Chapter 4
Equity, Diversity, and Social Justice in Science Education

LEARNING OBJECTIVES

• Construct a framework for equity, diversity, and social justice.
• Explore how marginalization and identity affect teaching and learning science.
• Explore Aboriginal world views in the context of science education.
• Identify and describe border crossings for students.
• Summarize the foundations of social justice in science education, including culturally relevant pedagogy and teaching.
• Explore social justice issues and resources for science curricula.

What does science have to do with social justice?
—Kim, preservice teacher candidate

I don't think science and social justice are compatible—science deals with facts and social justice is about feelings and emotions.
—Zu-Zhang, preservice teacher candidate

In science we learn about communities.
—Lilly, Grade 1 student
INTRODUCTION

Teaching for social justice is an educational choice that has implications for students and for curricular resources. What is the place of social justice in science education? There is controversy about what to include in contemporary science programs. Conventional teaching of science most often includes, according to Hodson (2003), “dealing with established and secure knowledge, while contested knowledge, multiple solutions, controversy, and ethics have been excluded” (p. 664). Science teaching that is grounded in social justice takes into account multiple perspectives, treats all knowledge as potentially problematic, and addresses issues of power.

Social justice includes values, ideologies, and practices that can be applied to individuals, groups, communities, or institutions such as schools as well as to society in the broader sense. Social justice is referred to as the elimination of behavioural and institutional barriers, including prejudice and discrimination, that preclude equality of opportunity, freedom, and choice (Sen, 2009). “It is about the right treatment of others and the fair distribution of resources or opportunities” (Reiss, 2003, p. 160).

There are aspects of school science that propagate science as elitist and powerful without problematizing how it can be used to reproduce the status quo in our society. Social justice science education questions structural barriers in society that prevent some students from succeeding in school (Gitari, 2003). It is not, and does not try to be, neutral, as decisions in education are never neutral, but rather are laden with the hopes, fears, beliefs, and culture of those who create the curriculum. Social justice science education is instead a more holistic representation of science, going beyond the facts of science to an understanding of the influences, power structures, and privileges that contribute to knowledge construction. Social justice science pedagogy helps students to understand the power and influence of science in our world, and to explore social justice and social responsibility issues related to science.

In this chapter we explore how to confront and change exclusionary practices when teaching science. Social justice issues can make science education richer, more equitable, and accessible to all. We will revisit some ideas from Chapter 2 about NOS and how it can encourage all students to see themselves as part of science. The chapter also explores pedagogy, identity, urban education, marginalization, Aboriginal education, and the development of an equity lens.

A FRAMEWORK FOR EQUITY, DIVERSITY, AND SOCIAL JUSTICE IN SCIENCE

Have you ever wondered why some children love science and others do not? Some of you may have enjoyed science in school. What were your reasons? What was engaging about it? You might have liked learning about how it impacts many aspects of life, from health to energy production and how chemicals in our environment affect us at work and home. Was your teacher welcoming and respectful? Did you enjoy conducting investigations? Were they relevant to your interests? What can teachers of science do to develop programs that invite students to participate in science in the classroom and outside of school?

Using a framework of equity, diversity, and social justice for planning science curricula can be helpful. At the heart of such a framework are the needs and aspirations of all students, including those who are marginalized. It incorporates NOS, acknowledges the bias within the discipline of science, and addresses issues of power and control. Such a framework prompts us to be more attentive to multiple perspectives in content choices we make and to include examples that present science as sometimes beneficial and sometimes implicated in injustice (Gill & Levidow, 1987). The framework shown in Figure 4.1 (inspired by Hodson, 1993) is organized into three parts that inform teaching: 1) interactions with students; 2) curriculum choices and examples; and 3) bias.
1. **Interactions with Students** In their daily interactions with students, teachers aim to create a positive classroom climate. This includes being respectful of students and providing an ethic of care; acknowledging diverse needs and accommodating student learning styles; recognizing cultural differences and Aboriginal status, race, class, gender, sexual orientation, and ability; and giving students opportunities for choice and control. (Please see Chapter 6 for a more comprehensive discussion of creating a positive classroom climate.)

2. **Curriculum Choices and Examples** As teachers plan their lessons around specific topics, they are faced with myriad decisions. These include choosing resources, selecting examples, identifying how our choices include or exclude students, demystifying the knowledge construction process, promoting content that will help students enter the subculture of science, and making modifications to the curriculum depending on student needs and interests. (See Chapters 6 and 7 for a more comprehensive discussion of curriculum design.)

3. **Bias Within the Discipline** Every academic discipline has inherent biases. Knowledge construction is never neutral; it is always context driven. All knowledge construction happens within the contexts of society, culture, time, and place, and, as James Banks (1996) notes, “students should be given opportunities to investigate and determine how cultural assumption, frames of reference, perspectives, and the biases within a discipline, influence the ways knowledge is constructed” (p. 169). It is important for teachers of science to understand these biases, recognize that science knowledge is created within a social context, and explore how science knowledge does or does not become part of school curricula.

