students have a non-traditional outlet in which to express themselves. And it was found that African Americans highly value community. The final project and the communication of their learning with the surrounding school/community provides an opportunity to be of value to their community and support it.

FIGURE 9. Summary of culturally responsive modifications made to one teacher's science unit on momentum and impulse.

ASSIGNMENT	DUE DATE	% OF FINAL GRADE
Class and Online Participation	Ongoing	25%
Reading Reflections	Weekly (Tuesdays)	20%
Classroom-Based Analysis Artifacts	Weekly (Thursdays)	20%
CRP Science* Curriculum Unit	July 15, 2016	35%

TABLE 3. Course assessments, due dates, and grade weights.
*Culturally Responsive Pedagogy in Science

Class and Online Participation

Because the class was conducted in a face-to-face format, all teachers were expected to fully participate in and, at times, facilitate our class discussions. The assigned weekly readings and Reading Reflections, on which many of the discussions centered, were due before class on Day 1 (Tuesdays). We expected that in-class and online contributions be professional, productive, and obvious. To concretize these expectations, we stated that class and online participation included, but was not limited to:

- Attending class, coming prepared to discuss the assigned readings.
- Regularly participating in in-class activities, such as the *Classroom-Based Analyses* (i.e., GAIn protocol-based assignments) that you will do on Day 3 (Thursdays) and the *Group-Level Repository* information that you will construct with your team.
- Maintaining your *Curriculum Design Ideas* log, including think-aloud comments.
- Regularly participating in your Group-Level Repository teams, as well as completing assigned online activities such as the *Reading Reflections*.

Reading Reflections

We also expected teachers to meaningfully engage with course readings. To guide this engagement, the first author purposefully created Reading Reflections questions and prompts. The questions/prompts were not intended to have a correct answer; rather, she expected that teachers answer them in a way that demonstrated personal and professional reflection, as these questions/prompts were often the foundation for subsequent in-class discussions. The Reading Reflection questions were available on our course Moodle site and were due before class time on Day 1 (Tuesdays) of each week, unless otherwise noted by the first author.

Classroom-Based Analysis Artifacts

Culturally responsive science teaching is heavily dependent on context. In other words, what might be considered "culturally responsive" for students in one classroom may not be relevant for students from another classroom. As a result, teachers were required to regularly analyze their own classroom practices in the form of the data they collected from their students (Identity Profile, Focus Group Interview), and the Group-Level Repository (on our course Moodle). To facilitate this analysis, on Day 3 (Thursdays) of Weeks 1—3, teachers completed GAIn protocols, student analysis protocols, and other artifacts. The first author previously created and researched GAIn protocols (Brown & Crippen, 2016b). All materials were available on the course Moodle site.

Culturally Responsive Pedagogy in Science (CRP Science) Curriculum Unit

As their capstone project, teachers designed an instructional unit with at least four lessons that reflected their students' backgrounds and were also responsive to their needs (based on findings from Classroom-Based Analyses, Day 3 of Weeks 1 - 3). Additionally, the science unit was required to align with state science standards. To assist with the unit design process, teachers were provided ample in-class design sessions, a lesson-planning template (selected by the second author), and a *CRP Science Unit Points to Ponder* guide (created by the first author). The final curriculum unit was due one week after the final day of class.

SUCCESSES AND CHALLENGES EXPERIENCED

Throughout the course, we continually provided feedback on teachers' assignments and participated in their small group discussions. These sources have given us insight into the successes and frustrations experienced by science teachers during the induction course. While we celebrated the successes, as instructional designers, we also honed in on the source of teachers' frustrations in considering possible areas for course revision. In this section, we share teacher successes according to guiding course conjectures, as well as design challenges.

Teacher Successes

Conjecture 1: Affirming views of students.

