MULTICULTURAL SCIENCE EDUCATION:
AN ANALYSIS OF CURRICULUM AND POLICY IN ONTARIO

by

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for the degree of Master of Arts
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Multicultural Science Education: An Analysis of Curriculum and Policy in Ontario
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ABSTRACT

Where science is viewed as a cultural construct, imbued with particular values and rooted in the context and backdrop from which it emerges, there is increasing recognition that science education is postulated within a Western or Euro-American cultural framework, creating a situation of cultural imposition and dominance over many others originating from diverse backgrounds. This thesis presents a paradigm for multicultural science education, aimed at providing scientific literacy for all and ameliorating the cross-cultural tensions which emerge, which comprises three fundamental domains: the personalization of learning (and knowledge), the demythologization of science and the science enterprise, and the politicization of science education. Subsequent analysis and evaluation of Ontario’s current policy and practice regarding multicultural and science education programs, under the defined criteria of multicultural science education, reveals several inadequacies and deficiencies in terms of the education ministry’s provisions. This thesis concludes with recommendations for science curriculum policy and practice reform in Ontario.
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CHAPTER 1
MULTICULTURAL EDUCATION: FOUNDATIONAL PERSPECTIVES FOR EDUCATION IN ONTARIO

1.1 INTRODUCTION

In the early 1960s, an eminent Canadian professor at the University of Toronto, by the name of Marshall McLuhan, spoke of what was then a novel concept. He called it the “Global Village” (McLuhan, 1964). He predicted that with rapid technological innovation would follow rapid globalization. McLuhan contended that people of diverse backgrounds and experiences would be forced to understand one another, as they would come into increasingly greater contact with each other.

In the decades that followed, our generation has witnessed the fruition of McLuhan’s vision. Today, we live in a society in which barriers of physical proximity have been diminished by the preponderance of information, which has become the most valued commodity. Indeed, with the proliferation of mass media outlets, whether print, television, or electronic, never has the dissemination of information been more rampant and widespread, and so easily accessible through the free flowing channels of global communication. This has had a very real impact on the way in which Canadian society is evolving. Canadians are constantly bombarded with facts, opinions, images, sound bites, and icons, which often contribute more to confusion than to clarity.

Education enters as an agent toward creating such clarity. Education serves to inform, instruct and inculcate the learner with an appropriate set of knowledge, skills and values, regarding the circumstances of a situation or environment, to be able to comprehend and negotiate problems, issues and challenges. Its fundamental purpose is to provide clarification, understanding and insight in any given subject. Education aims to provide a comprehensive array of experiences, information, and insights which will arm one with the intellectual and ethical prowess to productively function on
an individual, group, community and societal level, in order to contribute to the preservation and progress of one's culture and civilization.

Certainly, an environment characterized by the representation of a multiplicity of views, beliefs and attitudes requires the learner to acquire a significant dimension related to the skills and knowledge set imparted by a given curriculum – that of critical cognizance and reflection, which allows one to respect, appreciate and acknowledge, comprehend, evaluate, and negotiate the merit and functionality of any particular conceptualization, philosophy or thought. One's personal values, beliefs, attitudes, perspectives, preferences, practices, philosophy, thought, ethos, conceptions, mode of expression and communication are certainly a function of one's culture and experiences – contributing to the individuality of learners. Such personal effects are cherished dearly by individuals and sustained strongly by them. If the learner is not permitted to express and maintain such individuality, and is subject to an environment, and a realm of experiences, which require assimilation and conformity to a cultural paradigm which conflicts with one's own, tensions will certainly emerge resulting in either one's participation and compliance with the new culture, or one's marginalization and exclusion from the wider spectra of society. With the emergence of such cross-cultural conflict, cultural suppression and imposition would certainly result in the discontent and animosity of significant segments of society who would view their personal, ethnic, cultural or religious integrity as having been transgressed and violated. Hence, the need for a paradigm and philosophy which accommodates rather than impedes, which includes rather than excludes, which acknowledges rather than disregards, which celebrates rather than scorns, which ensures appropriate representation and cultural preservation rather than misrepresentation and cultural eradication, which ensures participation rather than marginalization, and which ensures free expression rather than confined suppression.

Indeed, multicultural education presumes to provide such a philosophy and paradigm which operates on the premise of ameliorating such a situation and aims at abating, if not altogether
abolishing, such cross-cultural tensions and conflict, and the possible disenfranchisement of the learner. Multicultural education is aimed at accommodating cultural diversity and the challenges of balancing the requisite needs of the host culture with those of the multicultural population of learners. Since learners' preconceptions and frameworks inevitably emanate from their particular cultural milieu, it follows that gaining an appreciation for, and a comprehensive scope of, the student's culture should ensure and facilitate a more efficacious delivery of the particular curriculum content. However, the question of explicitly defining how to proceed, and in which manner, remains problematic for educators.

Certainly, residing in a microcosmic "global village", such as Canada and in particular Ontario, inherently furnishes complex challenges and predicaments. The focus under such circumstances must extend beyond the interminable debates on issues of perspectives, to the examination of the manifest ramifications of policies and decisions which have been executed in both the present and the past, and those which have been proposed for the future, within the arena of education. One simply can not ignore the immense impact that such initiatives bear on the formulation and implementation of the educational curriculum of the day, which presumably serves as a primary foundation to establish, compose, configure, and dictate the concepts, notions and views of the societal framework. Hence, the aims and directives of an educational curriculum based on specific content and objectives would serve as a venue for investigation, whereby one would want to probe for factors and issues determining the content and objectives deemed valuable and relevant, while also keeping sight of their application in a socially practical, relevant, and responsible manner. As an adjunct to such investigation, one must consider issues of control, manipulation and exploitation of a learning environment which may be in conflict with the cultural values of children coming from varying backgrounds. Such issues and concerns would need to be addressed by any educational paradigm promoted by multicultural education.
Hence, one would need to survey perspectives and definitions for multicultural education. Who is it intended for? What problems are supposed to be addressed and what are the proposed solutions? What does it propose to practice and achieve? What is the Canadian policy and practice of multicultural education? What is the Ontario policy regarding multicultural education? How is it reflected in the Ontario curriculum documents?

Consequently, this chapter shall briefly survey the relevant literature on multicultural education and subsequently draw particular focus upon Canada and Ontario. This chapter shall seek to provide perspectives on assimilation, cultural and ethnic pluralism and anti-racist education. The purpose of this chapter is to define the concept of multicultural education and its related issues and furthermore, to contextualize them and define them for Ontario. Hence, it lays the foundation for subsequent chapters and discussion.

1.2 PERSPECTIVES AND DEFINITION OF MULTICULTURAL EDUCATION

The notion of formal education is normally associated with diverse objectives, content and style, where such dimensions evolve over time in reaction to changing currents of thought within education and society. Yet, despite whatever alterations and adjustments were accommodated, prior to the 1960s, the educational system had for the most part abided by a fundamental commitment to monoculturalism (Fleras & Elliot, 1992). The ideal of cultural assimilation prevailed within the school systems of Western democratic societies such as the United States, U.K., and Canada. However, much has changed over the last few decades. With the evolution of education due to shifting paradigms and philosophies, subsequently reflected in curriculum content, objectives, and implementation schemes, and in response to the often conflicting demands of an increasingly diverse and complex technological society, issues of culture and context subsequently surfaced, and have not only endured but, indeed, pervade much of the contemporary debate surrounding
education. Such focus, of course, has become clearly manifest in the form of multicultural education.

Prior to the 1960s, the predominant emphasis of Western society school systems, having to contend with children from ethnic, cultural and religious minorities, was an educational program designed to ensure cultural assimilation. The objective was to assist such learners to conform, comply and adapt to the dominant culture. This was the domestic policy practiced in such Western democratic nations as the United States, U.K., Australia and Canada up to and through the 1960s (Banks, 1986, 1997a; Fleras & Elliot, 1992). In Canada, such conformist ideology sought to absorb immigrant children directly into the schema of Canadian society by stripping them of language and/or culture (Berryman, 1988). Fleras and Elliot (1992: 183) note that “all aspects of schooling in English-speaking Canada, from teachers and textbooks to policy and curriculum, were rooted in the principles of assimilation and anglo-conformity. Anything which veered outside this anglo-centric framework was ignored as irrelevant or counterproductive.” Hence, the focus of this approach of cultural assimilation was geared toward the perpetuation, transmission and promotion of the cultural beliefs and norms of the host society and its dominant culture.

During the 1960s, Western societies were faced with the emergence of the ethnic revitalization movements. These movements were triggered by the civil rights movements led by African Americans in the United States, but witnessed resonance in the other Western democratic nations. The West Indians and Asians in Britain, the Indonesians and Surinamese in the Netherlands, the Aborigines in Australia, and the French and North American Natives in Canada, all formed a string of ethnic movements expressing their rage and discontent towards the establishment and “demanded that the institutions within their nation-states become more responsive to their needs, hopes and dreams,” (Banks, 1986: 3). Such commotion saw the previously employed assimilationist approach supplanted by a more liberal assimilationist approach seeking to integrate culturally and ethnically disparate peoples within the wider spectra of society (Banks, 1986). This
integrationist approach aimed to provide equal opportunity and access within a culturally diverse and mutually tolerant society (Mullard, 1982). "It was envisaged that mainstream society would become enriched by the admixture of attitudes, beliefs, customs, languages and cultural achievements of ethnic and religious minorities," (Hodson, 1993: 687). Differences between culturally disparate groups were to be accepted, tolerated and absorbed in order to produce a newly forged and pervasive cultural domain, what Aspin (1987) has termed a cultural mosaic, in which "the heterogeneity of the individual parts make up an identifiable cultural homogeneity."

While the promotion of cultural integrationism by white liberals offered an altruistic appearance of cultural egalitarianism as a new trend taking over the old establishment, such rhetoric was only a façade. Both policy and practice surrounding cultural integrationism through the 1960s and 1970s served only to reinforce the already prevalent assimilatory processes and procedures of North American society, while offering little in terms of meaningful change. Banks (1986) cites the incentives of economic, political and social mobility as the prime cogent factors which contributed then, and continue to contribute now, to the assimilation of ethnic groups into their national societies. "The strong appeal of attaining social mobility within the industrialized nation-states such as the United States, Canada, Australia, motivated many citizens of these nations to rid themselves of most aspects of their ethnic cultures and to become skeptical and ashamed of folk cultures and traditionalism," (Banks, 1986: 4). Certainly, without any substantial change directed at the policies and practices of accessibility to participation in the economic, political and social arenas of society, one would expect little effect in turning the tide of the strong underlying assimilationist currents. If anything, one would expect such cultural assimilationist currents to persist. Dissatisfaction with this situation gave rise to active lobbying toward a policy and practice of ethnic and cultural pluralism, which entails political (and subsequently societal) acknowledgement, acceptance, appreciation, tolerance of, and support for, the ethnic and cultural diversity found within the wider community.
A young fledgling of the mid to late 1970s, ethnic and cultural pluralism took full flight through the 1980s, most visibly in the form of the multicultural education juggernaut.

Hodson (1993) notes that for most white liberals, the notion of cultural integrationism represented a seemingly unattainable ideal. Yet, with the emergence of ethnic cultural awareness and revitalization movements (of the late 1960s, and through the 1970s), radicals and activists vociferously rallied against a policy which was viewed as representing little more than a "rhetorical smokescreen that masks an underlying assimilationist goal," (Hodson, 1993: 688). Hodson (1993: 688) encapsulates what ensued:

What they demanded was a shift toward ethnic and cultural pluralism, which accepts and promotes diversity. The intentions are that members of the dominant community learn to appreciate, understand and value the different conventions and cultural norms of other small groups of citizens, and that members of racial and ethnic minority communities perpetuate their own cultural identities, thereby developing more positive self-images. Cultural pluralism is now the dominant interpretation of multiculturalism in Europe, North America and Australasia, although it has to be admitted that the notion is still subject to a wide variety of interpretations (Aspin, 1987; Shaw, 1988). Often, the only thing on which writers agree is that multiculturalism is not well understood or well articulated!