**ACTIVITY 4.1**

**Using the Framework for Equity, Diversity, and Social Justice**

It may be difficult to envision the equity framework in action without seeing students in the classroom setting. For this activity, your instructor will make available a video recording of a science lesson. Watch the video and, in groups, critique it with respect to the equity, diversity, and social justice aspects.
Part 1 A Vision for Science Education

Social Justice in the Digital Age

In 2007, the General Assembly of the United Nations proclaimed February 20 a World Day of Social Justice. The UN stated that “observance of World Day of Social Justice should support efforts of the international community in poverty eradication, the promotion of full employment and decent work, gender equity and access to social well-being and justice for all” (United Nations, n.d.). The World Day of Social Justice encourages us to work toward removing all forms of exclusion. In our rapidly changing world, access to technology allows the inclusion of more people, more often, in more ways. However, it is important to note that digital exclusion and marginalization can be barriers to achieving social justice. (See www.infoxchange.net.au/news/social-justice-digital-age.)

Although print materials continue to be used in schools, as we move into the 21st century technologies are becoming more widely used in many aspects of teaching science. (See also Chapters 1 and 8.) Within the context of this chapter, think about how technology can be related to justice issues. For example, we should question practices such as pairing students who have smartphones with those who do not in order to complete a science task, or assigning work that must be done at home on the assumption that all students have access to a computer or the internet. Schools that are committed to social justice must equip classrooms and teachers of science with appropriate technology so that all students can participate and succeed.

MARGINALIZED STUDENTS AND ISSUES OF IDENTITY

Terms such as urban, inner city, or at-risk are used in different ways. Sometimes, when used to describe students, they imply low socio-economic status and racialization. Lack of access to resources, living in poverty, and low academic performance can lead to reduced achievement. Students, regardless of whether they live in the inner city, in suburban areas, or in rural areas, can face marginalization in science classrooms and run the risk of failing or dropping out. Often, such students are labelled as at-risk and are at the centre of a deficit discourse in education.

Teachers often view science as special and requiring unique qualities from students in order for them to succeed (Prime & Miranda, 2006). James (2012b) examines, for example, how stereotypes operate in the social construction of African Canadian males as at-risk students, while Emind (2011) writes about the state of urban science education and African-American males’ experience within it. After exploring underachievement, low participation, and, for some, dropping out, Emind says,

Teachers in urban science classrooms enact pedagogical practices that they believe are best for their African-American male students despite the fact that these practices are subversive to larger societal goals surrounding effective science education. These practices are triggers for the academic disinterest of African-American male students in school and science, and issues seemingly separate from science education, such as culture, rituals, identity, and stereotypes, may ultimately trigger changes to the exclusionary nature of the discipline. (p. 76)

DISCUSSION QUESTIONS

1. What aspects of the framework were evident in the video?
2. Describe examples of inclusive teaching.
3. In your teaching experience, recall and describe an instance where your teaching reflected one or more aspects of the framework.

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As educators navigate issues of underachievement, it is important to be aware of how they are constructing student identity based on generalities and stereotypes. It is equally important to remember that a particular student may not represent the group with which the student is identified.

**Student Identity and Diversity**

Science has historical and contemporary connections to issues of identity such as race, gender, and sexual orientation (Willinsky, 1998). When we say a diverse group of students, what do we mean? Teachers must consider the impact of racism, classism, sexism, homophobia, and ableism on their students’ lives. Educators would do well to reflect upon how they understand diversity, and whether they see it as something that needs to be changed, ignored, or recognized as a strength (Cochran-Smith, 2003; 2004). Teachers of science have the unique opportunity to address issues of diversity within the context of the curriculum, while exploring how humans interact with the natural world.

McLaren (1998) contends that teachers and researchers must understand the complexity of diversity and its relationship to curriculum construction. Diversity is understood to be individuals having, among other factors, identifications related to Aboriginal heritage, language, race, ethnicity, class, gender, and sexuality. Diversity must be understood in terms of its implications for individuals and for society. A re-envisioned science curriculum has the potential to allow students to see themselves in their lived realities. Students can be inspired and motivated to engage in science, and to study science beyond compulsory requirements.

A body of research explores student identity formation in the science classroom (Brickhouse & Potter, 2001; Carlone & Johnson, 2007). For example, Costa (1995) gathered qualitative data on 43 high school students enrolled in chemistry or earth science in two schools with diverse student populations. She concluded that, despite a range of descriptions of student worlds and science, there were distinct patterns of relations between students’ worlds of family and friends and their successes in school science. Costa describes these patterns and creates five categories: potential scientists; other smart kids; “I don’t know” students; outsiders; and inside outsiders (see Table 4.1). Although the context of Costa’s study was a high school, her findings have implications for all students.

Aikenhead (1996) used Costa’s categories to help clarify the curricular implications of a cultural perspective for science education. These consequences for teaching are also summarized in Table 4.1.

**Table 4.1 Student Identities in Science**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Consequences for teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Scientists</td>
<td>Worlds of family and friends are congruent with worlds of school and science.</td>
<td>These students enjoy the challenges of the academic subject matter.</td>
</tr>
<tr>
<td>Other Smart Kids</td>
<td>Worlds of family and friends are congruent with world of school but inconsistent with world of science.</td>
<td>These students prefer to engage in creative activities that require self-expression and human interactions.</td>
</tr>
<tr>
<td>“I Don’t Know” Students</td>
<td>Worlds of family and friends are inconsistent with worlds of school and science.</td>
<td>These students see science classes as no different than other classes at school. They may have learned to play the school game of passing a course without understanding the content. They do not care to replace their commonsense conceptions with self-constructed scientific knowledge or to engage in scientific inquiry other than going through the motions of getting the right answer.</td>
</tr>
</tbody>
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Teacher Identity

In order to fully understand teaching practices and decisions that are made with respect to curriculum development and implementation, teachers can begin by interrogating their own identity and factors that influence their identity formation (Grant & Zeichner, 1995). How we teach is a result of who we are. There is a robust body of literature that examines how teacher beliefs influence what science they teach and how they teach it; this literature is explored at various points throughout this book (see, for example, Brickhouse, 1990, and Mulholland & Wallace, 2001).