The teachers' note-taking and reflections after interacting with the Group-Level Repositories indicated that they developed better-informed perspectives of the cultural and religious practices, community events, and local issues of the ethnic groups on which they focused. For example, one teacher's notes included: *"Hmong 2.0 [name of article] refers to the first generation to be born in America…[they] feel an obligation to take care of their parents and give back* *to their communities"* (Hmong/Southeast Asian Immigrant Group-Level Repository) and another wrote, *"The issue facing Latinos...isn't unemployment...it is finding jobs that pay enough to get out of poverty"* (Latino/a Group-Level Repository). Moreover, a content analysis of Group-Level Repositories indicated that these groups were generally written about using affirming, rather than deficit-based language. One teacher stated, *"the schools weren't meeting the needs of the Latino kids - it's not that they can't learn, it's that they haven't been given the right opportunities for learning"* (Latino/a Group-Level Repository).

At the start of class, several teachers held deficit-based assumptions about culturally diverse students, which we noticed in their *Others' Success in Science* assignment. However, this had shifted noticeably to more affirming attitudes by the end of the course. For example, one Earth science teacher originally stated, *"Sometimes students' individual talents and abilities contribute greatly to achievement. If they really struggle with science they may lack the intrinsic motivation to learn science"* (Others' Success in Science, week 1), but near the end of the course, when reflecting on students' backgrounds, the teacher stated:

> *As I thought of the ELL students that I've had in the last few years and the over-simplification of the lesson I may have been doing...it is good to be reminded of the fact that ELL students need [higher level] opportunities for discourse with their classmates to truly engage with the materials and develop their English proficiency (GAIn Protocol 3, week 3).*

The small-group discussions during the Card Sort Activity also indicated the teachers had developed affirming views of their own students over the course of the four weeks. During this activity's small-group discussion in Week 4, one Physical Science teacher stated:

> *Funds of knowledge really made me think about those students that I have traditionally viewed maybe as disengaged or maybe not wanting to learn has helped me understand what they bring to the table and how I can meet them where they are at (Card Sort Activity, week 4).*

Conjecture 2: Culture in teaching and learning.

Completion of GAIn protocols indicated teachers were highly reflective of their teaching and the presence or absence of CRP in their classroom practices prior to the course. For example, after watching a video recording of their classroom, one Physical Science teacher wrote, "*I honestly did not see myself searching for any students' points of view*" (GAIn Protocol 2, week 2).

In-class discussions and teacher reflections suggested that teachers recognized the importance of adding culturally responsive practices into their courses and analysis of their curricula indicate this was a high priority. One Physics teacher reflected that:

> *...when Western culture places value on science content knowledge separately from the cultural context that a student brings, there is a disconnect. If a student can't see himself or herself in the topic or how it relates to them, they are not motivated to learn it. In addition to that struggle, the culture of the home and the student's background plays a large role in whether or not that student even values success in the Western sense of the word (Reading Reflection, week 2).*

In addition to the teachers' recognition that a student's culture influences learning, teachers also identified science as having its own culture that can influence students' learning in the classroom—particularly that of their diverse students. During the Nature of Science Activity, one group of teachers identified the culture of science in the lesson they were analyzing as being:

> *Similar to the way [science] has been traditionally taught. Students are expected to bring their knowledge from outside the class, collect data, and then analyze their data to further their understanding of the scientific knowledge and make connections between the evidence and their lives (Nature of Science Activity, week 1).*

In the discussion following the activity, it was evident the teachers recognized this is not always a natural or easy process for students. One Chemistry teacher stated:

> *Students who are able to develop a meaningful context for absorbing new information based on their personal experiences are able to improve their critical thinking and problem solving skills...but, science curriculum is set in middle class white knowledge and culture, which students from lower socioeconomic and immigrant classes do not possess (Reading Reflection, week 1).*

Conjecture 3: Legitimizing Funds of Knowledge.