Multicultural education has become a generic term encompassing a wide array of policies, programs and practices which entail the negotiation and management of socio-cultural diversity within the educational environment. While largely endorsed by educators concerned with culturally diverse learning environments, and adamantly advocated by its adherents, ambiguity of the term renders it subject to vast interpretation and opinion. As with any particular paradigm, philosophy, ideology or conception, there exists a wide spectrum of theory and thought. Hence, multicultural education may be defined in a variety of manners, depending on the origin of definition and the endemic emphasis of its source perspective. For some, the focus should be fixed on assimilatory procedures for the learning populace to indoctrinate students to the host culture, in order to ensure successful conformity and contribution to society. For others, the emphasis should rest upon promoting and celebrating cultural diversity and pluralism, while adopting an agenda aimed at integrating socio-culturally disparate peoples into the educational schema, and subsequently, the
various arenas of society. Yet, for others, the objective should be to critically address the learning problems and educational challenges which emerge from the promotion of cultural and ethnic pluralism in a manner which balances the needs of society with those of individuals to preserve the integrity of their personal cultural values, beliefs, practices, and identity, whilst engaged in a campaign targetted towards dismantling racist and prejudicial practices and institutions, and ensuring the participatory integration of the culturally diverse citizenry, thereby, as an adjunct, securing viable representation in the power brokerage ranks of society.

Defining multicultural education is certainly no easy endeavour (Lynch, 1981). Buillvant (1981: 1) has noted that "there is no one agreed body of ideas about multicultural education or the philosophy of multiculturalism: instead there is a very confused number of definitions and competing ideas about these very important issues.” Indeed, this dilemma of definition is exacerbated by the very nature of the definition process. Definitions may focus on any number of dimensions, from functions to structure to process, each with various emphases entailed within, depending on the perspectives held by the source of definition. In seeking to define multicultural education, one faces the very same phenomenon, where one's definition varies and correlates with one's personal, social, political, economic and cultural perspectives (Kincheloe & Steinberg, 1997; Mitchell & Salsbury, 1996), and whether one subscribes to assimilationist, integrationist, cultural pluralist or anti-racist approaches (Mogil, Verma, Mallick & Mogil, 1986). While perspectives and definition of multicultural education extend over an immense span of literature, thought and debate, for the sake of brevity, only a small selected survey of definitions will be offered here.

Fleras and Elliot (1993: 187) delineate the range of definition which multicultural education encompasses:

At a minimum, it would seem that multicultural education entails some degree of responsiveness to the presence of cultural diversity within the school environment. This would include an appreciation for the rich array of cultures in society and their contributions in the past and at present. At maximum, multicultural education encompasses a comprehensive plan for transforming educational policies, programs, and practices at all levels and across most domains. Reforms are all-encompassing, and include the total school
environment such as policy, counselling programs, assessment and testing procedures, teaching methods and materials, formal courses of study, staff attitudes and expectations, the hidden curriculum, institutional norms, and community input and relations (Melnicer, 1986).

Their own definition attempts to encompass such vantage points. Fleras and Elliot (1993: 187) define multicultural education as “an organized effort to accommodate and manage racial and ethnic diversity as an integral component of the school system. A commitment to multicultural education openly acknowledges ethnocultural variation, recognizes its validity within the educational environment and reaffirms its role in the formulation of philosophy, objectives, content, and delivery of services to students.” Central to their definition “is the belief that cultural diversity is not inimical to student needs or school goals. Instead, schools accept this diversity as a key ingredient in fulfilling their educational mandate,” (Fleras & Elliot, 1993: 187).

In her endeavour to seek out a clear definition which accounts for the spectrum of emphases of multicultural education, Katz (1982: 16-17) offers the following:

Multicultural education is preparation for the social, political and economic realities that individuals experience in culturally diverse and complex human encounters..... Multicultural education could include, but not be limited to, experiences which (i) promote analytical and evaluative abilities to confront issues such as participatory democracy, racism and sexism, and the party of power; (ii) develop skills for values clarification including the study of the manifest and latent transmission of values; (iii) examine the dynamics of diverse cultures and the implications for developing teaching strategies; and (iv) examine linguistic variations and diverse learning styles as a basis for the development of appropriate teaching strategies.

Lynch (1986: 14) defines multicultural education through its purpose and objective:

The task of multicultural education in a democratic society is therefore, to assist the individual by means of emancipatory curricular and educational pedagogies which appeal to and extend rational judgement, to reach out to and achieve a higher stage of ethnic and cultural existence than is the case initially, so that there exists sufficient cultural and social overlap for society to function, and for discourse across areas of crisis and conflict to take place.....This is one major reason why multicultural education must aim continually for higher levels of intellectual functioning and for affective and social competence increments. For ethnic captivity is a state which is debilitating both to members of minority communities, because of the negative self-images which they will have absorbed, and to members of majority communities, because they do not recognize as negative the self-images they have absorbed and the relationships which these imply with other cultural communities within a pluralist society as being destructive of the social cohesion which is necessary for cultural diversity to thrive.
From the preceding selection of definitions, one may certainly surmise that multicultural education as a concept, addresses a vast array of concerns and objectives. A recurring theme which runs as a thread through the various definitions, is the devotion to negotiating and managing the challenges posed by a socio-culturally diverse educational environment, and providing policies, programs and practices which support and sustain an educational experience which ensures equity and empowerment for all. Circumventing the course of direct definition, Banks (1997a) describes multicultural education as three things: an idea or concept, an educational reform movement, and a process. As a concept, it incorporates the notion of ensuring equitable access and opportunity to learn and succeed in school without violating the basic integrity of one's cultural values. As an educational reform movement, it aims to affect change within the policies, practices and politics of education, the school environment, and curriculum content and delivery, while preserving equal opportunity to learn for students from all social class, gender, racial and cultural groups. Finally, as a process, Banks (1997a) refers to it as the pursuit of an ideal, whose goals will never be fully realized. While one targets the eradication of prejudice and racism, and aims to ensure equality, liberty and justice within the educational arena, one should never be naively deluded into believing that such objectives will ever be fully attained. Banks (1997a) argues for continually striving toward the educational ideal, while retaining one foot in the reality that prejudice, racism, sexism and discrimination against the disempowered remain an inevitable and inescapable fact of life. "Multicultural education must be viewed as an ongoing process, and not as something we "do" and thereby solve the problems that are the targets of multicultural educational reform," (Banks, 1997a: 4). Such a notion is certainly subscribed to, here, in this thesis, by viewing multicultural education as a constantly evolving process which aims to encompasses an entire spectrum of problems and issues.

Hence, multicultural education may be viewed as a procedural paradigm from which to launch curricular and pedagogical responses to the various challenges posed by a diverse learning
population, whilst keeping sight of the targets it aims to strike. It should seek to not only provide education for emancipation (Parekh, 1986), but also to improve upon a quality standard of academic achievement (Banks, 1997a). Personal equity and empowerment in, and through, education should be echoed in the policies, programs and practices which are implemented. As such, multicultural education should not be viewed as static or immutable, but able to adapt and evolve to the dilemmas and challenges which present themselves within a progressive educational environment.

1.3 TOWARDS ANTI-RACIST EDUCATION

Multicultural education is a concept which is deeply entrenched within the Canadian educational psyche. Yet, as with any paradigm, philosophy, ideology or conception, there are both proponents and detractors. Some critics take aim at its inert capacity to meaningfully confront minority grievances and aspirations. Some contend that celebration of diversity is little more than patronizing tokenism. Others charge that multicultural education fails to furnish an agenda which adequately focuses on dismantling discrimination and the perpetuation of prejudice and racism, explicit or implicit, contained within the school system, and both the social and political arenas of society in general. As a result, critics would contend that equitable access and opportunity for participation is not only compromised, but often denied for minorities (Walcott, 1993). Hence, the emergence of a variant of multicultural education known as anti-racist education (Lee, 1985).

While certain parallels with multicultural education are readily apparent, “anti-racist education encompasses a distinctive orientation along a unique set of objectives that sets it apart from multicultural education, in large degree by conferring a “radical cutting edge” to the whole concept of managing diversity within the school system,” (Fleras & Elliot, 1992: 195). Where anti-racism is concerned with uncovering and combatting prejudicial and racist attitudes and practices which disadvantage and discriminate against minorities, resulting in an unequal distribution of opportunity, wealth and power, anti-racist education is an action oriented strategy for institutional,
systemic change to address the issues of racism and the interlocking systems of social oppression (Sefa Dei, 1994, 1996).

A commitment to anti-racist education represents a logical alternative to the shortcomings of multicultural education (Carr, 1996). Multicultural education has been criticized for its failure to redress issues of systemic and societal discrimination against minorities and to tackle their grievances and ambitions (Walcott, 1993; Carr, 1996). An emphasis on culture may prove to be a disservice to minorities since it interferes with the natural process of cultural adaptation to the environment (Ramcharan, 1989). Criticism also stems from its unwillingness to restructure the education system in a manner which ensures greater access and opportunity for minority students (Fleras & Elliot, 1992; Walcott, 1993, Carr, 1996). Moreover, much of what passes for multicultural education may be criticized for being excessively folkloric or based on attitudinal studies which ignore the institutional basis of domination and discrimination (Lynch, 1986). Troyna (1987) has asserted that the type of multiculturalism practiced in most British schools may be even reinforcing racism by focusing on what he pejoratively labels “The Three Ss Approach” (saris, samosas, and steel bands), where celebrating diversity places emphasis on the presentation of superficial curiosities of different customs and dress, festivals and holidays, and the more exotic aspects of the particular ethnic lifestyle. An analogue to Troyna’s (1987) “Three Ss” may be found on our domestic shores, where some in various Ontario school boards (particularly in the Greater Toronto Area) refer to “The Three Cs” of multiculturalism: celebrations, clothing and cooking. Such an approach is not only steeped in patronizing tokenism, it studiously avoids tackling the underlying racism and racist discrimination inherent in the school system, and society in general. In such light, multicultural education may be viewed as a strategy of containment (Fleras & Elliot, 1992), where ethnicity becomes de-politicized by rechannelled into the realm of culture, not that of structure or power (McAndrew, 1987).
Anti-racist education may be viewed as a natural progression from the multicultural education agenda, to provide a paradigm and pedagogical instrument which aims to penetrate and rectify the systemic and societal inequities previously rendered impenetrable (Walcott, 1993); a view which is shared, and subscribed to, in this thesis. Anti-racist education advocates a critical agenda aimed at recognizing racial discrimination as systemic and embedded within the policies and practices of institutional structures, their organization, the values which underscore them, and the manner in which they subsequently exercise and restrict powers. It is premised on the notion of informing students, and ensuring that they comprehend the nature and characteristics of these discriminatory barriers, in order to ensure that the prevailing distribution of resources and rewards no longer remains intact. Rather, they are dismantled and restructured, both within the educational establishment and the broader spectrum of society (Fleras & Elliot, 1992).

On a particular point of clarification, prior to proceeding in this text, it should be understood, for all intensive purposes, that when this thesis makes further mention of multicultural education, it is thought of to include anti-racist education, which itself implicitly includes a stance against discrimination, not just solely on the basis of race, but also on the basis of gender, culture, socio-economic status, political inclination, etc. This does not preclude acknowledgement of those who clearly differentiate between multicultural education and anti-racist education, on the basis that they do not share the same origins, philosophy, assumptions and end goals, and that there are irreconcilable differences between the two perspectives (Troyna, 1987). However, while this thesis clearly advocates coupling multicultural education with anti-racist education, as promoted by many such as Troyna (1987), the view which is adopted here is that the multicultural education paradigm has progressed in several directions over time, encompassing a broad spectrum of issues, challenges and concerns, and that such progression and evolution has created a shift towards the anti-racist education agenda, which multicultural education has now come to include.
1.4 FROM POLICY FORMULATION ON MULTICULTURALISM IN CANADA
AND ITS IMPACT ON EDUCATION

With the promulgation of multiculturalism as Canadian state policy in 1971, the foundation
was established from which radical change could be launched within the arena of Canadian
education. Certainly, since its inception, much debate, controversy and confusion has ensued. The
Canadian Prime Minister, Pierre Trudeau, upon introducing the legislation, criticized and denounced
the assimilationist ideology which dominated policy and practice at the time, and summoned the
nation towards a Canadian society which was proud of its multicultural diversity. Trudeau (1971: 1)
proclaimed, in no uncertain terms,

There cannot be one cultural policy for Canadians of British and French origins and one for
aboriginal people and yet a third for all the others. For although there are two official
languages there is no official culture, nor does any ethnic group take precedence over any
other. No citizen or group of citizens is other than Canadian, and all should be treated
fairly.

