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Crafting multicultural science education with preservice teachers through service-learning

ANGELA CALABRESE BARTON

Many science educators, in the US and elsewhere, support the idea that all students should have fair and equal opportunities to become scientifically literate through authentic, real problem-based science education. However, this challenge requires teachers to find ways to help all students feel comfortable with, and connected to, science. Despite the general consensus around the ideal of science for all, science teacher education programmes have had little or no impact on preservice teachers' philosophies of teaching and learning, especially as it relates to serving underserved populations in science. In this paper, I explore community service-learning as one way of addressing the multicultural dimension of preservice education with the following three questions: In what ways does involving pre-service science teachers in community service-learning influence their views on multicultural science education, in theory and practice? What qualities of community service-learning make multicultural science education a realistic objective? How might service-learning be used to push our collective understanding of what an inclusive and liberatory multicultural science teaching practice could be? I explore these questions and propose further areas of research by using a case study involving service-learning from my own teaching-research with preservice students.

Many science educators currently promote the idea that all students should have fair and equal opportunities to become scientifically literate through authentic, real problem-based science education (American Association for the Advancement of Science (AAAS) 1989). For many US junior and senior high school science teachers, this would seem like a welcome challenge: most teachers love their subject, and choose to go into science teaching because they want to share that love with others. In one sense it is tempting to believe that enthusiasm and personal interest will be catching and that this alone will be enough to engage students in science. However, this is only sometimes the case. Usually, the way that science is represented in the classroom—and perceived by students, even when teachers believe they are presenting it in authentic and context-dependent ways—tends to alienate many students from science. For this reason, many science educators also see the call to promote scientific literacy for all as a daunting

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task. This challenge requires teachers to find ways to help all students feel comfortable with, and connected to, science.¹

In this paper, I explore community-service learning as one way of addressing the multicultural dimension of preservice teacher education by asking the following three questions:

- In what way does involving preservice science teachers in community-service learning influence their views on multicultural science education, in theory and practice?
- Which qualities of community-service learning make multicultural science education a realistic objective?
- How might service learning be utilized for our collective understanding of what an inclusive and liberatory multicultural science teaching practice could be?

As I explore these themes, this paper takes three turns. First, I provide an overview of current efforts to promote multicultural science education and service-learning in US teacher education. Second, I present a case study involving service learning from my own teaching-research with preservice students. Third, I use the data from my case study along with the issues raised in the literature review to discuss the dimensions of community-service learning which are important in helping preservice teachers enact their visions of multicultural science education.

Multicultural science education

Transforming science education into a multicultural practice is a loaded objective (Hodson 1993, Stanley and Brickhouse 1994, Atwater 1996). Stanley and Brickhouse (1994: 387) have argued that if science curriculum should be, in part, about teaching the nature of science, then science educators need to question ‘Whose knowledge are we teaching?’ and, ‘Whose knowledge is of most worth?’. These questions fundamentally challenge the nature of science as reflected in the traditional science curriculum because they imply that scientific inquiry is subject to the cultural contexts of those who perform it. Multicultural science educators have responded to these questions and pushed the debate surrounding multicultural science education forward along, in particular, three domains: disciplinary knowledge; pedagogy; and the relationship between science, society and students.

Disciplinary knowledge

Multicultural science challenges traditional, western boundaries around what constitutes the content, process, rules for participation, and discursive practices of science (Harding 1998). For instance, the process of constructing scientific knowledge is not a one-way system where the atomized self uncovers truths. Instead, from a multicultural perspective, scientific knowledge is viewed as being constructed from social acts where the

individual, who is at the same time a social being, interacts with society and culture in a distinctive way to create something (Gill and Levidow 1989, Haraway 1997). Furthermore, the production of knowledge is linked to the social uses of, and needs for, scientific knowledge (Young 1989, Harding 1998). This means that the knowing and the doing of science are historically-, socially-, and politically-situated processes. It also means that the context of science shapes the purposes and goals of science (Helms 1998). Haraway's (1989) study of primatology, for example, suggests that science is an on-going interaction among 'core narratives' shaped by political, economic, and cultural contexts that reflexively guide both observations and interpretation.

Pedagogy

There is widespread agreement among multicultural science educators that students need to have access to the domain of western science, even if it has little immediate relevance to the lives of those students who are on the margins of school science (Atwater 1996). However, such access must occur in ways that are culturally relevant to students; it is not enough to teach students rules for participation in science if those rules do not connect to the students' out-of-school lives (Rosser 1990, Rosebery *et al.* 1992, Ladson-Billings 1994). Multicultural science education supports pedagogical strategies that link ways of knowing brought to school by students such as caring, co-operation, holistic approaches and out-of-school activities even when those ways are not obviously part of science (Barton and Osborne 1995, Roychoudhury *et al.* 1995). Strategies which seek to incorporate communication processes that reflect the lives and cultures of students who may be present in the classroom, such as oral narratives and story-telling are also supported (Atwater 1996). However, from a multicultural standpoint, pedagogy is not only about teaching strategies—it also about the goals and objectives of classroom life. Thus, Mary Atwater (1996: 823) suggests science educators need to use—and help their students to use—a 'critical lens' to question how scientific knowledge is learned and produced, and the ways in which classroom practice links (or does *not* link) science education to the 'self' and 'social empowerment'. Indeed, social empowerment and sociocultural transformation are underlying tenets in multicultural science education (Rodriguez 1998). These ideals, focused on questioning the origins and construction of scientific knowledge and its link to self and society, are supported by the larger body of literature in multicultural education where it is suggested that teacher education programmes must include multicultural experiences, allowing students to analyse their attitudes and beliefs about the nature and origin of societal inequalities (King 1991). These ideals also reflect, to varying degrees, Banks' (1994) dimensions of multicultural education: content integration; knowledge construction; prejudice reduction; equity pedagogy; and empowering school culture.