The Card Sort Activity, Reading Reflections and GAIn protocols demonstrated teachers' abilities and desires to add funds of knowledge to existing curriculum materials. The teachers acknowledged strengths of their existing practices (i.e., contextualizing content in real-life situations), but also found it important to extend beyond what they had previously done in their classrooms. For example, one Biology teacher indicated that:

> *I feel that I am good at giving students an opportunity to access their prior knowledge about subjects and discuss what they have seen or experienced in their own lives, but I could take that one step further and incorporate what I hear in mini-discussions with my students to improve their learning.*

Yet another Biology teacher reflected, "*I learned that it really is super important to try and make that connection and relationship with each student, but also to make a connection with their families*" (Reading Reflection, week 1).

Not only did the teachers seem to desire to extend their practices in ways that legitimized and made use of the students' funds of knowledge effectively, they also stretched themselves to come up with strategies to make this happen. One Physics teacher suggested "*utilizing resources within my school (teachers who are from the community and experienced science teachers) that might have some valuable insight*" (GAIn Protocol 3 - week 3). A second teacher suggested that

> *[In the past] I have found myself looking for a 'correct' answer and limited student discussion on the topic if it did not pertain to this correct answer. Upon looking at video of myself teaching I realized that I had stopped good critical thinking and scientific questions because I was looking for a correct answer that I had come up with. After reflecting I realized that my students had thought of new ways to answer the questions that I had posed to them based on their own experiences (GAIn 2, week 2).*

Conjecture 4: Sociopolitical Consciousness.

In addition to adding funds of knowledge, teachers felt compelled to extend their existing practices in such a way that they empowered students and raised critical awareness of social justice issues. For example, one Biology teacher reflected:

> *I need to be aware of the text that's found in society and the bias that comes along with it. Asking and encouraging students to think about the "why" behind rules and norms in schools and society helps engage students and gives them questioning and reasoning skills (Reading Reflection, week 3).*

Yet another Biology teacher reflected, "*This [conversation] is important to have because it's hard for the dominant group to relate to a situation from a viewpoint other than their own*" (Reading Reflection, week 3). It seems evident that the teachers felt compelled to alter their practices for reasons deeper than just that they "should."

In looking at how the teachers thought about their curricular modification, it was evident they were committed to improving incorporation of culturally responsive pedagogy (CRP) in their new science units. A Physical science teacher suggested that, "*Sociopolitical consciousness is one of the major areas I want to work on in this unit and I feel that the unit's topic offers up many cultural misconceptions [about chemical abuse] for my class…to learn about*" (Reading Reflection, week 4). Finally, a Life Science teacher reflected:

> *I took many of the Group-Level Repository findings into consideration as I was creating my unit. Although I have worked with Latino/a families extensively throughout my time in education, and even taught in a dual immersion school, I have never taken these findings into consideration in my teaching... according to a couple of [Latino/a Group-Level Repository] articles, maintaining, learning about, and celebrating culture can actually boost Latino/a achievement in school. I also noticed that the Group-Level [Repository] findings confirmed what I have heard from and know about my own students. Family is extremely important and comes first in the Latino/a community. Families are very close and often times either live together or close to each other. Another large theme is jobs...Although working hard is extremely important the articles also suggested that Latino/as are the largest group of undocumented workers in [this state] and many live in fear of deportation. Because of this fear there are many Latino/a families without health care or who do not receive services they need or could benefit from. To connect these Group-Level findings to my unit I will bring family experiences and culture into my lessons in the form of home interviews" (CRP Science unit).*

Through both ongoing conversations held with the teachers and evidence provided in their work, it was apparent that by the end of the course the teachers had developed more affirming views of their culturally diverse students, come to more fully understand the influence that culture has on teaching and learning, and recognized the importance of incorporating funds of knowledge and sociopolitical consciousness into their science curricula.

Design Challenges

Despite the successes we have shared, the first and second authors also encountered multiple challenges while implementing the course. We detail these here, accompanied by descriptions of teacher frustrations that led to identifying the specific design challenges.

Challenge 1: Teacher identity.