With this initiative, the Canadian government provided the impetus to introduce
multiculturalism into various arenas and aspects of Canadian society, in accordance with liberal ideas
of egalitarianism and social justice which ran prevalent, in the 1970s, across the national conscience.
Rezai-Rashti (1995) notes that focus was accordingly fixed on affecting change through education.

The educational system was targeted as the site from where multicultural ideas, views and
principles could be diffused among young Canadians. Students were perceived as the
individuals most likely to be receptive to the new programs of educational pluralism and
exposure to other, non-Western, cultures. They, therefore, could easily adapt and respond
to the needs of a rapidly changing Canadian cultural mosaic, (Rezai-Rashti, 1995: 3).

This, of course, subsequently spurred the multicultural education movement, producing an
abundance of literature, discourse and debate resulting in reform to educational policy and practice,
affecting both curriculum and pedagogy.

Since the central focus of this thesis is science education in Ontario, it is not appropriate to
launch into a detailed account of the various subsequent federal and provincial responses to the
newly initiated national policy of multiculturalism (see Masemann & Cummins, 1985: 13-23; Lynch,
However, attention should be drawn to certain events. In 1972, a Minister of State for Multiculturalism was appointed, to oversee multicultural program activities which were to be administered through the Multiculturalism Directorate of the Department of the Secretary of State by officers in Ottawa and in regional district offices of the Department of the Secretary of State. The Multiculturalism Directorate was charged with the responsibility to operate a variety of programs and initiatives, of which the most significant in the present context were the Cultural Enrichment Program and the Multiculturalism in Education program initiatives. This marked the beginning of a sustained series of concerted efforts aimed at realizing the national policy of multiculturalism, and achieving multiculturalism within a bilingual framework, unique in Western nations, (Lynch, 1986), leading up to its enshrinement in law in 1988.

Certainly, with the institution of a new national policy, there existed awareness and dialogue at the highest levels of provincial government. “For the provinces, implementation or development of further multicultural policies focussed on areas that were of provincial concern: reception services for immigrants, discrimination in relation to housing and employment, language classes in French or English for immigrants, violation of human rights for workers in the workplace (e.g. racial taunts, clothing requirements), education of adults and children, cultural activities of established and newcomer ethnocultural groups, access to provincial government services for non-speakers of English or French, and training of “front-line” civil servants to deal with a multicultural general public,” (Masemann & Cummins, 1985: 17). Each province developed an array of procedures and guidelines to contend with the multicultural reality of Canadian society.

In specific regard to education, with Canada’s educational policies determined through the Minister of Education in each province, response was varied. Several provinces, such as Ontario, Manitoba, Saskatchewan and Alberta, launched a series of conferences with representatives from all ethnocultural groups, resulting in several recommendations concerning education to be considered
and enacted. In the Northwest Territories and the Yukon, concern with multicultural education centered predominantly around the teaching of aboriginal languages and the provision of services for Dene, Métis, and Inuit children. In the Atlantic provinces, emphasis was placed on equitable educational provision for all students, with particular attention paid to the needs of Micmac Indians, Blacks, French and recent immigrants.

The culmination of such activity was witnessed in November 1981, with the National Conference on Multicultural Education, organized in Winnipeg by ad hoc committees from each of the provinces and territories in Canada, and with the support of the Multicultural Directorate. This resulted in the founding of a new organization, the Canadian Council on Multicultural and Intercultural Education (CCMIE), with representatives from various provincial and territorial committees. As well as fostering a commitment to multiculturalism and equal recognition and consideration in educational institutions of all cultures, one of the objectives of the CCMIE is to combat racism and discrimination. The organization represents a coalition of political, academic, lay, administrative and other representatives from different cultural and racial groups. Combined with the efforts of the Council of Ministers of Education, Canada (CMEC), as well as various other governmental groups and agencies, the permeation of commitment to multiculturalism and anti-racism has gone further than any other Western nation in achieving a national consensus (Lynch, 1986). "In particular, the multifaceted nature of the approach has ensured that, in addition to legislative measures to achieve equality of educational opportunity and to outlaw racism, financial and political support has been forthcoming for major initiatives at all levels, even taking into account the criticisms which Canadians themselves make of the Canadian policy of multiculturalism," (Lynch, 1986: 28). Indeed, despite whatever problems may exist or criticisms be levelled against the Canadian brand of multiculturalism, Canadians are largely looked upon as the world leaders in the multicultural education movement (Mitchell & Salsbury, 1996).
1.5 TOWARDS POLICY AND PRACTICE ON THE PROVINCIAL LANDSCAPE OF ONTARIO

In 1979, the Toronto Board of Education became the first school board, not only in Ontario but in all of Canada, to formulate and adopt an official policy on race relations. This monumental event set in motion a chain reaction, where today, within the province of Ontario, more than forty boards of education have followed suit by formalizing their own policies on race and ethnic relations. Rezai-Rashti (1995) reported recently that some twenty-five other boards were in the process of officially setting in place similar policies. However, Rezai-Rashti (1995) comments how this situation contrasts rather negatively with the realization that more than half of the boards of education in Ontario still remain without a formal policy on race and ethnic relations.

Following much policy discourse, in 1985, the Ontario government through its Ministry of Education, moved to establish an Advisory Committee on Race Relations. The mandate of this official advisory body included, among others, the following duties:

1. to promote the development of a Race and Ethno-cultural Equity Policy by all school boards in the province.
2. to assist and advise the Ministry of Education in the creation of guidelines for equity policy development and to recommend priority areas for policy development.
3. to identify strategies that will assist boards in developing and implementing racial and ethno-cultural equity policies.
4. to place concepts such as multiculturalism, race, and ethno-cultural relations and anti-racist education in their historical context as an aid to their proper use in equity policy development, and to identify the threads that link them. (Ministry of Education of Ontario, 1987: 2).

In 1987, the Advisory Committee on Race Relations published its much anticipated report. The report was largely concerned with multicultural education and its shortcomings, advocating the adoption of an anti-racist education agenda to buttress the limitations of the current multicultural education program. The report was criticized on several levels: for being too complex, occasionally vague, and laden with jargon and terms that needed to be defined in order clarify the position being asserted; and moreover, for failing to explicitly define the institutional policies and practices which it sought to target with its summons for an anti-racist agenda to steer multicultural education (Rezai-
Despite whatever criticisms were levelled against the report, this event did mark an influential juncture for the multicultural education program in Ontario, which was now spearheaded by an anti-racist education agenda.

In 1989, the Ontario Ministry of Education commissioned a study to investigate the implementation of race and ethnocultural equity policies in Ontario School Boards. Publication of the research findings, in 1990, revealed that policy formulation within this domain is often a long and drawn-out process; a major contributing factor to such delay is that “there is often tremendous resistance to overcome in policy development and implementation: this resistance may be obvious or covert,” (Mock & Masemann, 1990: 59). While school boards in Ontario have remained vested with the authority to formulate and enact their own explicit policy and practice regarding race and ethnocultural equity, the report findings indicated that the boards have been generally awaiting the Ministry of Education “to provide leadership and modelling for policy development and implementation by mandating policy” and look to the Ministry to “provide both financial and human resources and guidelines for boards in keeping with their needs and situations,” (Mock & Masemann, 1990: viii, 59-60). Among the chief recommendations for change was that “a policy development manual should be developed, based on the results of the study, to present various models of policy development and practical step-by-step guidelines on implementation,” (Mock & Masemann, 1990: 63). Other recommendations included the provision of resources and training for educators and those seeking teacher certification in Ontario, (Mock & Masemann, 1990).

In response to such recommendations, the provincial Ministry of Education published a resource guide for educators to supplement current curriculum documents (Ministry of Education of Ontario, 1992). In 1992, the Ontario government further followed through with the 1990 recommendations (Mock & Masemann, 1990) by legislating Bill 21, an amendment to its Education Act, requiring all Ontario school boards to develop and implement anti-racism and ethnocultural equity policies. Subsequently, in 1993, the provincial government produced its most recent
multicultural education policy document through its Ministry of Education and Training, providing guidelines for anti-racist and ethnocultural policy development and implementation for school boards across Ontario, to ensure that “the principles of antiracism and ethnocultural equity are observed everywhere in Ontario’s school system,” (Ministry of Education and Training, Ontario, 1993a: 1). The provincial policy manual was designed to work in conjunction with and further supplement “the principles, practices and outcomes of antiracist and ethnocultural equity education” as “enunciated in *The Common Curriculum, Grades 1-9* and other Ministry guidelines and resource documents,” (Ministry of Education and Training, Ontario, 1993a: 5).

Certainly, in parallel to such events, much literature has been published influencing educational practice in Ontario. This has meant several changes at the administrative level of school boards, including the appointment and hiring of consultants and advisors on race relations to facilitate formulation and implementation of policy and to maintain an ongoing dialogue with various community groups representing the extensive ethnic diversity found in Ontario. Changing philosophy and thought regarding multicultural education has also been reflected to varying degrees in provincial curriculum documents and resources, as well as pedagogical practice. Educators themselves have sought to produce their own resource material within this domain, an example of which is the recent publication by the Ontario Secondary School Teachers’ Federation (OSSTF) (Coelho, Costiniuk, & Newton, 1995), designed to provide a practical guide for educators by educators, aiming to realize multicultural and anti-racist education within school practice.

While much has developed in Ontario within the domain of multicultural education policy and practice, critics still charge that the gap between the principles stated in policy and the actual implementation of such policy has not been bridged satisfactorily enough (Rezai-Rashti, 1995). Rezai-Rashti (1995) points to two issues which in her opinion deserve greater attention and resource allocation, financial and otherwise: staff development programs for teachers and raising students’ awareness of ethnic and racial issues. Multicultural education in Ontario has certainly not reached
its ideal end, and should be viewed, as stated earlier, as an ongoing, evolving process. Multicultural education policy and practice in Ontario should continue to address new issues, challenges, and concerns, as they emerge.

Activists for multiculturalism and anti-racism have found themselves facing a daunting challenge, a serious force of concern to contend with, in the form of the currently residing Conservative government in Ontario, which recently enjoyed re-election to a second consecutive term. Critics charge that Premier Mike Harris has “ripped apart most of the province’s programs to give minorities a foothold in Ontario,” (The Toronto Star, 1999). They point to several significant actions taken by the government: the repealing of the Employment Equity Act in 1996, which requires employers to set goals for hiring and promoting visible minorities, women and the disabled; the tremendous cutting of funds to the Ontario Human Rights Commission, which handles complaints about discrimination; and (what is most relevant here) the dismantling of the education ministry’s anti-racism unit (The Toronto Star, 1999). Critics further charge that the Conservatives made no mention of combating discrimination in their last election blueprint. With the unveiling its newly formed, revamped curriculum documents in 1998, some have applauded the efforts of the government to introduce more multicultural and anti-racist content in various aspects of its curriculum, such as history and social studies, while others have criticized the government for not bolstering the new curriculum with a more clear commitment to multicultural education and not providing the funding and resources for implementation of multicultural and anti-racist curricular schemes. Moreover, critics charge that by dismantling the education ministry’s anti-racism unit, the government has failed to provide any alternative body to act under such responsibility. Further charges are that the government has yet to define its own policy mandate or take any continued strides towards that there is a province wide policy and practice of multicultural education. The government has up to now diffused such charges by pointing to existing policy documents from previous governments, citing the non-necessity to provide redundant policy documents, and
furthermore has deflected responsibility to Ontario school boards for failing to adopt adequate policy and/or practice. How the Ministry of Education and Training of the currently residing Conservative government seeks to proceed within the domain of multicultural education, or respond to the continued criticism regarding multicultural and anti-racist educational agenda, remains to be seen.