Relationship between science, society and students

The final domain used to articulate multicultural science education is related to the relationship between 'science' and those who are supposed to be learning the science. Multicultural science educators believe it is important for all students to know and be able to do traditional science, since that is what schools and society measure. Most also agree that science and its uses in society ought to be critiqued and challenged, although the degree of such critique and challenge is contested. Thus, some argue that it is the teaching methods and the applications of science that ought to be challenged—not necessarily the underlying scientific concepts and principles (Lee and Fradd 1998), whereas others argue that the underlying science needs to be challenged as well (Gill and Levidow 1989, Osborne and Barton 1998, Helms 1998).

Multicultural science teacher education

Multicultural teacher education has been an aspiration in the US for many years. The National Council for Accreditation of Teacher Education (NCATE) adopted such a requirement in 1979, although recent NCATE analysis reveals that only 13.6% of certification programmes were in compliance (Gollnick 1992: 234). Furthermore, a series of studies have shown that many of the active multicultural programmes are ineffective (Haberman 1991, McDiarmid 1992, Goodwin 1994, 1997, Phuntsog 1995). Goodwin (1997: 118) suggests that one reason that this may be the case is that many teacher education programmes attempt to 'multiculturalize teachers in preparation bypass the questions and concerns preservice teachers have, concerns that emerge from their own experiences in the field'. Rodriguez (1998) points out that this is certainly the case in science teacher education. In fact, Rodriguez, and others (Atwater 1996, Osborne and Barton 1998) argue that even though we, in science education, have a developing knowledge base of (a) preservice and practising teachers' beliefs about science and the nature of science; (b) preservice teachers' concerns about teaching science (generally); (c) ideals of what constitutes 'multicultural' science; (d) ideals of what constitutes gender-, race-, and language-inclusive science teaching and learning (although very little of that also takes into consideration class issues); and (e) images of dilemmas that practising teachers and teacher educators have in enacting inclusive curriculum and instruction we have *not* found ways to have this agenda influence preservice science education. This last issue is further complicated by the realization that science education as a community does not have a clear idea of what multicultural science teaching and learning looks like in practice!

Using the research from multicultural science education and multicultural teacher education, it seems important for multicultural science teacher education to focus on four sets of issues and questions if it is to be successfully infused into science teaching and learning. These questions and issues are listed in table 1. The choice of the phrase, 'understand,

Table 1. Issues in multicultural science teacher education

Issue	Related questions and concerns
Understanding, critiquing and transforming disciplinary knowledge of science (content, rules for participation, discursive practices).	<ul style="list-style-type: none"> • What constitutes science? Who determines this? How does this currently operate within the scientific community? within schools? and how might this be changed? What histories and technologies are included? • Why should teachers acknowledge and reflect on multiple ways of knowing the world/science?
Understanding, critiquing and transforming pedagogical knowledge.	<ul style="list-style-type: none"> • What does a science teaching practice look like that is consistent with a broader conception of science? In what ways is it inclusive of the students' lived experiences? • How can a multicultural pedagogy benefit everybody regardless of gender, class or ethnicity? How can it serve marginalized students? How can it serve traditionally mainstream students?
Understanding, critiquing and transforming teachers understandings of histories', purposes, and goals of schooling	<ul style="list-style-type: none"> • What do teaching and teacher educators see as the purposes and goals of schooling in science? • In what ways are these beliefs influenced by educators' views of what constitutes science and knowledge of science?
Expanding teachers' cultural understandings and worldviews of societies, communities, schools, and children	<ul style="list-style-type: none"> • What are the implications of multicultural education for our society and its political and economic structure? • How can the discourse of diversity stand side by side with the discourse of equality? • How do we deal with the tension between promoting cultural diversity and cultural homogenization that takes place in the classroom?

critique and transform' in the questions listed in the table is intentional. If one goal of multicultural teacher education is to encourage teachers to reflect on their own beliefs and practices, then teacher education courses must encourage these habits of mind across content and pedagogy.

Community service learning in multicultural science education

Service learning has been defined as activities that combine classroom work with social action and service in order to promote development of students' subject matter knowledge, practical skills, social responsibility and civic values (Checkoway 1996). Service learning has been used as a tool in a variety of educational programmes to help participants gain personal experiences in unfamiliar situations. Although most US research around service learning has occurred in K-12 education, the literature points to the significant impact service has had on the improvement in the attitudes, motivation, and achievement of all students, including students at the college level (Barber *et al.* 1997). This, especially at the tertiary level, have been attributed to the ways in which these community service-focused

activities integrate life-experience with substantive and practice knowledge and skills. Recently, service learning has been given attention in teacher education programmes as one way to help preservice and inservice teachers learn, through experience, about the complex social problems encountered in schools (DeJong and Groomes 1996). Such learning is enabled by opportunities for preservice teachers to explore education in out-of-school settings, develop relationships with children and families in non-school contexts, learn about children as children rather than as students, develop ties with the community, develop social and interaction skills and, to gain greater awareness of other cultural and social norms and values as well as their own beliefs, strengths and weaknesses (Stachowski and Visconti 1998).

Yet, despite the impression that might be given by the attention service learning has recently received, in teacher education it is not new. Although not always referred to as service learning, the ideal of learning about children, the community and disciplinary knowledge—and the relationships among these areas—in informal educational settings, has been advocated by many of the most influential thinkers in education, including Dewey and Freire. As John Dewey (1963: 25) reminded us, the ‘experience’ in itself is not enough, whether it be a service learning experience or any other kind. The experience has been examined, understood, and challenged, thus providing some sort of intellectual and psychological continuity and growth.

In science teacher education, very little has been written about service learning. What there is, has focused primarily on the involvement of preservice science teachers in informal learning settings such as science museums, zoos and aquariums, community-based projects and summer and other camp programmes (Lucas 1991, Tuckey 1992, Crane *et al.* 1994). Such various forms of informal science education have contributed to helping preservice and practising teachers make connections to science in personal and professional ways, integrating science learning inside the classroom with science outside the classroom and with everyday life experiences (Crane 1994). For example, research into the science-technology-society curriculum integration efforts illustrate how involving science teachers in community-based questions and projects leads to classroom practices that promote inquiry-based science that is connected to a wide variety of students’ experiences, questions, and content (Yager 1996). Research into museum education shows similar results (Crane *et al.* 1994). For instance, teachers, parents, and children who participated in museum-based informal science activities tended to be more committed to teaching and learning activities and hands-on based science involving inside and outside the classroom dimensions than those who had not (Novak and Musonda 1991, Clewell 1992, Crane *et al.* 1994, Dierking and Falk 1994). These achievements, promoted by community-based service learning, are crucial in the science education community’s effort to realize the goal of a scientifically literate population because they influence teachers’ beliefs and pedagogical practices.