For many teachers, the topics and conversations in the course were new and emotionally overwhelming. At times, this led to conflict, such as when they discussed Derrick Bell's (1992) *Space Traders* story. In such instances, we allowed multiple perspectives to be voiced but had difficulty deciding when to intervene, especially if conflicting views were shared in a respectful manner. We experienced both success and failure at properly facilitating those moments so that they allowed for difficult, yet productive conversations. Additionally, though we built in collaborative brainstorming opportunities around curriculum design on multiple occasions, teachers largely worked in isolation while constructing their curriculum units. Though they stayed in close proximity to one another, most teachers wore headphones, worked silently, and generally only asked for input from the course instructors while writing. Given that curriculum design is extremely complex (Forbes & Davis, 2010), we had hoped that teachers would draw upon each other's strengths throughout the entire process.

Challenge 2: Striking a balance between transforming ideologies and providing pragmatic assistance.

As "fundamental orientations" (Villegas & Lucas, 2002) and "ideological anchors" (Gay, 2010) for culturally responsive teaching, science teachers must have asset-based attitudes toward their students of color and ample sociocultural awareness. This knowledge transcends content area teaching; thus, teacher education experiences focused on strengthening these core areas do not always have explicit content ties. For example, the *Privilege Walk* and *The Space Traders* story can be used with teachers from all content areas. As instructional designers, we firmly believe that our science teachers must engage in such experiences. However, this created a tension at times, as teachers wanted more "example lessons" of culturally responsive science education for their content areas.

We attempted to create a balance between ideology transformation (i.e., developing teachers' affirming attitudes and sociocultural awareness) and pragmatic assistance (i.e., providing exemplar CRP Science lessons). However, this was a constant challenge for us, as we personally felt that providing exemplar lessons to teachers before they had adequate foundational knowledge was irresponsible and possibly counterproductive to cultivating cultural responsiveness.

Challenge 3: Logistics of the teaching context.

Another challenge suggested by the teachers is not unique to the development of CRP in the classrooms, but one that impacts all classroom pedagogy. This challenge is that of the ratio of teacher to students in high school classrooms, and the difficulty that comes in learning to know all students well. One Chemistry teacher suggested:

> *My concern is that you can't learn that much from all your students. [In one of the readings] they showed how important it is to go to the family's home and meet the family and see the home life to learn more about the student, but how could you possibly do that with all your students? I try to do the best I can within my own classroom to get to know the students and make a relationship, but even then that is hard. I had a class of 39 students. It is very hard to do all that a teacher is expected to do and more with that kind of class size (Reading Reflection, week 2).*

Yet another (Physics) teacher stated:

> *As science teachers, we are expected to provide students with equal and equitable opportunities to not only learn science but to…obtain high levels of science literacy… which is something that I currently don't feel I'm able to do, and that frustrates me. How are we supposed to do that for every single student from every single background? I am trying to approach this challenge with an open mind but it is difficult since I do not have the opportunity to experience…all cultures (Reading Reflection, week 3).*

Challenge 4: Racial homogeneity of teachers.

Lastly, the most vexing issue does not have an easy solution. As indicated in Table 1 our teacher population was racially homogeneous, which at times appeared to hinder the surfacing and challenging of multiple perspectives. Aside from the first author, only one teacher of color actively challenged the dominant perspectives being shared in small- and whole-group discussions, which she reported as being emotionally exhausting. Related to the first challenge, we also struggled with how to elicit varied perspectives when those that were shared often closely resembled one another. This was something identified and acknowledged by teachers themselves. One Physics teacher indicated that

> *…it takes time and a great deal of effort to create curriculum that is relevant to students' lives and to their Funds of Knowledge, not to mention, teachers or curriculum designers need to be very familiar with students' common experiences in order for the connections made to be authentic and actually support their learning. Many teachers today are not ethnically diverse, even though they are teaching a diverse population, and they perhaps do not receive sufficient information about various groups' Funds of Knowledge, making it difficult for teachers to come up with examples, explanations, lessons, etc. that would be relevant and helpful to their students (Reading Reflection, week 2).*

These challenges highlight the difficulty of teaching a course focused on equitable science teaching—a concept that can be personal, emotional, and challenging for some teachers. However, they also provide insight into ways the course can be modified for improvement in future implementation.