1.6 CURRICULUM IMPLICATIONS

There is no dispute that the curriculum should be responsive to the multicultural education agenda, although debate may persist regarding the most effective manner of curriculum formulation and implementation (Banks, 1997b; McCarthy, 1993, 1995). The curriculum should be able to reflect the cultural and ethnic diversity of its learning audience, without straying from the overall objectives of providing an efficacious and purposeful education to prepare everyone for the complexities of life and positive participation within the various strata of society. The principal concern is to avoid marginalizing minority students with their experiences and cultures and ensuring that the learning program does indeed reflect their dreams, aspirations and perspectives (Banks, 1997b; Tomlinson, 1986). Certainly, “students learn best and are more highly motivated when the school curriculum reflects their cultures, experiences, and perspectives,” (Banks, 199b: 229-230). Conversely, many minority students are likely to be “alienated in the school in part because they experience cultural conflict and discontinuities that result from the cultural differences between their school and community,” (Banks, 1997b: 230). Multicultural education seeks to alleviate the cross-cultural tensions which are likely to surface in a culturally diverse educational environment by ensuring curricula are reflective of the cultures, experiences, and perspectives of the learning population.

While the Ontario education ministry and the many school boards, along with educators across the province, have made strides by producing and publishing several curriculum documents
and resources in an endeavour to respond to the multicultural education agenda, practice does not seem to have strayed very far beyond the three “C”s (celebrations/customs, clothing and cooking), alluded to earlier. While Masemann & Cummins (1985) direct attention to curricular change "in all course material", their focus does not extend beyond the subject areas of social studies, history, or reading, where they advocate: introducing a greater diversity of reading and social studies texts and materials; the production of new readers in the elementary grades and a greater emphasis on ethnic diversity in curriculum materials in social studies and history; and similar changes to be affected at the high school level for history and sociology courses. Indeed, provincial curriculum documents have failed to make any significant strides beyond the concerns that Masemann & Cummins (1985) identified; the anti-racist education agenda seems to be restricted to these same subject domains. Textbook publishers have responded in kind, with focus primarily on the subject areas of social studies, history and reading.

Banks (1997b) echoes a concern conveyed by many (in Canada, two examples are: Masemann & Cummins, 1985; Kehoe, 1982): that the multicultural education program penetrate all aspects of the curriculum and subsequent pedagogical practice for all subjects, whether English, writing, language arts, history, social studies, mathematics, or science. Yet, in Ontario, the provincial curriculum documents for mathematics and science have yet to be affected in any such serious manner (Krugly-Smolska, 1989). If the curriculum is to be truly responsive to, and reflective of, the multicultural education paradigm, then it would seem only reasonable that it should extend to all areas of the curriculum, including mathematics and science. Yet, one major reason that mathematics and science curricula have not yet been affected, is the prevalent perception of these domains as "culturally neutral" subject areas. In recent years, such perceptions have been challenged.

The following chapters will seek to amplify this discussion for science education. Chapter 2 will seek to resolve the notion of science education and scientific literacy, exploring various conceptions, and seek to translate such discussion within the multicultural domain, beginning to
define curricular and pedagogical implications. Subsequently, chapter 3 will present the multicultural science education paradigm, elaborating its philosophy, aims and perspectives.
CHAPTER 2
IN SEARCH OF SCIENTIFIC LITERACY: SEEKING TRANSLATION IN A
MULTICULTURAL DOMAIN

2.1 INTRODUCTION

Science education has consistently echoed concern for students to acquire and develop meaningful conceptual understandings of science alongside its manners and methods for the description, explication, prediction, application, control and manipulation of natural phenomena. Central to this goal is the cultivation and development of what science educators have termed as “scientific literacy”. Over the recent decade or so, “scientific literacy” has become a fashionable slogan employed synonymously with science education (Aikenhead, 1990; Hodson, 1992a; Hodson and Reid, 1988; Pedretti, 1994; Roberts, 1983, 1988), emerging as a predominant curriculum emphasis (Roberts, 1983). Indeed, in recent years, the phrase has emerged as an umbrella objective for science education, apparently offering the potential to shape automatically what counts as science education, thus eliminating all the tumultuous trial and tribulation of policy formulation (Roberts, 1988). However, what exactly scientific literacy entails is defined by several disparate conceptions. How such definition then translates into curriculum formulation and subsequent pedagogical practice becomes another avenue of concern. Moreover, within a multicultural society, concerned with maintaining certain aims and objectives, focus might be directed at how such definition and translation would impact on the learning environment.

Hence, this chapter will seek to briefly survey the various calls for “scientific literacy” as an all-encompassing slogan for science education. Subsequently, with scientific literacy as an advocated agenda, focus will be directed towards surveying definitions and interpretations of “scientific
literacy” and their translation into curriculum and pedagogy. Finally, this chapter will seek to shift such translation to within a multicultural domain of education.

2.2 ADVOCATING SCIENTIFIC LITERACY

With the notion of scientific and technological advancement pervading much of our lives and prominently embedded in the conscience of North American society as being equated to economic and political primacy, political, social, cultural, and economic interests have prompted calls for scientific literacy (Roberts, 1983). Thomas and Durant (1987), upon an “extensive and diverse” review of the literature, identified nine arguments proffered for the promotion of the public understanding of science. These propositions are distinguished by reference to the benefits associated with them, namely, benefits “to science itself, to national prosperity, national power and influence, democratic government, society as a whole, intellectual life, aesthetic application and morality.” Hence, with the pressing perception of vast vested interests at stake, “scientific literacy” emerged initially as a rallying symbol for educational ideology, not as a defined objective (Roberts, 1983, 1988). However, this subsequently translated into a powerful platform for promoting science education.

The 1960s marked a period of rapid and revamping reform for not only science education, but the entire arena of education. This decade also triggered contemplation and consideration of the notion of scientific literacy (Roberts, 1983). By 1969, much thought and opinion had been expressed regarding scientific literacy. Hurd (1969), commenting on the scene, characterized it as follows:

No one seems to deny that developing a scientific literacy is an essential component of general education, although there is little agreement as to just what this means. One idea does seem quite clear: the role of science in our culture, its integration into nearly every aspect of human life and human needs, demands a revamping of science teaching to develop a coherence of science and society. The present curriculum reform has resulted in
courses that are bound to scientific disciplines neglecting the social aspects of science, (pp.108-109).

With the constantly changing face of scientific and technological progress, dissemination of fundamental understanding and competence has taken precedence in the arena of education, from its most elementary levels. The development and implementation of a coherent educational curriculum that addresses fundamental issues, such as content and methodology, is viewed as instrumental in ensuring the continued development of our society through the proper education and nurturing of young minds, in order to ensure future success. With the prevailing and widely accepted view of education as the fundamental foundation to any society, the concern extends beyond the actual acquisition of knowledge to the application and manifestation of it for social, political, economic and cultural gain and benefit. Consequently, calls for scientific literacy abound: American Association for the Advancement of Science (1986, 1993); Economic Council of Canada (1992); Government of Canada Consultation Papers (1991a, 1991b); Ministry of Education of Ontario (1988); Ministry of Education and Training (of Ontario) (1998); National Assessment of Educational Progress (1988); Science Council of Canada (1984). In response to what has been envisaged as a crisis in scientific literacy, various organizations and governmental agencies have issued recommendations for curricula, encompassing an array of perspectives (Pedretti, 1994). The following constitutes a small sampling of such proposals.

In 1982, the National Science Teachers Association (NSTA), in the United States, issued the following statement:

The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology and society influence one another and who are able to use this knowledge in their everyday decision-making. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual networks and process skills which enable the individual to learn and think logically. The individual both appreciates the value of science and technology in society and understands their limitations.
Following on the heels of a lengthy and thorough, in-depth investigation of the way science was taught in Canadian schools, the Science Council of Canada (1984: 10) urged that science be taught in such a manner as to:

1. Encourage full participation in a technological society;
2. Enable further study in science and technology;
3. Facilitate entry into the world of work; and
4. Promote intellectual and moral development among men and women.

In 1986, came the release of the widely publicized report, Project 2061, by the American Association for the Advancement of Science (AAAS), which offered its particular conception of scientific literacy.

Education has no higher purpose than preparing people for personally fulfilling and responsible lives. For its part science education — meaning education in science, mathematics, and technology — should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on. It should equip citizens in building and protecting a society that is open, decent and vital. America’s future — its ability to create a truly just society, to sustain its economic vitalities — depends more than ever on the character and quality of the education that the nation provides for all of its children, (AAAS, 1986:12).

More recently, with the publication of its Project 2061 Benchmarks, the AAAS noted that:

People who are literate in science are not necessarily able to do science, mathematics or engineering in a professional sense, any more than a music-literate person needs to be able to compose music or play an instrument. Such people are able, however, to use the habits of mind and knowledge of science, mathematics, and technology they have acquired to think about and make sense of many of the ideas, claims, and events that they encounter in everyday life. Accordingly, science literacy enhances the ability of a person to observe events perceptively, reflect on them thoughtfully, and comprehend explanations offered for them. In addition, those internal perceptions and reflections can provide the person with a basis for making decisions and taking action, (AAAS, 1993:322).

While the term “scientific literacy” has been scattered about with great promiscuity and ambiguity (Roberts, 1983), it remains very much an abstract image which directs science education reform (Eisenhart et al., 1996). Indeed, in reviewing such sundry summons for scientific literacy, certain common elements do emerge. Students are encouraged to appreciate, apply and
comprehend science, recognize their powers and limitations, engage in responsible decision-making and recognize the interrelatedness of science, technology and society (Pedretti, 1994), thereby producing individuals who contribute constructively to society in a manner which is "interesting, responsible and productive," (AAAS, 1993: xi). However, despite the common elements, the notion of "literacy" stemming from science education still demands further consideration.

2.3 IN SEARCH OF DEFINING SCIENTIFIC LITERACY

While strongly advocated by science educators (educational researchers, curriculum workers and instructors) en masse, the ambiguity of scientific literacy offers many disparate interpretations (Aikenhead, 1990; Eisenhart et al., 1996; Fensham, 1988; Jenkins, 1990; Pedretti, 1994; Roberts, 1983, 1988). With the widespread adoption of a platform considered to be both comprehensive and exhaustive, by numerous groups, each carrying its own competing demands (Fensham, 1988), one would naturally anticipate the proliferation of multiple interpretations and definitions emanating from several societal sectors, each laying stress to objectives commensurate with its own respective interests. Hence, while it is clear that diverse views are held concerning what exactly scientific literacy constitutes, there also exists considerable confusion and conflict (Pedretti, 1994). For the sake of brevity, the following text only briefly examines a sample of the many definitions of scientific literacy in the contemporary science education literature.

Miller (1983) attempts to measure scientific literacy along the "three constitutive dimensions of: the norms and methods of science; cognitive science knowledge; and attitudes towards organized science." Jenkins (1990) notes that these dimensions were evident in the investigation by the National Science Foundation of scientific literacy among adults in the United States in 1979. He further asserts that "this combined an understanding of the scientific approach, of basic science
constructs and of science policy issues into a single measure of public understanding of science,” (Jenkins, 1990:46).

Thomas and Durant (1987) concluded from their substantial survey of the existing literature, that scientific literacy entailed some, or all, of the following eight characteristics:

1. An appreciation of the nature, aims, and general limitations of science; a grasp of the ‘scientific approach’ – rational arguments, the ability to generalize, systematize and extrapolate: the roles of theory and observation.
2. An appreciation of the nature, aims and limitations of technology, and of how these differ from those of science.
3. A knowledge of the way in which science and technology actually work, including the funding of research, the conventions of scientific practices and the relationship between research and development.
4. An appreciation of the inter-relationships between science, technology and society, including the role of scientists and technicians as experts in society and the structure of relevant decision-making processes.
5. A general grounding in the language and some of the key constructs of science.
6. A basic grasp of how to interpret numerical data, especially relating to probability and statistics.
7. The ability to assimilate and use technical information and the products of technology; ‘user-competence’ in relation to technologically-advanced products, (pp.12-13).
8. Some idea of where and from whom to seek information and advice about matters relating to science and technology.