It would also seem that there should be a strong connection between service learning and the development of a multicultural science teaching practice among preservice teachers. Service learning provides teachers with

a community context in which to engage in collaborative science. This combination of service learning in science education across content, process and purpose makes an important distinction: it provides participants with opportunities to develop deep and meaningful understandings of the needs and questions of community members; it situates the doing of science within those needs and questions; and it authenticates the science being done. This is different from either 'service learning' or 'community science' alone because it involves and requires elements of both. Thus, we can speculate that such a community context could be vital in creating a multicultural science education because it forces the teaching and learning—and the knowing and doing—of science to occur in ways that are integrally connected to the participants.

The research study: creating multicultural science education through service learning

The concerns with service learning in science education have not yet focused on the role that it might play in facilitating a multicultural science teaching and learning practice among preservice science teachers. In particular, I am interested in the questions:

- In what ways does involving preservice science teachers in community service learning influence their views on multicultural science education, in theory and practice?
- What qualities of service learning make multicultural science education a realistic objective?
- How can service learning be used to push science education's collective understanding of what an inclusive and liberatory multicultural science teaching practice could be?

In light of these questions about and the arguments for service learning and multicultural education, I have attempted to introduce into my own work with preservice science teachers a service-learning approach as a vehicle for enacting multicultural science education. I have been teaching after-school and summer science in homeless shelters for several years utilizing a feminist-constructivist approach; I felt it would be useful to the children, the preservice teachers and me if we created a service-learning experience at the shelter.

Preservice science teachers in the science teaching programme, at a large US east coast urban university, were offered the opportunity to teach science collaboratively to children, after school, at a homeless shelter in a large metropolitan area in the northeast between 1996 and 1998. Preservice teachers who chose this opportunity were given course credit for the experience and, were required to:

- (1) meet with me, their course instructor and co-teacher at the shelter, each week to plan and to reflect on their developing teaching practice;
- (2) co-teach (with me and their peers) their designed lessons;

- (3) spend time with the children at the shelter in other kinds of activities in order to get to know them as individuals (rather than as science students);
- (4) create a science curriculum that was real problem-based, authentic and, most importantly, deeply connected to the community and the lives of the students within that community;
- (5) participate in discussions relating to our collective experiences and the literature around multicultural science education, urban education and, homelessness.

In other words, this particular effort attempted to bridge community service learning in content, process and purpose in order help preservice teachers co-construct multicultural science education.

This opportunity was offered across the three semesters to 24 students during the 1996–1998 academic years. All of the participants were full- or part-time students in the preservice programme in secondary science education (the preservice programme is a preparation programme for individuals seeking graduate-level education and teacher certification in the sciences for the middle and high school grades). The preservice teachers who participated in the course ranged in age from 21 to 33 years and had a variety of racial and ethnic backgrounds (white-American; black-North American²; Asian-American; Latino/a; South Asian).

The data collection strategies included the following. First, the preservice teachers participated in hour-long focus group conversations. The questions which guided the group centred on teaching in diverse settings, and in particular in settings where class, race and ethnicity were either diverse (mixed-class, mixed-race and, mixed-ethnicity classrooms) or where class, race and ethnicity were more or less homogenous, but largely outside the norms of the mainstream US (mainly classrooms reflecting high levels of poverty, and nearly 100% African American and Latino/a). Second, in two of the three semesters, each participating student was also interviewed individually before the start of the experience for 30–45 minutes to gather in-depth responses to the issues raised in the focus groups. During the experience, all participating students also kept a journal of their teaching experiences (the teaching journals were collected at the end of the experience). Third, inasmuch as I taught the course, co-planned and co-taught the science at the shelter with the students, I also collected detailed observer participant and supervisory fieldnotes. Finally, each participant (across the three semesters) was interviewed at the end of the experience by me or a research assistant in order to revisit the issues raised by the focus group, the first set of interviews, and/or their teaching experiences at the shelter.

The weekly planning and reflection meetings were designed to challenge current methodologies in traditional and multicultural science education and to create alternative possibilities for multiculturalism as content and pedagogy in the science classroom. For the participants this meant understanding and challenging the boundary between scientific investigations in the classroom and the cultural, social and, political worlds of students. In the weekly meetings, multicultural science education

was explored in two ways: (1) as an idea reflected upon, discussed, negotiated, created and re-created; and (2) as an idea enacted through collaborative lesson planning and implemented with children at a neighbourhood homeless shelter. The dialectic between reflection and action created a 'multicultural praxis' for the process of transforming curriculum.

Given the service learning objectives, a major goal of the weekly meetings was to provide a space for students to share their experiences and interpretations at the shelter; to provide space for students to challenge and support each other's experiences; to read and discuss papers related to homelessness, multiculturalism and science education as it directly related to their work at the shelter; and to collaboratively plan for and reflect on their teaching. Thus, although this was a university course, the primary focus was to provide students with scaffolded-opportunities to engage in crafting a multicultural science teaching practice through community service. The underlying belief of the course was that this sort of critical and scaffolded engagement in the community and community issues would challenge and expand students' beliefs about and experiences with multicultural science education.

Developing practising definitions of multicultural science education

According to the initial interviews, the preservice teachers entered the service learning experience with ideas about what constituted multiculturalism. Their ideas tended to centre on whatever needed to be added to the science teaching curriculum rather than questions about the nature of science or the nature of teaching and learning. Once the participants began teaching science at a homeless shelter they also began to question their own beliefs and attitudes regarding science, pedagogy, schooling, community and world-views. This alone is significant because it suggests that the preservice teachers' windows onto what constituted multiculturalism in science education broadened. Although, as the data described below will show, none of the preservice teachers left the guided teaching experiences with comprehensive ideas about what multiculturalism in science education means in practice, most of them left with a set of understandings framed through questions that could serve as a starting point for further exploration in their developing teaching practices. In particular, the students began articulating new ideas and challenges/tensions in the following areas:

- challenging the 'culture' in 'multicultural' through content and pedagogy;
- the place of uncertainty in connecting theory and practice;
- connections between multicultural science education and social and political issues.