CONCLUSION & FUTURE DIRECTIONS

Science teacher educators are faced with a grand challenge: to prepare equitable and reform-based science teachers. In response to concerns of science teachers feeling ill-equipped to educate culturally and linguistically diverse students (Lee & Buxton, 2010), we designed an induction course that blended theoretical foundations of culturally responsive pedagogy with practical applications in science-specific contexts. Applying principles of situated cognition (Brown et al., 1989; Putnam & Borko, 2000) to course experiences, we engaged teachers in collaborative and authentic activities such as critically reflecting on their classroom practices and student artifacts; problematizing science as it is traditionally taught in U.S. schools; experiencing, critiquing, and modifying CRP Science exemplars; and studying community-level funds of knowledge accounts. We were encouraged by course artifacts indicating that beginning secondary science teachers developed affirming views of culturally diverse students, demonstrated understanding of the influence of culture on learning, and designed curricula that integrated students' funds of knowledge and sociopolitical issues with rigorous science learning experiences. We experienced design challenges as well, leaving us to recommend the following course revisions.

Better Scaffolding of Difficult Conversations

As previously mentioned, at times we felt we could have better facilitated difficult conversations. Though we structured conversations through purposeful prompts, eliciting multiple perspectives, and involving teachers in crafting discussion questions, we sometimes struggled with adequately facilitating these discussions. To remedy this weakness, we suggest applying the dialogic conversation element of Rodriguez's (1998) sociotransformative constructivism model to better scaffold critical, productive discussions in future course iterations. According to Rodriguez, dialogic conversation:

> *moves beyond merely understanding what is being said to understanding the reasons why the speaker chooses to say what he or she says in a particular context. The dialogic conversation allows the listener/speaker to ask..."Who is doing the talking?" In other words, whose voice (insights, values, and beliefs) are being (re)presented by the speaker/listener? (p. 599)*

Structured dialogic conversations can provide "opportunities for open and intellectually honest communication" (p. 603) among teachers as they discuss social justice-related topics in the course.

Additional Curriculum Design Supports and Structures to Foster Collaboration

Though great care was taken to provide science teachers with curriculum development templates and helpful guides as they crafted their lessons, we did not ensure that the design process was collaborative. Given that some teachers chose similar science topics and focused on the same ethnic/cultural groups, we see the lack of collaboration as a missed opportunity. To teach in culturally relevant ways, as Mensah (2011) asserts, it was essential that the elementary pre-service teachers with whom she worked had "the support of diverse others (i.e., their pre-service teacher peers, course instructor, and cooperating teachers at the school) to exchange ideas and to engage in conversations that focus on student diversity, student learning, and pedagogical and content connections" (p. 307). When teachers plan in isolation, they may risk making superficial culturally responsive connections. In an investigation of elementary pre-service teachers' identification of and planning for funds of knowledge in science lessons for their field experiences, McLaughlin and Calabrese Barton (2013) noted that integration most often occurred as an engaging hook to begin the lesson, rather than through substantive connections.

Not all studies involving teachers as designers of culturally responsive science materials report similar findings, however. During a four-week summer course focused on multicultural science curriculum development, Suriel and Atwater (2012) required beginning secondary science teachers to develop curriculum units and provided them with an evaluation rubric aligned to Banks' (2015) typologies for guidance. The authors contended that having direct experience as a "marginalized 'cultural other' [was] principally crucial in developing teachers capable of highly multiculturally integrated curricula" (p. 1288), not collaboration. While we were pleased with the CRP Science curriculum units designed by our teachers, we aim to better support teachers in this process in the future. Though inconclusive, research suggests that collaboration during curriculum design may enhance the quality of the final products produced by science teachers.