Identity is a relationship of characteristics that make you who you are. (See Figure 4.2.) These factors are often dynamic in meaning and emphases, and they interact with each other. In order to explore your identity in relation to specific categories and other personal factors, such as volunteer service, use Activity 4.3 to create an identity wheel (Figure 4.2; adapted from Lee, 1985; see James, 2010, for a more contextualized identity wheel).

ACTIVITY 4.3
Create an Identity Wheel

Create an identity wheel like the one in Figure 4.2 and display as many factors as you wish to include about yourself. Share your wheel with a peer and describe your factors. Choose two factors and speculate as to how they might influence your work both as a general elementary school teacher and as a teacher of science.
DISCUSSION QUESTIONS
1. What aspects of your identity do you think will most influence your teaching practice? Explain.
2. What aspects do you think will least influence your practice? Explain.
3. Describe how you relate to people who are not like you.
4. How might different teacher identities within your school influence curriculum and collegial planning?

![Identity wheel]

Figure 4.2 Identity wheel

EXPLORING ABORIGINAL SCIENCE EDUCATION AS A SOCIAL JUSTICE ISSUE

Issues of power and access are interwoven with the needs, identities, aspirations, and achievement of Aboriginal students. The underrepresentation of Indigenous students in senior high school science and in science-related careers is complex, with many factors (for example, generations of colonization) undermining support for students’ education (Aikenhead & Michell, 2011). Teachers of science can positively influence this underrepresentation by creating a science classroom experience that respects cultural identities and infuses Indigenous knowledge within the curriculum.
Western science can conflict with the cultural beliefs of Aboriginal students, who might view science instruction as an attempt to assimilate them into the dominant culture (Aikenhead & Michell, 2011). When Aboriginal students feel excluded or experience “a cultural mismatch, between the values and philosophy of western science (particularly as these are typically exemplified in the classroom) and the values and philosophy held by many Aboriginal people and communities” (Canadian Council on Learning, 2007, p. 2), they can become marginalized from science curriculum and instruction. For example, Aboriginal peoples may view nature as a spiritual whole that is sacred and connected to all other things, whereas western science often reduces nature to a system of component parts that can be manipulated. (Aboriginal world views about nature are explored in more detail in Chapter 3.) The implications of conflicting world views in the classroom include the following:

1. Aboriginal students accept a western science world view and abandon Aboriginal values.
2. They learn western science in a superficial way to avoid threats to their identity.
3. They avoid learning science at all and often fail or drop out of science. (Canadian Council on Learning, 2007)

It is incumbent on educators to be respectful and inclusive of diverse world views in order to help students navigate multiple perspectives.

**ACTIVITY 4.4**

**Aboriginal Science Education: Provincial Perspectives**

Some jurisdictions have specific statements regarding goals and priorities for Aboriginal education and Aboriginal science. Four examples are detailed below. Some aspects of these policy statements intersect with the framework for social justice education described on page 61. Read each and answer the discussion questions at the end of the activity.

**Ontario First Nations, Métis, and Inuit Education Policy Framework**

The Ministry of Education has identified Aboriginal education as one of its key priorities, with a focus on meeting two primary challenges by the year 2016—to improve achievement among First Nation, Métis, and Inuit students and to close the gap between Aboriginal and non-Aboriginal students in the areas of literacy and numeracy, retention of students in school, graduation rates, and advancement to postsecondary studies. The ministry recognizes that, to achieve these goals, effective strategies must be developed to meet the particular educational needs of First Nation, Métis, and Inuit students. (Ontario Ministry of Education, 2007a, p. 5)

**Science 5**

The aim of K–12 science education is to enable all Saskatchewan students to develop scientific literacy. Scientific literacy today embraces Euro-Canadian and Indigenous heritages, both of which have developed an empirical and rational knowledge of nature. A Euro-Canadian way of knowing about the natural and constructed world is called science, while First Nations and Métis ways of knowing nature are found within the broader category of Indigenous knowledge. (Saskatchewan Ministry of Education, 2011, p. 6)

**Science K–7 Integrated Resource Package**

The incorporating of Aboriginal science with western science can provide a meaningful context for Aboriginal students and enhance the learning experience for all students. The inclusion of Aboriginal examples of science and technologies can make the subject more authentic, exciting, relevant, and interesting for all students. (British Columbia Ministry
Finding resources to broaden knowledge and enhance teaching can be a challenge. Refer to your provincial policy documents as well as resources such as The Cultural Divide in Science Education for Aboriginal Learners from the Canadian Council on Learning (2007), available online at www.ccl-cca.ca/CCL/Home.html, to help you develop an inclusive science education for Aboriginal students.