In what follows I summarize the preservice teachers' developing beliefs around these major points.

Challenging 'culture' in multicultural through content and pedagogy

The preservice teachers' practising definitions of multicultural science education developed along the theme of culture—what culture means, its place in science and its place in the classroom. Many of the preservice teachers expressed criticism towards what they considered personal, narrow views of multicultural science education. Although the preservice teachers did not begin the course with the same definition of multicultural science education, most expressed the belief that multicultural science education was something additional to 'regular' or 'traditional' science education. Mary, a mid-20s Latina who emigrated to the US in her teenage years, summarizes this perspective when she described her initial view of multicultural science education as 'adding activities that showed how science was done in other cultures'. Linda, a white woman in her early 20s, offered a similar view. In reflecting on an early teaching experience at the shelter involving crickets and mealworms, she described this kind of 'culture-as-an-add-on' perspective:

I thought that having the children bake with crickets would be such a great multicultural activity because it involved eating insects like people do in many cultures. Now I wonder about all of the other pieces, about what that means to label eating insects as multicultural. [Sigh].

Both Mary's and Linda's comments also suggest that this 'culture-as-an-add-on' perspective uses a superficial definition of what constitutes culture.

The importance and degree of movement beyond a superficial definition and application of culture varied among the preservice teachers. The most conservative stance was held by a handful who felt that 'although culture should not be an add-on'; they had difficulty in enacting practices or articulating ideas that suggested otherwise. For example, one of the younger white-American women and one white-American man argued with the rest of the participants in a debriefing conversation that even though they 'believed culture isn't just making baskets, science concepts are proven, and it's all about finding useful and relevant examples to involve the students'.

However, the majority of the participating preservice teachers pushed past this conservative definition of culture to include 'ways of knowing', 'personal histories and experiences', and 'foundational positions for enlarging western science'. For example, Theresa, a young white woman described moving beyond a superficial account of culture in order to provide a basis for critiquing western science. In a post-participation interview she stated:

Rather than explaining [multicultural science] as an acknowledgment of other cultures, which seems to be to focus on the superficial aspects of race and religion, I perceive multiculturalism to embrace all perspectives while simultaneously empowering students and teachers to safely critique traditional paradigms of western science.

Theresa's reasons for critiquing western science were twofold: she wanted to value the experiences her students brought to science class or after-school science, even when those experiences 'were not part of science'. She also wanted to work hard with her students to make science out of experiences. These two actions on her part, she believed, would address the 'alienating' aspects of traditional science. She described her initial limiting view of culture as not allowing her to accomplish these multicultural science goals. Michelle, also young and white, articulated similar goals for using culture as a foundational position from which to challenge and critique traditional science practices:

It is not just adding tidbits to the curriculum. [Multicultural science] is shared. It is something that you share with other people because it is in the context of a classroom, at least for me as a teacher. This multicultural science is a way of thinking about things, challenging the status quo, challenging what you are told, challenging powerful influences.

Mark, a mid-20s white man, shared a perspective similar to that of Theresa and Michelle although, unlike the majority of the preservice teachers, Mark's experiences with the programme came after a year of teaching in a private school. He, too, challenged himself to think about culture more broadly as a way to push himself and seriously consider his students' out-of-school experiences. For example, during an interview while participating in the experiences he stated:

The differences between my teaching at the shelter and at school are clear. At the shelter we try to account for the different ways of knowing science, the ways our students come to know science and to try to construct an inclusive teaching practice by insisting that everyone participates, that everyone counts equally, and following the democratic process. The activities at the shelter take into account the children, their needs. Many other programmes do not consider the different ways of knowing science, the different ways our students come to know science, and the construction of an inclusive teaching practice. It sounds off and unsupported to say science educators do not account for these things. This semester has taught me how many young educators do not account for these things!

A small but significant number—seven of the 24—of the preservice teachers also used their increasingly complex vision of culture to re-orient their flow of thinking from 'bringing culture into science' to 'seeing science as a part of culture'. For this subset of preservice teachers, science became a site for questioning accepted ideas in science and for challenging students to think beyond the 'status quo'. For example, for Tammy, an Asian-American woman, multicultural science was about 'co-constructing science, culture and the individual'. And Carrie, a young white woman, said:

Now, I think [multicultural science education] is about a way of thinking about science and it's a way of doing science. It is open to alternative frameworks and also challenging. It's an open-mindedness. It's about pushing and challenging accepted, powerful ways of thinking about things, and challenging the ways we think about things we've always been told to.

This broadened sense of culture also seemed to have influenced several of the preservice teachers to shift to perceiving multicultural science education as student-centred rather than science-centred. This is a particularly significant shift because science teachers are often taught to keep science at the centre of science education (Osborne and Barton 1998). For example, Mary, a Latina, describes this point in terms of how she learned to make students—not science—central to her classroom:

While doing this field experience, my view of multicultural science changed. Originally I viewed 'multicultural' as looking at other cultures and their perspectives and what they have contributed to society. But through this experience Michelle said something that really struck me. It's not just the other cultures, but the kids themselves, and their cultures and their viewpoints in the classroom, their interests, their ideas.

Arzfan, a black man, describes a similar perspective, although he goes a step further to suggest that the teacher must allow him- or herself to be transformed by students' lives and experiences:

Well, my definition has been broadened. It has been enriched. As a teacher, if you are doing multicultural pedagogy, which I think all teachers should, I don't think you can separate multiculturalism; you cannot even call it multicultural pedagogy, because all pedagogy should be multicultural nowadays. [You] have to come to appreciate where your students are coming from, to appreciate your students' culture, to appreciate your worldview, to appreciate and then to really believe it—not just to create fake spaces for them, where they can, oh-yeah, do things, and then you know, feel like, oh-yeah, you did this just because he is coloured or whatever, he's black, or he's Indian, or whatever. But you actually participate in it too. You actually believe in what this child is doing—to actually enter their worlds, and to come to appreciate it, and that means letting go of your world, transforming yourself, and that's a big part of multicultural education.