We also have unresolved challenges. We are still wrestling with better balancing experiences focused on transforming core aspects of cultural responsiveness in our teachers (e.g., attitudes toward students of color) while satisfying their need for concrete science-specific instructional examples. Given that the course spans four weeks, there is limited time to tackle these monumental goals. While teachers in the PREPScI course series can continue inquiring about culturally responsive science education during the fall action research course, not all teachers enroll in it. Moreover, though optional, CRP-focused action research projects are not required in that course. Instead, teachers may inquire about any element of their classroom that is inequitable and important to them. Solutions to date have eluded us to some extent, despite a wealth of previous experiences among our design team and a growing literature base to draw from. Accordingly, we are of the opinion that this is an important challenge deserving explicit attention.

By sharing our experiences designing and implementing this four-week induction course for beginning secondary science teachers, we aimed to provide direction for teacher educators and others interested in advancing culturally responsive science education. In detailing successes and challenges, as well as suggestions for course revision, it is our hope that science teacher educators and professional developers might envision how such activities might be adapted for their specific contexts. Continued conversations between researchers, teacher educators, and others involved in advancing culturally responsive science teaching are crucial to the academic success of culturally and linguistically diverse student populations.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under grant no. DUE-1540789. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

Banks, J. A. (2015). *Cultural diversity and education.* London, England: Routledge

Bell, D.A. (1992). *Faces at the bottom of the well: The permanence of racism*. New York, NY: Basic Books.

Brown, J.C. (2012). *Contemporary issues in science: Genetics and society in the 21st century* (curriculum guide): Gainesville, FL: University of Florida.

Brown, J.C. (2014). *Designing for culturally responsive science education through professional development* (Unpublished doctoral dissertation). University of Florida, Gainesville, FL.

Brown, J.C., & Crippen, K.J. (2016a). Designing for culturally responsive science education through professional development. *International Journal of Science Education, 38*(3), 470-492. https://doi.org/10.1080/09500693.2015.1136756

Brown, J.C., & Crippen, K.J. (2016b). The growing awareness inventory: Building capacity for culturally responsive science and mathematics with a structured observation protocol. *School Science and Mathematics, 113*(6), 127-138. https://doi.org/10.1111/ssm.12163

Brown, J.C., & Crippen, K.J. (2017). The knowledge and practices of high school science teachers in pursuit of cultural responsiveness. *Science Education, 101*(1), 99-133. https://doi.org/10.1002/sce.21250

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42. https://doi.org/10.3102/0013189X018001032

Calabrese Barton, A. (2000). Crafting multicultural science education with preservice teachers through service learning. *Journal of Curriculum Studies, 32*(6) 797-820. https://doi.org/10.1080/00220270050167189

Carlone, H., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching, 48*(5), 459-485. https://doi.org/10.1002/tea.20413

Danielson, C. (2007). *Enhancing professional practice: A framework for teaching.* Alexandria, VA: Association for Supervision and Curriculum Development.

Ellis, J. A., McFadden, J., Anwar, T., & Roehrig, G. H. (2015). Investigating the social interactions of beginning teachers using a video annotation tool. *Contemporary Issues in Technology and Teacher Education, 15*(3). Retrieved from http://www.citejournal.org/volume-15/issue-3-15/general/investigating-the-social-interactions-of-beginning-teachers-using-a-video-annotation-tool

Emdin, C. (2010). Dimensions of communication in urban science education: Interactions and transactions. *Science Education, 95*(1), 1-20. https://doi.org/10.1002/sce.20411

Ferguson, R. (2008). If multicultural science education standards existed, what would they look like? *Journal of Science Teacher Education, 19*, 574-564. https://doi.org/10.1007/s10972-008-9108-5

Forbes, C.T., & Davis, E. A. (2010) Curriculum design for inquiry: Preservice elementary teachers' mobilization and adaptation of science curriculum materials. *Journal of Research in Science Teaching, 47*(7), 820 - 839. https://doi.org/10.1002/tea.20379

Furman, M., & Calabrese Barton, A. (2006). Voice in an urban science video project. *Journal of Research in Science Teaching, 43*(7), 667-695. https://doi.org/10.1002/tea.20164

Gay, G. (2010). *Culturally responsive teaching: theory, research, and practice* (2nd ed.). New York, NY: Teachers College Press.