Consider the following two scenarios and reflect upon:

1. the topics usually included and excluded from science class
2. the consequences for Aboriginal students of experiencing an exclusively western science education
3. how a student’s world view may be at odds or may be interwoven with the world view of western science

Beaver

Cree hunters and their organizations have held management authority over beaver in northern Quebec since 1975. The Cree hunters have been able to combine their own traditional approach to monitoring beaver populations with a complementary Western science approach in order to generate accurate beaver population measures covering enormous geographic areas. The Cree hunters are skilled at determining the proportion of beaver lodges in a given area that are occupied. On their own, though, they have no way of generalizing this information over the full expanse of their vast territory. Conversely, the provincial resource managers can provide aerial survey data giving an accurate count of the number of beaver lodges over a large area, but these data provide no information concerning the number of lodges actually occupied. Combining these two approaches to population monitoring yields precise counts over large areas. (Canadian Council on Learning, 2007, p. 7)

Titi Chicks

In New Zealand, rakiura Maori harvest titi chicks every fall. Through years of observation, rakiura Maori titi harvesters have noticed that chicks tend to be fat during years of high abundance and thin during years of low abundance because chick size and abundance both depend on the adult birds’ ability to feed their chicks. Recently, however,
titi harvesters noticed surprising occurrences in which there were small numbers of fat chicks. When the harvesters drew attention to this event, Western scientists began using state-of-the-art technology to track adult titi over their trans-equatorial migrations in order to identify the causes of the event. Combining aboriginal knowledge of normal titi patterns with Western technology for studying aberrations in these patterns allowed scientists and titi harvesters to discover that titi were suffering from the effects of global climate perturbations. (Canadian Council on Learning, 2007, p. 7)

How might teachers of science help students to navigate diverse world views while maintaining their own cultural identities?

**FIXED BORDERS/FUZZY BORDERS: BORDER CROSSINGS**

The metaphor of border crossings (Giroux, 2005) can be useful in understanding what some students experience during a science class—it can feel as though they have crossed a border into a foreign place. Some students feel as though they do not belong, cannot speak the language, and do not understand the customs. For example, students who identify as something other than male or female may find their identities excluded in science curriculum materials (Bazzul & Sykes, 2011), or students who have had a refugee experience or have been displaced for other reasons may feel alienated from school (Bash & Zezlina-Phillips, 2006). Aikenhead (1996) categorizes the process of “border crossing into the subculture of science” as smooth, managed, hazardous, or impossible (see Table 4.2).

Many students dislike science, never opt in, opt in half-heartedly and may not develop deep understandings, or opt out as soon as their compulsory requirements are met. Opting out of science education can limit students’ future possibilities. Additionally, society misses out on the wider range of perspectives held by these students that may inform future science practice. To help students navigate the different worlds they inhabit, Calabrese Barton (1998) suggests blurring the fixed borders between cultures:

> If the borders of science are expanded or made fuzzy, then there will be more room to fit children’s experiences that cannot be neatly labeled as science. Valuing these experiences shifts the dynamics of what counts as science and who can do science because children would not have to silence certain experiences or feelings traditionally labeled outside of science. (p. 386)

An expanded view of science education is essential to the challenge of empowering students to successfully cross borders. Table 4.2 revisits the student categories described in Table 4.1, focusing on the relationship of student profiles to border crossings. As you study the table, ask yourself what strategies might make science less foreign and border crossings smoother and easier to navigate.

**ACTIVITY 4.5**

**Read and Reflect: Border Crossings**

This chapter highlights some of the ideas from Glen Aikenhead’s (1996) paper on border crossings as a way to think about how students participate in science and the implications for social justice issues. We encourage you to read the entire paper: Aikenhead, G. S. (1996). Science education: Border crossings into the subculture of science. *Studies in Science Education*. 27(1), 1–52. We also refer to this paper in Chapter 12. As you read the paper, think about the ways that students experience border crossing in science and how we can help them navigate difficulties.
Foundations for Social Justice in Science Education

Social justice is important in science for two separate but overlapping reasons: a) the power of science and its relationship to access and inclusion for students of all cultural backgrounds and b) the selection of science topics and examples of a social justice nature that affect individuals, communities, and society.

Social Justice and Issues of Power, Access, and Inclusion

Social justice in this context relates to how science can be used to reproduce social stratification and addresses issues such as inequality, oppression, and the unequal distribution of wealth. Teaching science for social justice should include presenting the discipline as dynamic and socially constructed in order to allow students to see themselves as participants in science. When students understand NOS perspectives, including the impact of funding for research and socio-political pressures, they understand science in a more authentic way. You might explore questions such as why and how groups of individuals are represented or underrepresented in science.

Science holds social power in schools and in society (Sleeter, 2000, 2009; Young, 1987). It is often associated with success in schools and affects access to higher education. Furthermore, material taught in science classrooms can be seen as more valuable than other forms of knowledge. Science content is constructed knowledge (Aikenhead, 1994; Harding, 1998; Kuhn, 1996), and exploring NOS perspectives can help students