Arzfan's point is extremely important. He made this particular comment in one of the debriefing conversations and his point about transformation was taken up by the larger group. He consistently pushed the group to think about multicultural education as 'transforming education', and that every part of that education from teachers, students, to science ought to be transformed through the 'understanding' and 'exploring' and 'valuing' of 'multiple cultures and worldviews'. In particular, Arzfan discussed the implications of how the level of a teacher's knowledge of a students' out-of-classroom experience can have radically different effects on the science curriculum as well as on the teacher's relationship with and understanding of a child:

Homelessness is definitely a subculture. I learned so much through this course, more than through anything else, that they do have a culture of their own. There are so many examples of people writing in their journals about how these kids were seeing nature completely differently from what a mainstream child might see or, you know, a child who is socio-economically better off, might see it completely differently. And these conceptions would get completely marginalized in a traditional classroom. They would get swept under the rug and these kids wouldn't have a voice. And I am now seeing

how important it is for teachers to listen to their kids. If we are studying plants, and this child wants to see the tree as a metaphor for homelessness, which one girl did [this summer], then so be it. I mean the teacher has to allow that space, has to get into that child's world, and understand why is this child seeing that tree as a metaphor for homelessness.

In short, the opportunity to practise multicultural science education at the shelter forced the preservice teachers to enact and reconsider head-on their ideas about multiculturalism in science education. When confronted with creating activities that reflected their developing beliefs, they responded with increasingly complex visions of what culture and multi-culture is in a community setting and, how these concepts might be most powerfully used with students doing science. Although not all of the preservice teachers moved beyond an 'add-on-to-science' vision of culture, the majority did, and in ways that significantly altered their pedagogical and content choices.

The place of uncertainty in connecting theory and practice

As the preservice teachers began to broaden their visions of multicultural science education, they also tended to become less certain of and more questioning of their knowledge-base and subsequent actions. As a feminist science teacher educator, I view this shift in a positive way. Historically, we are taught in school science that there are right answers and that to be a master of science, we need to know the right answer. Making a shift from knowing to not-knowing allowed the student teachers to be more inquisitive of science, the students and pedagogy; and to be more critical of their own actions, especially when their actions reflected a reversion to traditional teaching. Thus Carrie described her developing uncertainty in the context of authority in her own science classroom where she recently began her first year of teaching:

I think one of the things I remember the most, one of the conversations I remember the most from the summer [service learning experience] was a time when I was talking about how there was an inverse proportion relationship going on between the number of children you are dealing with and the amount of attention you pay to doing multicultural science; as the size of the group went up, my investment in sharing power, and my investment in being critical of ideas, and my investment in encouraging people to challenge me just plummeted like it; it totally went like graphic thing, I became more traditional in terms of authority, and the need for authority. Absolutely, I was desperate, grasping for calmness and attention! It happens now: I find myself saying things that I don't even believe. Patted-down version of the truth, it isn't even the truth, things that like we are doing parts of the cell, and they say things like 'What does this part of the cell do?' and I say like 'It makes energy'. What does that mean? make energy? But I am definitely, I am very surprised. I was very surprised at the shelter and at my job, how little time I actually spend on doing multicultural science, and how not-important it is. When I am there and the shit is flying. All right everyone, critique! Yah right, everyone listen to me! I sometimes do all of the things that, just all of the things that would make my skin crawl!

As was the case with Carrie, this uncertainty usually emerged when the preservice teacher was placed in a position of having to make a decision about what to do. Furthermore, this uncertainty was often focused around ‘what constitutes the science we are to teach’—as was the case with Carrie—but also ‘what is the responsibility of a teacher?’ For example, Alexis, a white woman who grew up in extreme poverty, had been working on a project about asthma for the children, in part because the children lived in a geographical area known for its high asthma rates. She also wanted the children to develop a ‘scientific understanding’ of the causes and sources of the problem so that they could begin to act on that knowledge. However, as she described to me, her impassioned goal, to help her students ‘uncover truths’, was questioned when she interviewed a community nurse:

I interviewed the head nurse at [the centre], and she raised some huge dilemmas for me as a teacher. She talked about the high rates of asthma . . . I was surprised she didn’t want the children to be educated about how air-quality affects asthma. I believe the reason was she didn’t want to add to their already considerable suffering. This raises the questions: Is it right to focus on the ‘truth’ even when its painful? I believe we must empower our children with the truth. Some of the children, if educated, might make life-choices that lead them to being politically active in environmental justice, or living in a place where the air-quality is good. But, it is a dilemma. Does the truth hurt, or do we cause more hurt by suppressing it as teachers?

This statement from Alexis, along with the earlier statement from Carrie, illustrates the power some of the preservice teachers found in uncertainty—for that position could be used to challenge seemingly straightforward teacher decisions. In Carrie’s case it allowed her to question her own comfort with a simple definition of energy. For Alexis it meant challenging what it is she really wanted her students to know about asthma and how she might help them know it. Arzfan, Mary and, Michelle described the personal and emotional dilemmas inherent in making the kinds of questions raised by this teaching stance. Arzfan described the dilemmas in terms of how far he was able to push himself as a teacher:

A transformation must begin deep inside of yourself, and I think, I’m not saying that I reached that, but I think a lot of what has helped me is the fact that I’ve been exposed to so many cultures in my life. And I think we need to start questioning that more deeply. You know, what are we doing? Are we really listening to these kids? Are we really entering their worlds? . . . I don’t think I entered their worlds as much as I wanted to. I think at times I was lazy, at times I felt ‘I don’t want to’. I think there is an element I might discover something I don’t want to know and I don’t want to deal with. I sometimes do that because I’m afraid I don’t want to know more about this kid because I get disturbed.