While scientific literacy clearly extends beyond mere mastery of a specific set of scientific concepts and theories, to what degree it extends is certainly a contestable issue. Despite widespread usage for more than a decade within science education literature, there is still no consensus about what precisely scientific literacy entails (Jenkins, 1990; Eisenhart et al., 1996; Galbraith et al., 1997). Indeed, Orpwood and Garden (1998) comment on the great difficulty and arduous challenge of synthesizing an assessment scheme for something still not clearly defined or universally agreed upon.

While some may view scientific literacy as the capacity to read, with reasonable understanding, lay articles regarding scientific and technological affairs and themes published in the popular media, others would regard it as being in possession of the requisite knowledge, skills and attitudes deemed appropriate for a professional scientist. Others more ambitious, such as the
AAAS, attempt to incorporate both elements, where a scientifically literate individual is defined as one who “is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes,” (AAAS, 1989:4). They further direct attention towards scientific literacy for a more socially compassionate and environmentally responsible democracy when they declare that science may provide knowledge “to develop effective solutions to its global and local problems” and may foster “the kind of intelligent respect for nature that should inform decisions on the uses of technology” and without which, they warn, “we are in danger of recklessly destroying our life-support system.” However, they fail lamentably, to suggest that scientific literacy might also include the capacity and disposition to behave in environmentally responsible and socially just ways. Such a component appears absent from the definition proposed by the Council of Ministers of Education (1997:4) to guide curriculum construction throughout Canada. Here, scientific literacy is seen as “an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them.”

It should be noted that there are those who would argue that such notions of widespread scientific literacy are too grand and ambitious as a concept and attempt to encompass more than they are capable of delivering. These critics contend that such a broad and far-reaching platform should be abandoned for an agenda more likely to be realistically achievable (Bauer, 1992; Jenkins, 1990; Shamos, 1995). Jenkins, (1990) suggests a more restricted concept of “scientific literacy”, in favour of adopting universal scientific literacy as an educational objective, balancing “a more
positive and conventional range of meanings of scientific literacy as a determinant of objectives of school science education," (p.50). Bauer (1992) contends that scientific literacy should put less emphasis on the traditional notions of the scientific method and seek to provide more of a sophisticated social understanding and context for science in the vein of STS (Science-Technology-Society) education, noting it to be “more important than science itself for a liberal education,” (p.17). Hence, scientific literacy might serve as a branch of social literacy. Finally, Shamos (1995) suggests that the notion of developing a significant scientific literacy for the public domain is “little more than a romantic idea, a dream that has little bearing on reality,” (p.215). Hence, he argues that it should be abandoned altogether, to be replaced by more realistic goals such as fostering “science awareness” or “science appreciation”, and that the public must learn “to seek credible advice from (scientific) experts” who would serve not so much “as surrogates for the public in determining proper course of action on science/technology-based social issues, but as advisors on the purely technical aspects of such issues, from which the public might hopefully reach better-informed judgments,” (pp.206-207). Although the preceding examples appear to advocate a concerted shift away from scientific literacy, it may be argued that each of them represents a particular interpretation of what may still be termed “scientific literacy”, while defining it with its own respective emphases and shifting its particular focus of intended goals in particular directions.

As an example of such a semantic shift, the Scottish Consultative Council on the Curriculum (SCCC, 1996: 15) has adopted the term “scientific capability” instead of “scientific literacy” on the grounds that “it conveys more clearly a flavour of science education for action as well as for personal enlightenment and satisfaction.” Scientific capability is defined in terms of five distinct, but clearly interrelated, aspects: scientific curiosity (an enquiring disposition), scientific competence (the ability to conduct a scientific investigation), scientific understanding (an understanding of scientific
ideas and the way science works), scientific creativity (the ability to think and act creatively), and scientific sensitivity (a critical awareness of the role of science in society, combined with a caring and responsible disposition). Hence, scientific capability extends considerably beyond the acquisition of scientific knowledge, skills and understanding but also encompasses the development of personal qualities, attitudes, critical awareness and reasoning, offering a more personalized and politicized form of what might still be termed “scientific literacy”.

From such an abundance of diverse definitions and interpretations, Roberts (1983:27) points to what he describes as “the most exhaustive composite definition of scientific literacy to appear in the science education literature to date”, referring to the “theoretical model of scientific literacy” developed by Gabel (1976). Gabel’s (1976) model enumerates eight “dimensions”, each of which refers to an aspect of science education advocated in the literature.

1. Organization of knowledge.
2. Intellectual processes.
3. Values and ethics.
5. Human endeavour.
8. Interaction of science, technology and society.

Gabel (1976) added a second dimension to his model which combining the six major categories for cognitive objectives (knowledge, comprehension, application, analysis, synthesis, and evaluation), widely employed through taxonomy developed by Bloom (1956) and others, with the three major categories for affective objectives (valuing, behaving and advocating) provided by Krathwohl et al. (1964). Roberts (1983) notes that what is immediately striking about Gabel’s model is that it includes, under the definition of scientific literacy, every conceivable category of science education, and every dimension or facet of the learning process, even venturing into both the cognitive and affective domains.
With such a wide range of definitions and interpretations of scientific literacy, the problem is to sort through them, make an appropriate selection, and translate them into a viable science education curriculum, which supports, and is supported by, viable pedagogy. This will serve as the focus for the following section, an examination of implications for both curriculum and pedagogy.

2.4 CURRICULUM AND PEDAGOGICAL IMPLICATIONS

Given the daunting range of disparate conceptions, the notion of synthesizing a curriculum in pursuit of scientific literacy, presents a formidable task for science educators. While the messiness of policy formulation is seemingly removed by adoption of the umbrella platform of scientific literacy, this perception is illusory. Because of the considerable scope for definition and interpretation, the problems policy makers have in adjudicating amongst the conflicting wishes of stakeholders still remains (Roberts, 1988). Indeed, the situation is further exacerbated by the competition of several additional factors, which influence curriculum construction and final formulation. Fensham (1988) offers insight into the competing segments of society which place their personal demands on schooling and science education. He indicates that there are certain societal demands which compete for priority in a science curriculum's emphases; these are rooted in the preservation and primacy of the following interests: political, economic, cultural, social, individual and subject maintenance. Fensham (1988) asserts that each of these elements plays a vital role in influencing and impacting decisions about schooling and science education. Each, of course, emphasizes objectives commensurate with its own respective interests.

Roberts (1983,1988) describes seven science curriculum emphases, which may be found from surveying the history of science education practice in elementary and secondary schools in North America, and asserts that scientific literacy is achieved through the balance of these
competing curriculum emphases. The respective title of each curriculum emphasis is largely self-explanatory and suggestive of its inherent meaning. They are:

1. An everyday coping emphasis, which orients science teaching towards the application of science to objects and events of fairly obvious importance to the student.
2. A structure of science emphasis which orients teaching in such a way that the student comes to understand how science functions as an intellectual enterprise.
3. A science, technology and decisions emphasis which draws attention to the limitations of science, but also to its strengths, in dealing with the practical affairs of mankind.
4. The scientific skill development emphasis has science subject matter taught in the service of developing conceptual and manipulative skills, such as observing, measuring, experimenting, hypothesizing, etc. It represents an emphasis on the means of scientific inquiry.
5. The correct explanations emphasis focuses heavily on the ends of scientific inquiry, rather than the means. The emphasis is familiar to anyone engaged in science teaching as the "master now, question later" strategy.
6. The self as explainer emphasis, which concentrates on the similarities between a student's explanatory activities within his/her cultural context and the explanatory ideas of scientists within their own cultural matrix. Thus, the idea of scientific ideas shows up as a function of human purpose, and it is only a short step from there to looking at other modes of explanation, such as religion or magic, to see that a different kind of human purpose is served by them.
7. The solid foundation emphasis answers the student query about the purpose of learning "this stuff" in a straightforward manner: "to get ready for the 'stuff' you are going to learn next year." In some ways this is the reassuring curriculum emphasis, for it indicates to the student that he/she is learning something that fits into a structure which has been thought about and planned. (Roberts, 1983:13-15).

Consequently, scientific literacy is viewed as a composite curriculum emphasis which encompasses and balances the preceding individual emphases for science education.

In line with the Science-Technology-Society (STS) educational movement, Pedretti (1994) offers five prevalent paradigms, adapting Hodson's (1992a) conceptual framework for a science education curriculum which attaches priority to universal scientific literacy. Without launching into STS education in much detail, it essentially rests on the premise of interpreting science and technology as complex socially embedded enterprises and seeks to promote the development of a critical, scientifically and technologically literate citizenry capable of understanding STS issues, empowered to make informed and responsible decisions and able to act upon such decisions
(Pedretti, 1994). Pedretti (1994) argues that the inclusion of STS curricula in science education is one attempt to further promote and engage students in scientific and technological literacy building. Pedretti’s framework is developed from a synthesis of the work completed by Hodson (1992a), Prakash and Waks (1985) and Shen (1975), and represents different aspects of science and technology education which affect curriculum development, reform and teacher practices.

Hodson (1992a) presents a convenient way of viewing science education as comprising three major elements. Firstly, doing science, which involves actually engaging in and developing expertise in scientific inquiry and problem solving. Secondly, learning science, which entails acquiring and developing conceptual and theoretical knowledge. And lastly, learning about science, which comprises developing an understanding of the nature and methods of science, and an awareness of the complex interactions among science, technology, society and environment.

In pursuit of scientific (and technological) literacy, Pedretti (1994) presents a similar model: five prevalent paradigms, comprising different dimensions of such literacy. Firstly, doing science and technology entails a practical literacy aimed at both the processes and practices involved in conducting a scientific and/or technological exercise. Secondly, learning science and technology requires a rational literacy, where acquisition and development of appropriate knowledge (conceptual and theoretical) takes precedence, and where such a process is closely related to doing science. Lastly, learning about science and technology demands a cultural literacy which ensures cultural awareness, relevance and application of knowledge; a personal literacy, where one’s individual values, attitudes and skills are incorporated with those of science and technology, leading to a personalized learning ensuring relevance and familiarity; and social or civic literacy, which empowers the individual with the knowledge, skills and attitudes of science and technology, towards a politicized learning. In Pedretti’s (1994) view, the last three are highly integrated and interdependent aspects of literacy.
In reviewing the various summons and definitions of scientific literacy, certain common elements become evident. Chiefly, that “students are encouraged to appreciate, apply and understand science (and technology), recognize their powers and limitations, engage in responsible decision-making and recognize the interrelatedness of science, technology and society,” (Pedretti, 1994:15). Indeed, each of the preceding paradigms for scientific literacy seeks to ensure a comprehensive curriculum which preserves the integrity of science education without neglecting social concerns and implications. In this vein, Hodson and Reid (1988) call for a curriculum which ensures universal scientific literacy, accessible to all students, regardless of social, cultural and economic considerations, and irrespective of their different interests, experiences and abilities. Their “science for all” curriculum outlines aspects which should be incorporated as a minimum in the final formulation of any science curriculum.

2. Applications of knowledge – the direct use of scientific knowledge in real and contrived situations.
3. Skills and tactics of science – familiarity with the processes of science (classifying, hypothesizing, etc.) and in the use of apparatus and instruments.
4. Problem solving and investigations – application of knowledge, understanding, skills and tactics to real investigations.
5. Interaction with technology – practical problem solving, emphasizing scientific, aesthetic, economic, social, and utilitarian aspects of possible solutions.
7. History and development of science and technology.
8. Study of science and scientific practice – philosophical and sociological considerations centring on scientific methods, the role and status of scientific theory and the activities of the community of scientists. (Hodson & Reid, 1988:658-659).