<table>
<thead>
<tr>
<th>Category of students</th>
<th>Consequences for border crossing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Scientists</td>
<td>Border crossing into school science is so smooth and natural that borders appear invisible.</td>
</tr>
<tr>
<td>Other Smart Kids</td>
<td>Students find the subculture of science to be personally unimportant and inconsistent with the subcultures of their school, peers, and family. However, border crossing into school science is managed so well that few students express any sense of science being a foreign subculture.</td>
</tr>
<tr>
<td>“I Don't Know” Students</td>
<td>Students do not know much about the subculture of science and when asked they simply submit to the wisdom of the media and treat scientists as experts. Border crossing into school science poses real hazards, but these students generally navigate successfully around those hazards.</td>
</tr>
<tr>
<td>Outsiders</td>
<td>Subcultures of science are highly discordant with the subcultures of peers and family. Students do not know or care about the subculture of science. School and science are indeed foreign subcultures for most outsider students and border crossing into school science is virtually impossible.</td>
</tr>
<tr>
<td>Inside Outsiders</td>
<td>Because of their unconventional lives, these students find border crossing into the subculture of school to be almost impossible, preventing participation in school science.</td>
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</tbody>
</table>

Source: Adapted from Aikenhead, 1996.
understand the limitations of the enduring power of science in our society. Teachers must be willing to ask questions of themselves and of their teaching, such as the following:

- How can we help all students to see themselves as “having potential to participate in society’s power structures and to generate knowledge” (Aikenhead, 1996, p. 15)?
- How can we demystify science and make it more accessible to students (Hodson, 2003)?
- Why and how do schools reproduce oppressive structures seen in society (Cummins, 1996)?

**Social Justice and Science Curriculum Topics** Many science curriculum topics lend themselves to a social justice approach to instruction. For example, we might explore who pollutes and who lives near polluted land, where our food comes from and how it is distributed, what the impact of mining is on Aboriginal communities and farmers, and how classroom waste affects the school community.

Teachers want to create a more inclusive curriculum, but often feel discouraged and frustrated in their attempts to do so. Teachers face challenges and barriers, including insufficient background knowledge, time restraints, school expectations, or anxiety about being controversial in the classroom. Another source of tension is resistance from students who have varying ideas about what science is and what should be taught in a science class (Bellomo, 2003).

Science, technology, society, and the environment (STSE) can be an entry point for teachers to consider curricula in terms of social justice. For example, issues such as poverty overlap with health and disease, economy with energy resources and production. Conducting inquiry and exploring the tenets of NOS also serve as appropriate entry points for science lessons.

Moje (2007) acknowledges that while all teachers want to be socially just and provide equal opportunities for all, this is different from a social justice pedagogy that provides opportunities for transformation and the reconstruction of knowledge. This is a particular challenge in science, which many identify as a neutral discipline that involves understanding or memorizing without questioning (Hodson, 2003, 2011). Calabrese Barton (2003) shares stories from students as they explore meaningful science experiences that help them construct science knowledge. She promotes a vision of teaching science that is responsive to student needs. According to Calabrese Barton and Upadhyay, 2010, p.5:

> The history of social justice research in science education is still in its infancy—[but]—it is clear that science education for social justice is premised on three broad assumptions:

- Having the opportunity to learn science as content knowledge, discourse, and practice is a civil right.
- Teaching and learning science involves critical activism and citizenship.
- The goals of science literacy involve personal, social, and economic empowerment.

**Classroom Teaching**

Teaching is at the intersection of the two foundations: power and inclusion, and social justice curriculum topics and examples. (See Figure 4.3.) Science pedagogy should acknowledge each. A science program for social justice, equity, and diversity, then, is not an added on, extra notion, but central to the curriculum development process and embedded into the daily experiences of students.
Culturally Relevant Pedagogy

Socially just teaching overlaps with what Ladson-Billings (1995a) describes as culturally relevant pedagogy: “a pedagogy of opposition not unlike critical pedagogy but specifically committed to collective, not merely individual empowerment” (p. 160). Culturally relevant pedagogy focuses on helping students experience academic success and develop a critical consciousness through which they are enabled to challenge the status quo. James (2012a) uses the term community-informed pedagogy, since the communities to which our students belong, or from which they have come, shape them and should inform teachers’ practice.

Understanding that there is cultural multiplicity within a community, the following list expands on the notion of culturally relevant and community-informed pedagogy. All teachers can

a) explore privilege, power, and economics, and the unequal distribution of these elements in our society
b) question school and institutional practices that are coercive or oppressive
c) recognize the value of the knowledge and experience that all students bring to classrooms
d) ensure that students see themselves in curricula
e) address marginalization in society and how it can be reproduced in schools
f) question the notion of meritocracy
g) recognize how knowledge construction practices operate in science
h) understand the power structures that underpin and fund scientific research
i) recognize science as a process of inquiry and encourage students to see themselves as able to participate in that process
j) understand how social justice issues can influence the content of science
k) examine bias in interpersonal relationships, curricular choices, and the discipline of science
l) incorporate the contributions of a diverse body of scientists, including historical, non-western, Aboriginal, Indigenous, neo-Indigenous, and western traditions

The Venn diagram in Figure 4.4 illustrates how culturally relevant pedagogy can be incorporated into curricula.
Science Curriculum Guidelines and Social Justice

Social justice issues can be woven through many topics. In this section we explore food—a common theme in most curriculum guidelines. We might begin, for example, by asking students (a) what they already know about food and (b) what they would like to learn more about. Their ideas might include the following:

- types of plants used for food
- types of foods eaten around the world
- foods children like to eat
- organic food
- food for good nutrition and health
- soil nutrients needed for food crops
- reasons some people do not have enough to eat and are hungry
- feeding the world population
- ways to cultivate more of the available land on the planet
- clearing land for cultivation and the resulting loss of forests