Mary also discussed her teaching dilemmas about initiating multi-cultural science education from students’ lives. However, her dilemmas were different from Arzfan. Instead of worrying that she would learn too much about her students, Mary worried that this approach would not help her meet her teaching objectives. She also worried that she would not learn enough about the children to make it worthwhile:

I don't feel that I incorporated [the students'] ideas into the lessons. For example, with the paper-making lesson, I don't think that I incorporated their ideas. When I sit down and think about, I think that it is something that I hold strongly, about wanting to make paper and recycle it in the classroom. And the way I felt at the beginning was that I wanted to show them that it was so simple, that anyone could make, that it doesn't require really extensive knowledge. It was more my view than anything of their's that I had noticed. But my reason for doing it was that I wanted them to be able to go home and do it as well, it was something that they could do outside of class ... I discovered in the field, it is so hard to figure out what the kids really like. Not just like, but what their ideas are. Especially in the classroom, and even in that setting where we worked with two kids, I don't really feel like I got to know them.

Michelle discussed the dilemmas in terms of her own sense of self, and how that was challenged through developing her multicultural teaching practice:

I think the biggest thing that changed was my understanding of teaching multicultural science education, and how different it is for me to sit here in the conference room and talk about it from being in a situation where you are trying to do that and trying live that way. Also grappling with my ego and vulnerability and administration and all other emotional things, and not even saying curriculum as if it wasn't a part of multicultural education.

In short, these situational uncertainties added depth to the preservice teachers' view of multicultural science education by merging practical challenges with theory. Although not all of the preservice teachers expressed such uncertainty, those that did began to ask the most difficult and self-challenging questions regarding what they know and the implications that this has for children and for their own sense of self. In Arfan's words, this kind of uncertainty is what will 'bring about the kinds of transformation required in multicultural education'.

Connections between multicultural science education and social and political issues

For the preservice teachers, multicultural science developed into something broader than the science to be learned or even the pedagogical strategies. It also became about social issues such as power, control, and school politics. Michelle and Theresa addressed the relationship between control, schooling and, multicultural science education:

I think the issue of control is an important issue for me because that is one of the things in multicultural science education, one of the biggest jobs as a multicultural science educator is challenging that idea that I have control over you or that my ideas are more important or more powerful or meaningful than yours, or I get to say something because I went to college. That is the root in some sense of the whole philosophical conversation, but there is a real thing, a real tension in the classroom. It's not the best thing; the best thing is not necessarily to come in without any lines, without any ideas about how things should be or how things are going to be regardless of what people bring to the table. I am still struggling alot.

The important point raised by Michelle and one that is characteristic of many of the preservice teachers' beliefs, is that there is a hierarchy of valued knowledge in society and in schools, and that the position of teacher automatically placed one within that hierarchy. A teacher's decisions about what is important and worthy of time in the classroom has immediate and lasting impact on how multicultural science education gets defined for children in schools. Theresa raised the question of control in a slightly different way. She, too, recognized that a teacher has the authority to value students' voices in the classroom and that this is significant in terms of building a multicultural science education; however, she was also afraid that if she shared authority she would somehow 'lose control' of her students:

In the future my pedagogical practices will echo with many of the beliefs of bell hooks. I recognize that silence in the classroom can be a symbol of complicity and should be challenged. I will focus on the fact that all my students have an invaluable voice that must be heard in some form. I wrestle with the issue of power, however, because I am terrified to lose control. Yet, I am coming intellectually closer with a safe and healthy balance of free dialectical exchange without losing authority.

The fear of losing control once authority and voices are shared in the classroom was one of the most powerful themes to emerge in my conversations with the preservice teachers throughout all three semesters. This dichotomy between shared authority and losing control was often reinforced through some of the preservice teachers' school experiences outside of the service-learning experience. For example, many of them mentioned how their co-operating teachers or department chairs consistently warned them 'not to smile before Christmas' or 'not to give the students the upper hand'.

Another dichotomy involving the relationships between culture, society, schooling and politics set up by all preservice teachers involved in this study was between 'regular' science education (and what children are expected to know and do) and 'multicultural' science education. The preservice teachers held onto a science education/multicultural science education dichotomy in two particular ways: what counts as (1) learning science and, (2) science curriculum. Ruth, for example, wrote in her journal:

Throughout the semester I have tried to iron out the ideas of multicultural science education in my mind. The enormity of implementing such a curriculum is overwhelming and confusing . . . But, I hope we had some effect on the kids [at the shelter]. Even if these kids did not learn any 'science' from us (which they definitely did), the reasons they had to what we exposed them to were with the time we spent at the shelter, both for us and for them.

In discussing this dichotomy, many of the students, in their own way, became conscious of the imposed nature of the dichotomy and worked to resist it in favour of a more holistic view of science education. Arzfan contrasted his experiences in student teaching with his summer experience to stress the importance of breaking down such a dichotomy:

There is a difference [between multicultural and traditional science] and there isn't one. There is one if the teacher wants to stick to traditional science, like, you know, 'This is a word and you're supposed to know in chemistry or whatever'. Then I think teachers have to start merging the two, so that there is no difference between multicultural science and science . . . I don't think that teachers should tear them apart because as soon as you do that, its like you are creating these fake spaces for students . . . For example, [in my student teaching], Mr. S. said, 'Oh yeah, this is what they do in Nigeria.' 'Oh, okay.' Now that is it. End of story. Or 'This is what they do in India.' 'Okay, fine, yeah.' Whatever, it's out of the way. I've shown my class what they do in India. I've done my bit for multicultural science now I can move onto the real thing which is what you are supposed to know.

Some of the reasons the teachers gave for finding it hard to resist such a dichotomy related to the politics of schooling. For example, this dichotomy seemed present in the preservice teachers' talk and actions even when they themselves did not want to believe it. They seemed to let things like the omnipotent 'schooling' and 'prescribed curriculum' rule their thoughts even before they had accepted teaching positions. Michelle described this position in terms of what her official teaching responsibilities are in the classroom:

I liked having a chance as a *not*-mature teacher to get in there and say I am not going to worry about it if everyone is bouncing off the walls; it doesn't matter because I am trying to see if I can do this thing [multiculturally] we are talking about, trying to really make it happen here and I don't know if I am going to have, definitely not in the public school, an opportunity to do that because I have responsibilities [to the school] that supersede my own interest to do multicultural science education.