To reiterate a point made earlier in this text, any science education curriculum seeking particular educational objectives ensures its viability by supporting and being supported by appropriate pedagogical practice. Indeed, the disparity between the “intended” curriculum and the “implemented” curriculum is a consequence of a number of factors: availability of resources, teaching context, available support, teacher beliefs. Also key to this incongruity between the
intended and implemented, is an approach to curriculum development which fails to identify and engage teachers as the key agents of change, and ignores the uniqueness of educational settings. In other words, scientific literacy will not be achieved successfully except through a viably formulated curriculum, which balances the various emphases in science education and reconciles competing interests, coupled with pedagogy which accounts for the factors commensurate with its implementation and delivery. This would necessitate a curriculum which ensures provisions and resources in favour of critical pedagogical practice. However, this must also include a reciprocation on the part of teachers to ensure adherence and advocacy of the curriculum directives.

The past two decades have witnessed extensive research into children's alternative conceptions in science, which has led to the formulation, development and widespread adoption of constructivist approaches to teaching and learning science (Atwater, 1996; Cobern, 1993; Driver et al, 1994; O'Loughlin, 1992; Tobin, 1993; Tobin & Tippins, 1993). Constructivism refers to a pedagogical paradigm for the practice of science education currently in vogue. While the term "constructivism" encompasses a wide array of theoretical positions (Good, 1993; Geelan, 1997), and has been variously used to refer to diverse views about learning, teaching, curriculum development and pedagogical development, what is common to constructivist learning theories is that they squarely place the action of learning with the learner. In essence, constructivist psychology asserts that all knowledge is constructed as a result of cognitive processes with the learner, through their experiences rooted in particular contexts. Constructivism is a way of thinking about knowing, a referent for building models for learning, teaching and curriculum, to be put to use in the learning environment (Tobin, 1993; Tobin & Tippins, 1993). In summary, there are four main pedagogical processes through which learning is precipitated (Hodson & Hodson 1998:34):

- Identify students' ideas and views.
- Create opportunities for students to explore their ideas and test their robustness in explaining phenomena, accounting for events and making predictions.
• Provide stimuli for students to develop, modify and, where necessary, change their ideas and views.
• Support their attempts to re-think and reconstruct their ideas and views.

In this regard, from a constructivist perspective on pursuing scientific literacy, students' preconceptions and cognitive frameworks command prime attention, especially since preconceptions and frameworks inevitably emerge from one's cultural milieu. Hence, understanding the student's culture would facilitate more effective teaching. Within a multicultural educational domain, such consideration would be of considerable significance. Indeed, the various definitions and interpretations of scientific literacy offered here, suggest a significant social and cultural factor which is sure to have impact on the learning process and environment.

2.5 DILEMMA WITHIN A MULTICULTURAL DOMAIN

The intersection of science and society demands focus on a significant dimension which pervades both – culture. Certainly, there appears to be a considerable consensus amongst educators, both researchers and practitioners, that learning is an exercise acutely affected by the impact of culture, context and environment. Consequently, within the span of scientific literacy, which encompasses a focus on science, technology and society, a consideration of culture represents a critical avenue of exploration and evaluation of science education and learning, and how they are influenced by the impact of culture and its various facets.

Living in a multicultural society, such as Canada, inherently carries with it certain challenges and dilemmas. Aside from debating issues of perspectives such as assimilation, integration, and ethnic and cultural pluralism (recall chapter 1), it is vital to view the extensive ramifications of policies and decisions regarding education, which serve as a primary foundation to establish, compose, configure, define, and dictate concepts and notions of any societal framework. The
purpose of an educational curriculum based on specific content and goals then becomes a venue for investigation, whereby one would want to seek out factors and issues determining the content and objectives deemed valuable and relevant. Narrowing the focus would subsequently lead one to analyze specific subject areas and the concept of their application in a socially practical, relevant, and responsible manner. Further to this, emerge issues of control, manipulation and exploitation of a learning environment which may be in conflict with the cultural values of children coming from varying backgrounds.

The primary goal of science education has always been to aid students in developing meaningful conceptual understandings of science and its manners and methods of describing, explaining, predicting, applying, controlling and manipulating natural phenomena. Fostering and developing scientific literacy (with an emphasis on knowledge acquisition) amongst students has remained a central goal of science education. Toward this end, science instruction has consistently been designed to integrate science processes and conceptual knowledge. While what science educators hope to achieve, with regard to scientific literacy, continues to reside within some general domain of objectives, the question of how to achieve such objectives has persisted in debate through the history of science education. The science curriculum has consistently been geared toward facilitating the educative process, in the most efficacious manner deemed appropriate, by focusing on investigations and activities designed to help students modify their intuitive, “everyday” modes of explaining nature and the universe. Through such modification, students are expected to displace their former seemingly dysfunctional theories, by fresh and functionally valid theories of science, to be adopted and incorporated within their personal framework of scientific concepts and ways of thinking. However, what of conflict still persisting with the learner’s conceptual framework and the conceptual understanding proffered by the teacher?
Over the last few decades, science education emphasis has shifted from a “science for scientists” focus to a “science for all” focus and science education has aimed to foster scientific literacy among a much larger cross section of society. Thus, science education has become an enterprise engaged in incorporating scientific knowledge, skills and attitudes within the distinctive framework of a very diverse learning audience (Atwater & Riley, 1993). It is important to acknowledge that all arguments for scientific literacy are value laden and may not easily cross national or even sub-cultural boundaries (Jenkins, 1990). In a multicultural classroom, therefore, the problem is that students must cross quite formidable boundaries in order to gain access (Atwater, 1995).

In other words, one can not ignore “that science and science education are cultural enterprises which form a part of the wider cultural matrix of society and that educational considerations concerning science must be made in light of this wider perspective,” (Maddock, 1981:10). Sociocultural factors contributing to one’s social and cultural identity, comprising gender, ethnicity, religion, economics, politics and the sociocultural environment, impact quite considerably on the learning process. Science education is no exception (Atwater, 1996; Atwater & Riley, 1993; Krugly-Smolska, 1989; O’Loughlin, 1992).

The cultural milieu has long been recognized as a major influence on scientific thought (Aikenhead, 1996; Krugly-Smolska, 1989). Anyone who has introduced concepts and notions of science and technology into a community either within, or from, a developing nation, or those who have attempted to teach science to children in such communities will appreciate the full impact of such statement (Aikenhead, 1980). For instance, many cultures do not believe as we do in the value of relating events in terms of the relationship between cause and effect (Aikenhead, 1980). Hence, science must be viewed as a social phenomenon in which people are trained to view the world in
certain ways. Such world views are bound by traditional habits of perceiving and thinking, situated within a cultural mindset. Indeed, Cobern (1993) has asserted that different cultural environments give rise to different "worldviews", defined as composite sets of beliefs, values and ethos, maintained consciously or subconsciously, regarding the nature of reality and the process of pursuing knowledge concerning it. Such "worldviews" predispose people's emotions, thoughts and behaviours in particular ways. Consequently, one should anticipate very conspicuous cross-cultural differences to emerge in the ways people conceptualize and interact with the natural environment and, hence, significantly diverse manners of response to Western science and its endemic protocol for conceptualizing and investigating natural phenomena. Hence, educational research becomes vital in seeking to understand and develop a pedagogical approach sensitive to the larger dynamics surrounding education, such as overriding social, political, economic and cultural contexts and issues.

If science is a cultural construct, imbued with particular values rooted in the context and backdrop from which it emerges, science education may also be viewed as being postulated within a Western, or Euro-American, cultural framework and creating a situation of cultural imposition and dominance over many others who originate from diverse backgrounds (Aikenhead, 1993, 1996; Atwater & Riley, 1993; Hodson, 1992b, 1993, 1999; Jegede, 1997; Rakow & Bermudez, 1993; Stanley & Brickhouse, 1994). Because literacy is inextricably linked to language and culture, the literacy of scientific literacy is that of Western culture, so that when science content and methodology are taught, there is a simultaneous conveyance (instruction, and to a significant extent indoctrination) of a dimension of Western culture (Aikenhead, 1996; Hodson, 1992b, 1993; Krugly-Smolska, 1989; McKinley et al., 1992). As a consequence, cross-cultural tensions are likely to surface. Within the multicultural domain of education, how are such situations to be addressed? How are such tensions
to be ameliorated? Is the integrity of science education and scientific literacy compromised? Is the integrity of the child's cultural beliefs, values and ethos violated, even if the child is initially unaware? Translating scientific literacy into a curriculum and an effective pedagogy poses significant problems, as outlined earlier. These problems are considerably exacerbated by the multicultural domain, with serious concern directed at the problem of reconciling cultural integrity with scientific integrity.

2.6 PROGRESSING TOWARDS A SOLUTION

Previous discussion has argued that the task of teaching science in contemporary Western societies requires that we support all children in their efforts to acquire scientific knowledge, interests, skills, attitudes and ways of thinking without committing violence against their particular cultural beliefs and experiences (Hodson, 1992a, 1993). An approach needs to be sought which establishes a framework of guidelines to assist the planning of a science curriculum and a pedagogical approach capable of achieving a synthesis between multicultural and anti-racist procedures. This approach should emphasize the reconciliation of individual needs within a culturally diverse social environment, while also ensuring that due attention is paid to raising issues of equality, justice and empowerment. Taking account of science as a cultural phenomenon means giving attention to all societal influences which vie for their demands to be emphasized in the decision making process of the science curriculum. Given the goal of scientific literacy for all, and the reality of a multicultural society, it becomes necessary to ensure the maintenance of equitable access and the elimination of sociocultural marginalization and disenfranchisement of learners. Hence, within the sphere of science, technology and society education, the notion of scientific literacy necessitates a much broader social and cultural consideration of, and reflection on, the history, philosophy and sociology of science. The next chapter focuses on the philosophy,
objectives and perspectives of multicultural science education.
CHAPTER 3
MULTICULTURAL SCIENCE EDUCATION: PHILOSOPHY, OBJECTIVES AND PERSPECTIVES

3.1 INTRODUCTION

_Tell me, I forget._
_Show me, I remember._
_Involve me, I understand._

Ancient Chinese Proverb

As suggested earlier, there is increasing recognition that science education is postulated within a Western or Euro-American cultural framework, creating a situation of cultural imposition and dominance over many others, people and ideas, originating from diverse backgrounds (Aikenhead, 1993, 1996; Atwater & Riley, 1993; Hodson, 1993, 1999; Jegede, 1997; Rakow & Bermudez, 1993; Stanley & Brickhouse, 1994). As a result, cross-cultural tensions emerge. Multicultural education operates on the premise of ameliorating such a situation and, moreover, minimizing, if not altogether eliminating, such tensions and the possible marginalization of students (Atwater, 1993, 1995, 1996; Atwater & Riley, 1993; Hodson, 1993, 1999; Stanley & Brickhouse, 1994). Since preconceptions and frameworks inevitably emanate from one's cultural milieu, understanding the student's culture is an essential element in facilitating a more effective delivery of the particular curriculum content.

Atwater (1996) has noted that traditional paradigms for science education focused on the learning of science with little regard for the sociocultural context, or the cultural composition, of its learner audience. Aikenhead (1996) notes the emergence of a literature addressing such issues, pointing to a seminal volume of _Studies in Science Education_, in which Maddock (1981) proposed
that science and science education are cultural enterprises which form a part of the wider cultural matrix of society and that educational considerations concerning science must be made in the light of this wider perspective," (p.10). Aikenhead (1996) also notes that the same volume contained Wilson's (1981) comprehensive review of a diverse body of literature dealing with the cultural contexts of science education. "Over the ensuing years, research into multicultural science education has enriched Maddock's and Wilson's original work," (Aikenhead, 1996: 1).

According to Atwater (1996: 822), "Multicultural science education is a field of inquiry with constructs, methodologies, and processes aimed at equitable opportunities for all students to learn quality science." Earlier, Pomeroy (1994) had identified the major issues and tensions driving the multicultural movement in science education and explored numerous programs and research proposals, analyzing them into nine research agendas, each depicting a distinct facet of cross-cultural endeavours. All of the studies in Pomeroy's (1994) survey examined science education in non-Western nations, or in indigenous societies, or science education for minorities in industrialized countries (groups underrepresented in science and technology professions). Her discussion of the nine agendas creates a general progression from a more static view of multiculturalism, which maintains the status quo structure of institutions of science and culture, to a more dynamic intercultural or cross-cultural view which requires the deconstruction of Western science as universal and a fresh construction of, and most importantly access to, alternative views and methods.