 Provincial guidelines incorporate many expectations related to food; below are a few from K–3. As you read through the list, think of how ideas from earlier in this chapter might influence the way you would teach these outcomes, keeping in mind:

- the equity framework
- foundations for social justice in science education
- culturally relevant, community-informed pedagogy

Sample Outcomes from Various Provincial and Territorial Curriculum Guidelines

Grade 1:

- Students can try to guess the identity of types of food by closing their eyes and smelling, touching it, or if possible tasting it. (Nova Scotia Department of Education, 2005, p. 22)
Students might explore how their sense of smell can help them identify when food has gone bad. For example, students could discuss previous experiences with food that has gone bad—mouldy bread, sour milk . . . ). (Nova Scotia Department of Education, 2005, p. 22)

Grade 2:
- We shouldn’t waste water, for the same reasons that we shouldn’t waste food—for example, because others don’t have enough and it costs money. (Ontario Ministry of Education, 2007b, p. 67)
- Recognize that food is a form of energy and that healthy eating is essential for growth and development. (Manitoba Education and Training, 1999, p. 3.28)
- Investigate food groups and plan a menu for one day based on the four food groups outlined in Canada’s Food Guide to Healthy Eating. (Manitoba Education and Training, 1999, p. 3.28)

Grade 3:
- Recognize that plants use the sun’s energy to make their own food. (Manitoba Education and Training, 1999, p. 38)
- Identify how humans from various cultures use plant parts for food and medicine. (Manitoba Education and Training, 1999, p. 3.39)
- Describe various local and domestic plants used in food preparation (e.g., vegetables, fruits, spices, herbs) and identify places where they can be grown. (Northwest Territories, Education, Culture and Employment, 2004, p. 27)
- Identify some functions of different local plants (for example, trees for shade or to break wind or bind soil; trees also provide building materials). (Northwest Territories Education, Culture and Employment, 2004, p. 27)

Activity 4.6 explores how justice issues can be incorporated into science through the theme of food.

**ACTIVITY 4.6**

**Exploring Social Justice Teaching Through the Topic of Food**

**Part A**
The table below lists specific outcomes or expectations from the K–3 provincial guidelines discussed above along with some ideas about how to teach them through a social justice lens. Complete the table using two other expectations from the K–3 guidelines. Brainstorm teaching strategies, activities, ideas, or issues that children could explore.

<table>
<thead>
<tr>
<th>Social Justice and Food</th>
<th>Using a social justice lens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate food groups and plan a menu for one day based on the four food groups outlined in Canada’s Food Guide to Healthy Eating.</td>
<td>Explore what healthy eating means in other parts of the world.</td>
</tr>
<tr>
<td></td>
<td>Plan a healthy menu for one day based on food that is grown in other parts of the world.</td>
</tr>
</tbody>
</table>

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As you may have noted, it can be challenging to view a topic through a social justice perspective while adhering to curriculum guidelines. While food lends itself to many aspects of social justice, not all science topics are so rich in possibilities. Still, always be mindful of issues of power, access, and inclusion, and the curriculum choices we make. As Angela Calabrese Barton (2003, p. 18) argues, “Until an approach to science and science education in our (urban) classrooms focuses on what it might mean to create a more just world, then we will fall short of our goal of truly building a science education for all.”

**Social Justice and Food**

<table>
<thead>
<tr>
<th>Outcome or expectation</th>
<th>Using a social justice lens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognize that plants use the sun’s energy to make their own food.</td>
<td>Explore the idea that plants need water, soil, and the sun to grow. If land is degraded or polluted, it may not be suitable for plant growth, perhaps resulting in food shortages for humans and other animals. Climate change may also affect rainfall or droughts and so affect food supply.</td>
</tr>
<tr>
<td>We shouldn’t waste water for the same reasons that we shouldn’t waste food—for example, because others don’t have enough and it costs money.</td>
<td>Research parts of the world experiencing food shortages. Organize a food drive for a local food bank.</td>
</tr>
</tbody>
</table>

**Part B**

Repeat this activity for Grades 4 to 6 using one of the following:

a) a theme such as water or energy
b) a theme of your choice (perhaps a topic you will be teaching during your practicum)
c) continue the theme of food using the outcomes and expectations found in Appendix 4.B

As you may have noted, it can be challenging to view a topic through a social justice perspective while adhering to curriculum guidelines. While food lends itself to many aspects of social justice, not all science topics are so rich in possibilities. Still, always be mindful of issues of power, access, and inclusion, and the curriculum choices we make. As Angela Calabrese Barton (2003, p. 18) argues, “Until an approach to science and science education in our (urban) classrooms focuses on what it might mean to create a more just world, then we will fall short of our goal of truly building a science education for all.”

**ACTIVITY 4.7**

**Read and Reflect: Exploring Research**

The journal *Equity & Excellence in Education* published a special issue titled Teaching and Learning Science for Social Justice (Volume 43, 2010). Read one of these articles, from this issue, and reflect on how it fits within the framework outlined in Figure 4.1.