Gay, G., & Kirkland, K. (2003). Developing cultural critical consciousness and self-reflection in preservice teacher education. *Theory into Practice, 42*(3), 181-187. https://doi.org/10.1207/s15430421tip4203_3

George, J. M. (2013). 'Do you have to pack?' - Preparing for culturally relevant science teaching in the Caribbean. *International Journal of Science Education*, *35*(12), 2114-2131. https://doi.org/10.1080/09500693.2012.760138

González, N., Moll, L.C., & Amanti, C. (2005). *Funds of knowledge: Theorizing practices in households, communities, and classrooms.* Mahwah, NJ: Lawrence Erlbaum Associates.

Gorski, P.C. (2009). What we're teaching teachers: An analysis of multicultural teacher education coursework syllabi. *Teaching and Teacher Education, 25*, 309-318. https://doi.org/10.1016/j.tate.2008.07.008

Hang, M., Thao, M.S., Xiong, M.B., & Vang, C. (2012, Mar 21). SoLaHmo: Building on cultural strengths for safe, healthy, & strong families and communities. *Hmong Times*. Retrieved from http://hmongtimes50.1upsoftware.com/

Hernandez, C.M., Morales, A.R., & Shroyer, M.G. (2013). The development of a model of culturally responsive science and mathematics teaching. *Cultural Studies of Science Education*, 8, 803-820. https://doi.org/10.1007/s11422-013-9544-1

Howard, T.C. (2010). *Why race and culture matter in schools: closing the achievement gap in America's classrooms*. New York, NY: Teachers College, Columbia University.

Johnson, C.C. (2011). The road to culturally relevant science: Exploring how teachers navigate change in pedagogy. *Journal of Research in Science Teaching, 48*(2), 170-198. https://doi.org/10.1002/tea.20405

Johnston, A., & Settlage, J. (2008). Framing the professional development of members of the science teacher education community. *Journal of Science Teacher Education, 19*, 513-521. https://doi.org/10.1007/s10972-008-9112-9

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491. https://doi.org/10.3102/00028312032003465

Laughter, J.C., & Adams, A.D. (2012). Culturally relevant science teaching in middle school. *Urban Education, 47*(6), 1106-1134. https://doi.org/10.1177/0042085912454443

Lee, O. (2004). Teacher change in beliefs and practices in science and literacy instruction with English language learners. *Journal of Research in Science Teaching, 41*(1), 65-93. https://doi.org/10.1002/tea.10125

Lee, O., & Buxton, C.A. (2010). *Diversity and equity in science education: Research, policy, and practice*. New York, NY: Teachers College Press.

McFadden, J.A., Ellis, J., Anwar, T., & Roehrig, G.H. (2014). Beginning Science Teachers' Use of a Digital Video Annotation Tool to Promote Reflective Practices. *Journal of Science Education and Technology 23*(3), 458-470. https://doi.org/10.1007/s10956-013-9476-2

McLaughlin, D.S., & Calabrese Barton, A. (2013). Preservice teachers' uptake and understanding of funds of knowledge in elementary science. *Journal of Science Teacher Education, 24*, 13-36. https://doi.org/10.1007/s10972-012-9284-1

Mensah, F.M. (2011). A case for culturally relevant teaching in science education and lessons learned for teacher education. *Journal of Negro Education, 80*(3), 296-309. Retrieved from http://www.jstor.org/stable/41341135

Mensah, F.M. (2013a). Theoretically and practically speaking, what is needed in diversity and equity in science teaching and learning? *Theory into Practice, 52*(1), 66-72. https://doi.org/10.1080/00405841.2013.743781

Mensah, F.M. (2013b). Retrospective accounts in the formation of an agenda for diversity, equity, and social justice for science education. In J.A. Bianchini, V.L. Akerson, A. Calabrese Barton, O. Lee, & A.J. Rodriguez (Eds.) *Moving the equity agenda forward: Equity research, practice, and policy in science education* (pp. 317-336). London: Springer.