Hodson (1993, 1999) categorizes major thrusts of multicultural science education as: personalization of learning (which this thesis advocates as the most significant element), the demythologization of science, and the politicization of science education. Toward this end, the demands of cultural pluralism and anti-racism must be reconciled with cultural diversity and the science enterprise. In examining the multicultural science education agenda, this thesis employs Hodson's (1993, 1999) classifications as a way of facilitating discussion of the pertinent objectives
and considerations identified in earlier chapters. This chapter is principally concerned with the implications of the formulation of a science curriculum for universal scientific literacy and with debating its practicality and validity in the context of a multicultural society, bearing in mind the previous distinctions drawn among assimilation, integration, ethnic and cultural pluralism, and anti-racism.

3.2 PERSONALIZING LEARNING AND KNOWLEDGE

“Personalization of learning means taking account of the knowledge, experience, needs, interests and aspirations of each learner, regardless of their sociocultural background, and acknowledging that cultural factors outside the immediate environment of the school play an important role in the development of students’ scientific concepts and, therefore, in the ways they respond to curriculum experiences” (Hodson, 1999: 217). The past two decades have witnessed extensive research into children’s alternative conceptions in science, which has led to the formulation, development and widespread adoption of constructivist approaches to teaching and learning science (Atwater, 1996; Cobern, 1993; Driver et al, 1994; O’Loughlin, 1992; Tobin, 1993; Tobin & Tippins, 1993). Constructivism is a way of thinking about knowing, a referent for building models for learning, teaching, and curriculum, to be put to task in the learning environment (Tobin, 1993; Tobin & Tippins, 1993). Its basic essence is centered on students’ construction of knowledge and understanding through a personalized experiential learning process. In summary, there are four main stages to the constructivist approach: identifying students’ ideas and views; creating opportunities for students to explore their ideas and test their cogency and soundness in explaining phenomena, accounting for events and making predictions; providing stimuli for students to develop, modify and, where necessary, change their ideas and views; supporting their attempts to rethink and reconstruct their ideas and views (Hodson, 1999). It follows that students’
preconceptions and cognitive frameworks command prime attention, especially since preconceptions and frameworks inevitably emerge from one's cultural milieu. Hence, a good understanding of the student's culture should facilitate more effective teaching.

Posner et al (1982) have argued that new learning is attained when learners are dissatisfied with their current convictions, and understanding, and have ready access to a new or seemingly more accommodating notion. They further argued that the acceptability of a new conception is contingent upon certain criteria. Firstly, it must be intelligible, in that the learner must comprehend what it means and how it can and should be applied. Secondly, it must be plausible, so that it should be consistent with and reconcilable with other aspects of the students' understanding. Thirdly, there should be dissatisfaction with existing conceptions, either prior to, or as a consequence of, exposure to the new conception. Lastly, the new conception should prove fruitful, in that it should possess the capacity to provide something of value to the learner by not only solving significant problems, and suggesting new interpretations, but furthermore, leading to new insights and discoveries.

Discontent with a prevailing notion may reside in experiencing an anomaly when attempting interpretation, or in the current conception's inability to correctly predict, control or manipulate events beyond its previously restricted context. That is, it no longer proves fruitful in the new situations one confronts. It might also be encountered in the realization that other alternative modes of explanation satisfy the conditions of intelligibility and plausibility more adequately than existing beliefs. Hodson (1999) states that the conceptual change approach described by Hewson and Thorley (1989) regards teaching and learning science as a matter of modifying the status of rival conceptions with respect to the aforementioned conditions of Posner et al (1982). "Put simply, the teacher's task is to lower the status of the existing ideas and the raise the status of the new one," (Hodson, 1999: 218).

However, there are two limitations to this conceptual change view of learning, which
Hodson (1999) has indicated. Firstly, it ignores the tendency of students to persistently cling to existing views despite the overwhelming evidence to the contrary, and despite the powerful arguments in favour of the teacher’s proffered alternative. “For example, young children attempting to explain floating and sinking will quite happily shift from explanations based on weight to those based on size or texture, depending on the particular context. If children don’t expect consistency among explanations, then inconsistency between existing views and ‘official’ views is not an incentive for change,” (Hodson, 1999: 218).

A second limitation exists in the treatment of conceptual change as an entirely rational process in which learners decide between rival conceptions, or competing theories, on the basis of compelling empirical evidence, and/or theoretical assertion. By contrast, Kuhn (1970) has maintained that scientific revolutions (major theoretical revisions) may not always be explained in entirely rational terms. Since, it is not possible to conduct critical experiments capable of furnishing theory-independent data, it follows that there are no purely logical criteria (in the familiar usage of the term) for substantiating the superiority of one theory over another (Hodson, 1999). “In other words, theories are empirically under-determined. Empirical adequacy is not enough in itself to establish validity and, in practice, empirical inadequacy is frequently ignored by individual scientists fighting passionately for a well-loved theory, and is often considered subordinate to the ‘context of discovery’ by the community appointed validators,” (Hodson, 1999: 218).

In other words, knowledge is negotiated within the community of scientists by a complex interplay of theoretical argument, experiment and personal opinion, underpinned by a complex of personal feelings and attitudes rooted in social, economic, political moral and ethical considerations. If the community of scientists changes its views for all kinds of ‘non-rational’ reasons, why should it be any different for individual learners? A learner’s goals, aspirations, feelings, experiences, values and attitudes will play a part. So, too, will the learner’s other knowledge (both scientific and non-scientific), intellectual tools, linguistic competence, and overarching epistemological and metaphysical beliefs. The greatest influence of all, however, may be the sociocultural location of the learner and his/her sense of identity – principally, class, gender and ethnic identity. Hence, ‘non-rational’ factors that might influence an individual learner’s acceptance or rejection of a new idea in a science class include: interest; perception of relevance; self-interest; feelings of anxiety, uncertainty,
satisfaction, confidence and pride; aesthetic, political, economic and moral-ethical concerns. Put simply, how students feel about the ideas being presented to them, for whatever reasons, influences their learning. Feelings of wonder, delight, amusement, interest, disinterest, boredom and disgust will clearly impact in different ways on a learning task — sometimes favourably, sometimes unfavourably. (Hodson, 1999: 219)

In addition to the aforementioned limitations to constructivist approaches, O’Loughlin (1992) has contended that constructivism is flawed because of its inability to come to grips with the essential issues of culture, power and discourse in the classroom. He presented a sociocultural approach to teaching and learning which takes seriously the notion that learning is situated in contexts; students bring their own subjectivities and cultural perspectives to bear in constructing comprehension; issues of power exist in the classroom that warrant addressing; and “education into scientific ways of knowing requires understanding modes of classroom discourse and enabling students to negotiate these modes effectively so that they may master and critique scientific ways of knowing without, in the process, sacrificing their own personally and culturally constructed ways of knowing,” (O’Loughlin, 1992: 791). This approach has been advocated by others and adopted under the banner of social constructivism (Atwater, 1996; Cobb, 1994; Driver et al 1994). The common consensus among its advocates is that social constructivism provides a framework for science educators and researchers to study the nature and quality of socially and culturally situated constructions in science education (Atwater, 1996). Essentially, this translates into two major responses: regarding scientific understanding as the development of a personal framework of understanding, within which seemingly anomalous conceptions can co-exist; and affording a more prominent role to the affective and social dimensions of learning. Both of these concerns shall be addressed later through the course of this text.

Another objection raised against the conventional rhetoric of constructivism, though of a fundamentally different kind, is the charge of neglecting and trivializing scientific understanding.
(Hodson, 1999). At the heart of such criticism is the concern that constructivist approaches imply that students who construct their own understanding of the world of natural phenomena are also building scientific understanding. Opponents to a sociocultural approach further charge proponents with not taking science seriously, allowing anything to count as science (Good, 1995; Loving, 1995), with the criteria of scientific truth disregarded in favour of appealing to students’ cultural relevancy and ensuring equitable educational access for all. “Students are to be immersed in issues relevant to their particular region, school, classroom, and culture – a potentially relativist notion if students are free to choose everything they study in each setting.” (Loving, 1995: 342).

While Hodson (1993) advocated teaching multicultural science so that students can “acquire scientific knowledge, interests, skills and ways of thinking without doing violence to their particular cultural beliefs and experiences”, Williams (1994) levelled three charges against him, stating that such an approach does violence to science, it patronizes ethnic and cultural minorities, and it “clash(es) with the accepted goals and values of education in a Western democratic society.” Hodson (1994) argued, however, that his curriculum proposals were “rooted very firmly in the notion of critical thinking and sociopolitical action by students on matters that relate to scientific, technological, and environmental issues.” If such approach were to clash with existing goals and values, Hodson (1994) proclaimed himself guilty, though not for the reasons Williams (1994) presented. Moreover, far from marginalizing minority group students, multicultural science education was designed primarily to empower them.

Scientific knowledge is more than personal belief reinforced by personally gathered observational confirmation; it is an attempt to explain and account for the real nature of the physical universe, regardless of whether it is cogent in the common conveyance of such expression (Hodson, 1988, 1999; Koertge, 1996). “Indeed, much scientific knowledge flies in the face of common sense, and the physics of Galileo, Newton or Einstein compares unfavourably with Aristotelian views if
common sense is to be the arbiter” (Hodson, 1999: 220). A crucial component of science education comprises understanding the particular rationality which scientists employ in generating and validating claims, what that rationality is, and how it might be influenced by social, economic, political, moral and ethical factors (Hodson, 1988; Koertge, 1996). However, definition of rationality and the degree to which such factors influence it, is a matter of some contention (Hodson, 1988, 1999), not to be discussed here for the sake of brevity. Suffice it to say that learning science travels beyond conducting a “fair test” by systematically manipulating variables in order to satisfy oneself concerning a particular belief, but rather involves inculcation of “established techniques, strategies, standards and criteria of science,” (Hodson, 1988). Hodson (1988) argued that this understanding entails critical cognizance of the nature of scientific evidence, understanding the role and status of scientific knowledge, and recognition of the social situation, and therefore cultural contingency, of the scientific enterprise.

It is enculturation into these distinctively scientific ways of knowing, acting and communicating that constitute one of the principal goals of science and technology education. However, this goal of enculturation does not mean that the drive to personalize learning has to be abandoned. Nor does it mean that students have to give up other beliefs and values they may currently hold. Enculturation without assimilation is possible. Science education as enculturation can be reconciled with the notion of personalization through a reconsideration of the nature of scientific understanding and the elaboration of the idea of a personal framework of understanding. (Hodson, 1999: 220).

There is no denying that children are inculcated with a certain belief system which is introduced from the elementary stages of schooling, where they are explicitly exposed to a certain cultural framework, that of the host culture, through literature used to acquire basic literacy skills (Houser, 1996). The notion of educational subjects being laden with values and centered on a particular culture is well established in the literature, whether in history, language studies or science (Houser, 1996; Krugly-Smolska, 1989). For example, consider the use of the American reading series of Dick, Jane and Spot. In certain cultures you would never have Dick and Jane playing
together, but Dick and John, or they would not play with Spot the dog but Spot the cat, or some other animal, or they would not be playing with Spot but rather would be eating him. Educating through such materials immediately conveys cultural conceptualizations, views, beliefs, practices, and norms. This challenge might be accommodated through curriculum materials that reflect cultural diversity, so that children recognize for themselves that they and other people do things differently, so that one does not adopt an individual cultural view as the law of the universe. However, the problem is that despite exposure to diverse curriculum materials, what is actually taught very much subscribes to the cultural views, beliefs, practices and norms, of the host culture, further reinforced by the media, society, and the sphere of public interaction, including education (Houser, 1996). Does multicultural education then really achieve what it has set out to target? In a science context, what does multicultural science education intend to achieve? Moreover, what precisely does it propose and for whom?