**DISCUSSION QUESTIONS**

1. How does the article you read address the following three components of Figure 4.1:
   a. social justice and issues of power, access, inclusion, and NOS
   b. social justice and curriculum choices
   c. science classroom teaching
2. How is inquiry (doing science) related to social justice?
3. How is urban education defined? How is it described in the context of science classrooms with respect to challenges and solutions?
4. How is specific subject matter knowledge, such as health or the environment, addressed in social justice classrooms?
SCIENCE CURRICULUM FOR SOCIAL JUSTICE: SOME PROGRAM SUGGESTIONS

Teaching science for social justice can be rewarding for teachers and students as they engage in a more holistic approach to societal inequities. Some aspects of the issues raised in this chapter may be viewed by some teachers as controversial. We argue that all decisions are value laden, and so ignoring or omitting controversial social justice issues is inherently just as contentious as confronting them. Below are four program suggestions for how to include social justice in your teaching of science. These suggestions raise questions about where teachers and students can find appropriate resources—this issue is addressed in the last section of the chapter.

Suggestion 1: Inquiry and the Nature of Science

Science instruction should reflect what science is and how it is done. An inclusive science curriculum includes access to resources and ideas that give students experiences with the nature of science. This can be achieved by engaging students in scientific inquiry and asking them to do, and assess, science as a practice (Thadani, Cook, Griffis, Wise, & Blakey, 2010). As students view science as a process of knowledge construction and not just content, they begin to see themselves as able to actively participate in the process. Authentic experiences involving open-ended inquiry, experimental design, data collection, and the interpretation of data can contribute to an understanding of NOS and can “position students as knowledge-constructors and critics (rather than passive recipients) [and] can help promote social justice in science education” (Thadani et al., 2010, p. 22).

Suggestion 2: STSE, Problem Solving, and Community

Community problem solving and content that is anchored in the lives of students can further social justice education. When school science has a focus on community issues, then society and community can intersect with education in an authentic way. Sometimes this is related to an STSE approach, which is detailed in Chapters 10 and 11 (see, for example, Buxton, 2010; Pedretti & Little, 2008).

Suggestion 3: The History of Science from Non-western Traditions

The history of science from non-western traditions can contribute to an understanding of historical and global perspectives. The inclusion of non-western traditions provides avenues to explore social justice, and to address marginalized or forgotten science. Refer to provincial documents that suggest how to incorporate history. (See, for example, Quebec (1998, p. 26), which states, “The history of science will be a major focus of the science program. This will contribute to a proper appreciation of the contributions of different cultures to the development of the sciences.”)

The following are suggestions for how to incorporate history into science topics:

- astronomy from Chinese perspectives
- metallurgy and jewellery engraving in West Coast Aboriginal cultures
- chemistry and alchemy in Islam and the Arab world
- crop breeding in Africa or Asia
- medicine and healing in non-western cultures
Recognizing science from non-western perspectives can also be explored in terms of what knowledge is valued and whose knowledge has influence and power. Additionally, teachers can address what knowledge is included in the science curriculum and what knowledge is marginalized and why.

**Suggestion 4: European Inventors and Inventors from Non-western Perspectives**

In addition to teaching about European contributions to science, incorporate the inventions of Aboriginal, Indigenous, African, Asian, and other populations. Recognize and include the experiences of diverse groups, the lives of the inventors, and the social, cultural, and political contexts from which their work emerged. You might consider teaching about the following inventors:

- Ibn Sina (Avicenna), a polymath renowned for his philosophy and medical expertise
- Gurtej Sandhu, who produced thin film processes and materials, very large-scale integration, and semiconductor device fabrication
- Jan Ernst Matteliger, inventor of a shoemaking machine that increased shoemaking speed by 900 percent
- Otis Boykin, who invented 28 different electronic devices, including control devices for guided missiles, IBM computers, and the pacemaker

Begin to build your own library of print, media, and web-based resources that you can use to help plan for topics with specific outcomes or expectations. Appendix 4.A includes a few suggestions. You may want to simultaneously refer to curriculum outcomes to determine if and how your teaching can be enhanced with these resources.

**CONCLUDING THOUGHTS**

Teaching for social justice is an educational choice that has implications for how we include all students and for the curricular resources and examples we use. Social justice science education is an inclusive representation of what science is that goes beyond facts of science to an understanding of influences, power structures, and privileges that contribute to knowledge construction. Social justice science pedagogy supports students in understanding the power, influence, and authority of science in our world, and exploring social justice issues related to the discipline. Below we summarize key ideas related to the learning objectives provided at the beginning of the chapter.

**Framework for equity, diversity, and social justice**

Using an equity, diversity, and social justice framework for planning science curricula means including multiple perspectives in content choices and examples that present science as sometimes beneficial and sometimes implicated in injustice. The framework we suggest is organized into three parts: interactions with students; curriculum choices and examples; and bias within the discipline of science as knowledge construction occurs.

**Marginalization and identity**

Regardless of whether students live in the inner city, in suburban areas, or in rural communities, they can face marginalization in science classrooms and can run the risk of not being successful. Often, such students are described as at-risk. Effective teachers consider the impact of Aboriginal heritage, language, ethnicity, class, gender, and sexuality on students’ lives.

**Aboriginal world views in the context of science education**

Issues of power, access, inclusion, and social justice in the curriculum are interwoven with the needs, aspirations, and achievements of Aboriginal students. Western science at times conflicts with the culture of Aboriginal students, who may view science instruction as an attempt to assimilate them into western culture.
Border crossings for students
The idea of border crossings is a metaphor for what some students face when they enter a science class. Often they feel as though they do not belong; they cannot speak the language; and they want to leave. The process of border crossing into the subculture of science can be smooth, managed, hazardous, or impossible.