It is important to note that Michelle did not connect her official teaching responsibilities (and hence traditional science) with multicultural science. This is different from the perspective expressed by Arzfan who said that 'true multiculturalism' would include 'all of the traditional science that students need to know'.

Despite the preservice teachers' adherence to this dichotomy, the majority of the preservice teachers were able to articulate a more integrated vision of science, schooling and society. In the interview quotations that follow, Arzfan, Michelle and Shazia describe, from slightly different viewpoints, the importance of the teacher in breaking down the barriers between science, schooling, politics and society. First, Arzfan discussed how starting science from a students' life-experiences can be an empowering tool to help children otherwise marginalized in school:

I think I've a lot more hope now. I used to think that [homelessness] was really a hopeless condition to be in, in the sense that I used to think that teachers probably can't do anything about homelessness. But I see now that multicultural education can be an excellent tool to change that. I think [as teachers] we need to enter the world of a child and to help them build a relationship with science . . . in a way that is meaningful to them. I think there's a lot of hope in that. There's a tremendous hope in getting these kids to maybe escape the cycle of poverty ultimately through that. Yeah, so I see a lot of hope now, before I didn't think that was possible. I didn't think that

teachers could do much. Now, I think really listening to these kids and what they want and what they are going through and to help them build those spaces where they can interact with science positively.

Michelle considered how teachers can help to break down the ‘regimes of truth’ enacted in schools. She equated the messages of schooling as vital in children’s lives because of the role of schooling in ‘sorting and labeling’ children and in providing credentials. Most importantly, she talked about how this is fundamentally a teacher’s responsibility, especially if that teacher embraced multicultural education:

I think it is important because school science is sort of a legitimator. It’s the institution in which people get their ideas about science. Where science comes from. What it means—that is where they get their ideas. It’s the institution of schooling, and with that huge responsibility comes. It’s important that multicultural science education becomes a part of how we think about teaching science because in my opinion it is a more real authentic and fair way of thinking about the way things actually work in the world. To deny it in school or education would be like a big, like lying, like doing a disservice in the world.

Shazia, a south Asian woman living in the US only for her graduate education, also discussed the role that the teacher in classroom has in legitimating knowledge. She stated that teachers needed to work with students to ‘get over’ issues of power and control before schools or society would be successful in embracing a multicultural science:

Does it make a difference if the modern science or another science has originated from China, India or Greece? It will remain knowledge and science, and to me, all of this is knowledge, regardless of origin, is science. The issue here is to label science one way or the other, but why to label? For authority, ownership and power. Can we own knowledge? Knowledge is knowledge for everybody, the more we explore, the more we learn. As stressed by Iqbal [the National Poet of Pakistan and a Muslim scholar], the world is expandable, you can explore it as much as you wish. Anyway, why waste time arguing the origin of science of science and who did what in which field? If people in the West don’t have the courage to acknowledge Eastern science, and if Eastern people can appreciate their contributions—I know it is a silly thought, but someone got to do it. As teachers, we have this great challenge, how to develop this attitude, looking over each others’ mistakes and to develop a sense of community through dialogue and discourse among this group of children.

All of the preservice teachers linked multicultural science education with social and political issues. This meant questioning what they were responsible for in their classroom teaching. For the majority of the preservice teachers this also meant seriously considering their role as teacher as other than ‘knowledge-disseminator’ and it also meant seriously considering their role in legitimizing various forms of knowledge and knowing, in breaking down issues of authority in the classroom and, questioning the role of schooling and science education in society.

Discussion: doing multicultural science education through community-service learning

The preservice teachers' experiences in the community-service learning project suggest both that these preservice teachers had enacted visions of multicultural science education and that service-learning experiences can help students refine and challenge their enacted definitions in three particular ways.

First, the service-learning experience provided preservice teachers with opportunities to reflect on science, teaching and students separate from 'schooling', and therefore, separate from their perceived expectations of schooling. This is important. As pointed out earlier, the preservice teachers often discussed the dichotomy between 'regular' science education and 'multicultural' science education. Although it is my hope this barrier will come down, it seems that the structures of schooling help to keep this barrier alive. This seems a particularly salient issue when working with a set of preservice teachers concerned with the content covered in state- and district-mandated curricula.

This separation between regular schooling and the service-learning experience also is important because it provided preservice teachers a place to 'play around' with their own understandings of the ways in which multicultural science education met the objectives of 'regular' science education. As Arzfan said, they had a chance to question and experience how 'multicultural science education [might] become regular science education'. This is important because their experiences constructing multicultural science education were then used to challenge their understanding of schooling. This was no easy task. As described earlier, through this experience the preservice teachers challenged their definitions of and uses for science, culture, student experience in their teaching. I question where such a risky practice as challenging ideas like these could have happened within the confines of schooling with its particular history and social structure.

For example, as I suggest in the opening sections of this paper, science as defined in schooling is a body of knowledge to be disseminated to students. This vision of science lacks the inquiry-focus found within the scientific community. It also lacks the links between the society and social context found in the practice of science. These are significant issues. Placing preservice teachers in a context *outside* of regular schooling opened doors for them to explore science in different ways with their students. The important point here is that this service-learning experience allowed the preservice teachers to explore the complexity of teaching and learning science across diversity—including definitions of science, students, teaching and learning—without the added complications of acceptable definitions of schooling (DeJong and Grooms 1996).

Second, the preservice teachers were able to work with children more informally. Although they still used the space of the service-learning project to write and enact curricula for children collectively, they also had the freedom to spend time with children individually or in small groups, to be flexible in their planning and activities (in terms of time and

location) and to feel comfortable disbanding a particular plan midway through the lesson because it was clearly not working. I believe that it was this kind of informal work with children that provided space for the preservice teachers to accept and use the position of uncertainty: They did not have the immediate worry of losing control of a real school classroom. They also could begin to explore how children, including children with life-histories they might have initially not known much about, might serve as the focal point of science education rather than a prescribed science.