Minnesota Historical Society. (2017). *Becoming Minnesotan: Stories of recent immigrants and refugees*. Retrieved from http://education.mnhs.org/immigration/

Morrison, K.A., Robbins, H.H., & Rose, D.G. (2008). Operationalizing culturally relevant pedagogy: A synthesis of classroom-based research. *Equity & Excellence in Education, 41*(4), 433-452. https://doi.org/10.1080/10665680802400006

Nasir, N.S., Rosebery, A.S., Warren, B., & Lee, C.D. (2009). Learning as a cultural process. In R.K. Sawyer (Ed.) *Cambridge handbook of the learning sciences* (2nd ed.) (pp. 489-504). New York, NY: Cambridge University Press.

National Research Council [NRC]. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board of Science Education, Division of Behavioral and Social Sciences and Education. Washington, D.C.: The National Academies Press. Retrieved from http://www.scimathmn.org/stemtc/sites/default/files/downloads/framework_for_k-12_science_education_final_0.pdf

Paley, V.G. (1986). On listening to what children say. *Harvard Educational Review, 56*(2), 122-131. https://doi.org/10.17763/haer.56.2.p775487x30tk69m8

Patchen, T., & Cox-Petersen, A. (2008). Constructing cultural relevance in science: A case study of two elementary teachers. *Science Education,* 92(6), 994-1014. https://doi.org/10.1002/sce.20282

Powell, R., Cantrell, S.C., Malo-Juvera, V., & Correll, P. (2016). Operationalizing culturally responsive instruction: Preliminary findings of CRIOP research. *Teachers College Record, 118*, 1-46. Retrieved from http://www.tcrecord.org/Content.asp?ContentId=18224

Powell, R., & Rightmyer, E.C. (2011). *Literacy for all students: An instructional framework for closing the gap*. New York, NY: Routledge.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15. https://doi.org/10.3102/0013189X029001004

Rodriguez, A.J. (1998). Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and understanding. *Journal of Research in Science Teaching, 35*(6), 589-622. https://doi.org/10.1002/(SICI)1098-2736(199808)35:6<589::AID-TEA2>3.0.CO;2-I

Roehrig, G.H., Donna, J. D., Billington, B. L., & Hoelscher, M. (2015). Design of online induction programs to promote reform-based science and mathematics teaching. *Teacher Education & Practice*, *28*(1-2), 286-303.

Sternberg, R. (2004). Who are the bright children? The cultural context of being and acting Intelligent. *Educational Researcher, 36*(3), 148-155. https://doi.org/10.3102/0013189X07299881

Suriel, R.L., & Atwater, M.M. (2012). From the contribution to the action approach: White teachers' experiences influencing the development of multicultural science curricula. *Journal of Research in Science Teaching, 49*(10), 1271-1295. https://doi.org/10.1002/tea.21057

Upadhyay, B.R. (2006). Using students lived experiences in an urban science classroom: An elementary school teacher's thinking. *Science Education, 90*(1), 94-110. https://doi.org/10.1002/sce.20095

Upadhyay, B. (2009). Teaching science for empowerment in an urban classroom: A case study of a Hmong teacher. *Equity & Excellence in Education*, *42*(2), 217-232. https://doi.org/10.1080/10665680902779366

Villegas, A.M., & Lucas, T. (2002). *Educating culturally responsive teachers: a coherent approach*. Albany, NY: State University of New York.

Wiggins, G.P., & McTighe, J. (2005). *Understanding by design* (2nd ed.) Alexandria, VA: Association for Supervision and Curriculum Development.

Zozakiewicz, C., & Rodriguez, A.J. (2007). Using sociotransformative constructivism to create multicultural and gender-inclusive classrooms. *Educational Policy, 21*(2), 397-425. https://doi.org/10.1177/0895904806290126