Foundations of social justice in science education, including culturally relevant pedagogy and teaching
Social justice in science is foundational in building an inclusive and just science education. The first foundation is the power of science and its relationship to access for students of all cultural backgrounds. The second foundation relates to science issues of a social justice nature that affect individuals, communities, and society. Some of these issues are implicated in injustice. A social justice science education questions structural barriers in society that prevent some students from succeeding in school. Just pedagogy and teaching overlap with culturally relevant curricula.

Social justice issues and resources for science curricula
Four program suggestions are presented as examples of how to include social justice in science education. Explore inquiry and NOS; STSE; problem solving and community; the history of science from non-western traditions; and European and non-western inventors.

BRINGING IT ALL TOGETHER: FINAL QUESTIONS
1. Describe your understanding of the foundations of social justice within a science classroom from reading this chapter.
2. What are obstacles to including social justice in the science classroom?
3. Work in pairs or groups of three and discuss (a) ways to make your class more socially just (by addressing issues of power, access, and inclusion) and (b) ways to include social justice issues that are connected to science content.

MyEducationLab®
Visit MyEducationLab® to access an electronic version of the text, as well as a variety of topics that enhance the text material. The topics include the following to support your learning in the course:
- Assessments, including interactive case studies, activities, and video assignments
- Discussion board questions
- Videos, simulations, a lesson plan builder, and other useful course resources


Curriculum Services Canada (CSC)
www.curriculum.org/content/home
CSC works with government agencies, NGOs, and private organizations from across Canada to develop and evaluate print, multimedia, and web-based resources that support learning. It provides educational services that promote professional growth. Its services include, for example, webcasts (such as “Creating the conditions for learning mathematics”) and sites with a specific theme (Black Canadians Portal for Educators—a portal listing resources to support teachers and students in learning about the contributions of African Canadians).

Canadian International Development Agency (CIDA)
www.acdi-cida.gc.ca/acdi-cida/acdi-cida.nsf/eng/home
CIDA is Canada’s lead agency for development assistance. Its mission is to lead Canada’s international effort
to help people living in poverty, and its mandate is to manage the nation’s resources effectively and accountably to achieve meaningful, sustainable results. The organization engages in policy development in Canada and internationally, enabling Canada’s effort to realize its development objectives.

Canadian Council On Learning (CCL)
www.ccl-cca.ca/CCL/Home.html

CCL is an independent, non-profit corporation that promotes and supports research to improve all aspects of learning across the country and across all walks of life. In 2012 the organization was dissolved. However, CCL has taken measures to ensure that the work they have done is still accessible to all Canadians. Sample CCL publications include:

- Lessons in Learning
  www.ccl-cca.ca/CCL/Reports/LessonsInLearning.html#2007
- Aboriginal Learning
  www.ccl-cca.ca/CCL/AboutCCL/KnowledgeCentres/AboriginalLearning/index.html
- Gender Differences In Career Choices: Why Girls Don’t Like Science
  www.ccl-cca.ca/CCL/Reports/LessonsInLearning/LinL20071101_Gender_differences_in_science.html

APPENDIX 4.B Grades 4–6 Outcomes and Expectations from Provincial and Territorial Guidelines

Grade 4

- Classify organisms and draw diagrams to illustrate their role in the food chain. (Nova Scotia Department of Education, 2006, p. 13)
- Demonstrate an understanding of the food chain as a system in which energy from the sun is transferred eventually to animals. (Northwest Territories, Education, Culture and Employment, 2004, p. 28)
- Humans depend on natural habitats and communities for many things, including food, building materials, clothing, and medicine. (Ontario Ministry of Education, 2007b, p. 85)
- When scarce farmland is used for development, we lose family farms and a way of life, as well as local sources of fresh food and important open spaces. To lessen such impacts, we need to think of alternative ways of meeting our needs. (Ontario Ministry of Education, 2007b, p. 85)

Grade 5

- Students could discuss the following questions: Why do we need to eat? How does food give us energy? What do my lungs do, and how do they work? What happens to food after I eat it? (New Brunswick Department of Education, 2002, p. 20)
- Describe how the digestive and excretory systems work together to make certain the body uses the food you eat and the waste is processed properly. (New Brunswick Department of Education, 2002, p. 29)

Grade 6

- Research one of the following topics to find out how it affects the growth and development of the body: tobacco, alcohol, steroids, marijuana, tanning salons, junk food. (New Brunswick Department of Education, 2002, p. 31)
- The use of chemical preservatives makes foods last longer, but the preservatives may have an impact on human health. (Ontario Ministry of Education, 2007b, p. 105)
- Analyze the roles of organisms as part of interconnected food webs, populations, communities, and ecosystems. (British Columbia Ministry of Education, 2005, p. 39)
- Explain and provide several examples of how energy is transferred through food webs and food chains within an ecosystem. (British Columbia Ministry of Education, 2005, p. 117)
- Assess the benefits that human societies derive from biodiversity (e.g., thousands of products such as food, clothing, medicine, and building materials come from plants and animals) and the problems that occur when biodiversity is diminished (e.g., monocultures are more vulnerable to pests and diseases). (Ontario Ministry of Education, 2007b, p. 113)
- Explore the transformation of energy in living things: food chains and ecological pyramids. (Quebec Education Program, Preschool and Elementary Education, 2001, p. 176)