For example, through the community service-learning project, the preservice teachers began to articulate their role as a teacher, and an awareness of how their beliefs about themselves, science, schooling and society influenced their relationship with children. In her journal, Tammy described this relationship in terms of having to move away from a science-centred to children-centred focus in multicultural science education:

In the lesson [about our trip to the park], we were supposed to ask our group about their feelings on nature. The origin of this question is so science-centric. It assumes that the students have feelings for nature and recognize their attraction to nature, if they have such an attraction, as feeling. Here, the direction has been constructed by the teacher. The question could just as easily have been 'What do you feel about Newton's theory of relativity?' Both of these questions are at equal risk for sounding foreign.

Arzfan and Michelle also described how a teacher's perspective is critical in creating a multicultural science education that is responsive to the needs of children. In particular Michelle suggested that, as a teacher, she had to take responsibility for understanding and integrating student experience into science and that she had to learn how to do this. Arzfan described how he had to critically examine his own beliefs about science, children and society, and how that impacted his intentions:

My main preconception I had when I went to the shelter was that the things that we talked about would be more perfectly made real. [I thought] it was just a matter of having the right intention. Well it's not just that that matters, but a big part of it is having thought about it and to have been critical in thinking about how you wanted something to go, or how you wanted this lesson to go . . . I think another very important change that took place was my idea of, umm, see I used to see these kids as violent because of their parents, I used to really blame the parents for their actions. And now, I'm beginning to see there are other causes that might be at play. You know what Michelle was stating that kids are kids and kids will fight no matter where they come from. . . . You know Carleen's mother was really special. She was a very wonderful woman and she sort of broke my stereotype of this woman who beats up their kids.

Third, the immediate challenge of working with an unfamiliar population, in this case homeless children, provided a context that opened up more forcefully the question of 'context' when doing science and when teaching. It was not easy for the students to be complicit with what they defined as 'regular' or 'traditional' science education in their constructions of science or teaching. Theresa, for example, discussed how a teacher's

experiences outside of the classroom influence how a teacher is able to relate to children or science inside the classroom:

We keep on stressing the importance of starting science from the students' experiences. I can see how this is really important, to make science connected to their lives, their experiences. But the other day I was thinking about how you also have to start with the teacher's experiences. I mean I was talking to my dad, and I told him I was doing this work at a homeless shelter in [this part of the city] and he said to me, 'I don't want you going to [there]!' and 'I didn't send you to Teachers College to have you endanger yourself in those parts of the city!' This is my father. I don't believe I have the same beliefs as him, but I was nervous the first day that I went, and I can see now how these kind of home experiences are influential. I mean, before I even met the children, I was, well, afraid of them and their community.

Jason discussed how a teacher's attitude and belief in children influences how he or she is able to relate to children and see children's emerging (and often surprising) relationships to the natural and designed worlds:

Towards the end of the session, when we were cleaning up the paint mess, Mac [a 6-year-old boy] was using up huge stretches of paper towels at a time. In addition, he was cleaning certain areas very thoroughly, going over them with multiple balled-up stretches. After the paper towels were completely unrolled, Van used the yarn he had been playing with earlier, as well as some ribbon he obtained, to construct a toy. Totally on his own, he found scissors, made a hole in one end of the tube, and tied the ribbon and yarn in place. To me, what I learned, was that this is an amazing example of Van's vision of what could be created by the materials available to him, of his resourcefulness in procuring the materials, of his focus in seeing the project through to completion, and of his independence in not seeking help for his mission nor praise in his accomplishment.

In short, the service-learning project provided these preservice teachers with opportunities to explore education in out-of-school settings, develop relationships with children and families in non-school contexts, learn about children as children rather than as students, develop ties with the community, develop social and interaction skills, and gain greater awareness of other cultural and social norms and values as well as their own beliefs, strengths, and weaknesses. Furthermore, this occurred in ways that did not bypass the questions and concerns preservice teachers have, concerns that emerge from their own experiences in the field, a critical component of meaningful multicultural education (Goodwin 1997, Rodriguez 1998).

Conclusions

This study shows some ways in which teacher education programmes can not only prepare teachers to teach all children but also continue to push the boundaries on what teaching might look like. This project engaged students in service-learning as one way to begin to help students imagine what constitutes multicultural science education in content and pedagogy, a difficult thing to do since there are relatively few examples of what this

looks like for students to model. However, designing inquiry-focused service-learning projects might provide science teacher education students with opportunities to construct new ideas about teaching science for all without all of the mental and physical constraints of schooling.

However, this project opens up new questions and challenges that must be responded to in order to move forward, to create 'science for all' in schools. Specifically, we must face the question: how can we promote multicultural science teaching in schools? This service-learning project occurred outside the schools. The preservice teachers recognized this distinction in that they felt that schools placed many more requirements on what they could and could not do. Follow-up studies need to be done to understand the ways in which this kind of experience may have had (or not had) long-term impact on the participants' teaching of science, especially that teaching which occurs within schools.

We must also face the question: is it possible to provide all preservice teachers with this kind of intense service-learning experience? The case study involved only eight preservice teachers. All of the participants said that they would not have wanted the number of participants to be any larger because of the sheer amount of time needed for the personal, and challenging, discussion in the seminar. As the course instructor, I also would not have wanted the course any larger because it would have been impossible to provide the kind of support for the students in the field that I was able to provide eight students. It would have also been difficult to manage more than eight adults in the same 'learning setting' with 15 to 20 children. In response to this question, we need to figure out more and different ways to provide preservice teachers with out-of-school, yet still guided, collaborative opportunities to craft multicultural teaching practices in science.

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Notes

1. Despite the general consensus in the US around the ideal of science for all, science educators have been largely unsuccessful in transforming the traditional curricular and pedagogical strategies of science education to ones that are inclusive of all students (Atwater 1996, Osborne and Barton 1998). Teacher education programmes have had little or no impact on preservice teachers' philosophy of teaching and learning, especially as it relates to serving underserved populations in science (Rodriguez 1998). In fact, teacher education programmes are often populated with students resistant to deep exploration of racist and other socially oppressive classroom practices (Rodriguez 1998).
2. The phrase 'black-North American' is used at the students' request because the African-American was not a phrase that they felt was inclusive enough because of the combination of origin ethnicities (Canadian, American, Caribbean, and African).

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