Living in a multicultural society requires and necessitates abandoning, sacrificing and relinquishing certain cultural beliefs, norms and practices – one can’t possibly recreate one’s indigenous environment without impeding someone else’s ability to do the same. We must arrive at some sort of cultural nexus – a meeting place of diversity. In essence, to adopt a common culture for utilitarian purposes of functioning in this society, so that we in effect accommodate everyone, is perhaps to accommodate no one. However, we can create in the host society a much greater range of options, level of flexibility and accommodation to different ways of thinking, acting, and believing, though accommodation will necessarily be of a relatively limited degree due to the parameters defined by the dominant culture (Houser, 1996).

Development of a personalized learning framework runs counter to the traditional methodology of science education to ignore, suppress, or eliminate, personal, idiosyncratic and emotional connotations (Hodson, 1988, 1999; Koertge, 1996). For example, the science enterprise
demands the employment of specialized scientific terminology and the insistence on a formalized vernacular. Hodson (1999) has noted that while specialized terms such as 'photosynthesis' offer increased explanatory power, which is sufficient cause for their use, jargonization often increases difficulty, decreases interest, and possibly alienates some children from science. He presents the view of encouraging rather than discouraging the connotative aspects of understanding, and their sub-cultural variations, as "it is likely that these other, personalized aspects of meaning, with their everyday associations, can provide the key anchoring points for new learning, and so render it more meaningful" (p. 221).

Nurturing and fostering scientific literacy for all students, in terms of adopting a personal framework of knowledge and learning, necessitates enculturation and personal incorporation of scientific concepts and ways of thinking which are similar to, or coincident with, those accepted and sanctioned by the scientific community, or their school curriculum versions. The primary task of science educators is to aid students in developing meaningful conceptual understandings of science and its manners and methods of describing, predicting, explaining, controlling and manipulating natural phenomena. Subsequently, science instruction is specifically steered to integrate science processes and conceptual knowledge (Koertge, 1996.). The science curriculum is further geared toward facilitating this process by its focus on investigations and activities designed to help students modify and develop their personalized knowledge and learning, so that their intuitive, "everyday" modes of interpretation, explanation, and prediction, incorporate the desired scientific aspects of meaning and a comprehensive grasp of their appropriate use.

However, adopting new meaning should not necessarily entail relinquishing the old. Certainly, approved scientific meanings can exist, juxtaposed to a wide range of personal, idiosyncratic beliefs, understandings, and associations (Aikenhead, 1996; Cobern, 1993; Hodson, 1993, 1999; Jegede, 1995, 1997). Hodson (1999) offered the simple example of the scientific

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understanding that cucumbers and tomatoes are fruit, yet it does not preclude the common sense understanding that they are located in the vegetable section of a grocery store. He stresses the importance "in recognizing when particular meanings are appropriate and being able to use them properly within the appropriate discourse."

Sociocultural factors contributing to one's social and cultural identity, comprising gender, ethnicity, religion, economics, politics and the sociocultural environment, impact quite considerably on the learning process, with the science education endeavour itself being no exception (Atwater, 1993, 1996; Chamberlain, 1986; Jegede, 1997; O'Loughlin, 1992). Cumber (1993) argued that different cultural environments produce different "worldviews", defined as composite sets of beliefs, values, and ethos, maintained consciously or subconsciously, regarding the nature of reality and the process of pursuing knowledge concerning it. Such "worldviews" then predispose people's emotions, thoughts and behaviours in particular ways. Consequently, one should expect very conspicuous cross-cultural differences to become manifest in the ways people conceptualize and interact with the natural environment and, hence, significantly different manners of response to Western science and its endemic protocol for conceptualizing and investigating the natural world.

Jegede (1995, 1997) has discussed, at considerable length, the challenges faced by African students and their science educators due to the incompatibility and incongruency of the African worldview with the worldview implicit and inherent in Western Science. Moreover, Hodson (1993) has pointed toward other examples of cultures facing similar crisis, such as the North American Natives, Maori of New Zealand, Japanese, and Muslims. Consequently, it should be realized that such problems are not confined to non-Western nations. Rather, they exist in any classroom comprised of a diverse student population, arriving from various sub-cultural backgrounds, where various worldviews come into contact with a common agenda of learning science (Atwater, 1995; Chamberlain, 1986), staged on the common platform defined by the host culture, which is implicitly
Western oriented in the case of multicultural societies such as Canada, Britain, America and Australia.

### 3.2.1 BORDER CROSSING

Giroux (1992) referred to movements between the various groups and sub-groups one belongs to, and interacts with, as “border crossing”. Each of us carries particular social and cultural knowledge sets, comprising values, beliefs and etiquettes, which allow us to communicate and interact with a number of societal sub-groups, where each group and sub-group can be thought to possess its own “culture”. Effective participation in such groups is dependent on one’s possession of the appropriate cultural knowledge set. In consequence, one’s profile of cultural knowledge is unique, reflecting the particular constellation of group memberships. This further elaborates the concept of each student’s distinctive and unique personal framework of understanding, which would translate into the development of unique personal learning contexts. An appreciation of this would provide greater insight into learning facilitation, so that teachers might conceive how students negotiate certain boundaries successfully and are impeded by others.

Aikenhead (1996) has explored border crossing into the subculture of science. Students cross various borders from the home culture, to the host society’s culture, to the school culture. Science learners encounter an additional border to cross, that of the culture of science, or the particular curriculum version of it. Aikenhead (1996) seeks to identify the various borders that science students cross, in reference to four types of transitions, where: congruent worlds support smooth transitions, different worlds require transitions to be negotiated, diverse worlds lead to hazardous transitions, and highly discordant worlds cause students to resist transitions which then become virtually impossible. He points to the work of Costa (1995), who, guided by this model, identified five distinctive patterned groups regarding the relationship between personal experiences
and success in school and science, drawing attention to the necessity of curriculum and school practices that facilitate the integration of students' multiple worlds. Costa's five categories are:

- **"Potential scientists":** where the worlds of family and friends are congruent with the worlds of both school and science, hence transition into the school science culture is unproblematic; such students usually have educational and vocational aspirations prominently tied to science.

- **"Other smart kids":** where the worlds of family and friends are congruent with the world of school but inconsistent with that of science; such students negotiate transition into school science culture with little difficulty, and while science is not of paramount interest to them, they can make potentially instrumental use of it in their educational or vocational pursuits.

- **"I don't know' students":** where the worlds of family and friends are inconsistent with the worlds of both school and science; transition into school science culture is hazardous, possibly at some personal expense; usually, such students will negotiate the demands of the system, obtaining reasonable grades, without ever gaining a firm grounding in the material.

- **"Outsiders":** where the worlds of family and friends are discordant with the worlds of both school and science; such students will tend to be disillusioned with, or alienated from, school; generally, transition into the school science culture will be essentially unfeasible; they neither know, nor care, about science.

- **"Inside outsiders":** where the worlds of family and friends are irreconcilable with the world of school, but are potentially compatible with the world of science; while such students possess a natural interest in science, transition into the culture of school science is prevented through lack of support from both inside and outside school, and further
by their distrust of schools and teachers.

Hence, science education becomes a cross-cultural event for most students (Costa's "Outsiders", "I don't know students" and "Other smart kids"), which begs the question of whether science curricula can be developed for students identified by their border crossing needs. After all, it is quite likely that students stemming from different ethnic groups will perceive boundaries differently and employ different strategies for adaptation as they move, or attempt to move, between sociocultural settings (Aikenhead, 1996). Research conducted on gender issues in science education is quite extensive (Atwater, 1996) pointing to the notion of girls perceiving boundaries differently than boys, and hence adopting distinct strategies for effecting transition. Hodson (1999) comments that for any particular individual, patterns are not necessarily stable over time and may be profoundly affected by changes in the classroom or school environment, family climate and peer group relationships. It is significant to note that in Costa's (1995) study, students in the "Inside outsider" category were entirely African American. Moreover, she observed that the population for whom transition into the school science culture was smooth and unproblematic, were primarily from white middle class family groups, and that transitions were generally easier for boys than girls.

3.2.2 TOWARDS ENCULTURATION WITHOUT ASSIMILATION

Any multicultural science education curriculum would need to consider students' cultural perspective and experiences with school science in terms of crossing borders from the subcultures associated with peers, family, media, and the school, into the subcultures of science and school science. A cultural perspective should recognize science teaching as a process aimed at enculturation, or assimilation – cultural transmission that supports or replaces one's life-world subcultures, respectively (Aikenhead, 1996). Aikenhead (1996) comments that smooth border crossings are experienced by students whose life-world subcultures harmonize with that of science.
Hence, for them science instruction would be enculturation. However, for the remainder of students whose life-world subcultures, to varying degrees, are at odds with the subculture of science, conventional instruction in school would translate into assimilation.

One of the intended goals of multicultural science education would be to seek out appropriate instructional strategies to allow children to be encultured within a particular framework (that of scientific cultural procedure), without having to assimilate, and therefore compromise, their particular cultural belief system. Clearly, science educators need to be more cognizant of the ways in which transition into the school science culture may be eased for those learners currently experiencing difficulties, or who quit in the face of excessive emotional stress (Hodson, 1999). Any science curriculum assessment should include investigating the possibility of compatibility, or conflict, between the curriculum goals, the learning experiences and the assessment scheme (Hodson, 1986). Whether it is indeed possible to not only accommodate all this within science education, but also to actually achieve it, is a subject of contention in the arena of education and educational research.

Opposition to treating science as a cultural enterprise is rooted in the premise of the philosophical presupposition known as “the universality of science” — that science is the same everywhere. Moreover, science is conceived as an enterprise which uncovers knowledge, or solves problems, irrespective of the culture, race, or gender of the individual scientist involved (Stanley & Brickhouse, 1994). Proponents of universalism in science education (Good, 1995; Loving, 1995; Williams, 1994) question the kind of science that would be taught and produced if it catered to cultural relevancy, charging that established expectations for scientific and technological literacy would take a back seat. However, it should also be noted that such thinking is usually synonymous with advocating the full cultural assimilation of the U.S. melting pot. Their opponents (Aikenhead, 1996; Hodson, 1993,1995; Rakow & Bermudez, 1993; Stanley & Brickhouse, 1994, 1995a, 1995b)
would contend that science does indeed harbour norms, values, beliefs, expectations and conventional actions which are generally shared in various ways by communities of scientists, and hence science forms a culture of its own. However, these norms, values, etc. vary with individual scientists and situations (Aikenhead, 1996). Aikenhead (1996) has compiled a list describing the cultural features of Western science: mechanistic, materialistic, masculine, reductionistic, mathematically idealized, pragmatic, empirical, exploitative, elitist, ideological, inquisitive, objective, impersonal, rational, universal, decontextualized, communal, violent, value-free, and embracing disinterestedness, suspension of belief, and parsimony. This may be contrasted, for example, with Jegede’s (1997) characterization of the African mode of thought, which is: anthropomorphic; monistic-vitalistic and metaphysical; based on cosmology interwoven with traditional religion (as opposed to Western science which is public property, divorced from religion); orally communicated; unchallenging of the elder’s repository of knowledge; accepted as truth (contrasted with Western science where truth is tentative and challengeable by all); a process of learning as a communal activity, rather than an individual enterprise.

Multicultural science education would still fundamentally preserve the scientific process of investigation, examination and discovery, as there must be some common forum for science communication, process, evaluation and dissemination. However, it would allow for sociocultural factors which might affect perspectives on process, results and interpretation due to one’s personal framework, seeking to enculture one with the science process without socioculturally assimilating individuals. Pomeroy (1994) focuses on modifications that may be effected by science educators, including provision of career support, adoption of culturally sensitive pedagogy, promotion of science language skills, and epistemological studies. However, of paramount precedence is the need to create school structures and curriculum experiences which would facilitate border crossing and not require students to abandon or suppress significant features of their lives outside the science
classroom, in order to attain access to science. This would entail "the creation of a school culture that values differences, ensures that all students feel a sense of belonging and self-worth, centralizes the ideal of social justice, and places a high value on teachers who can, themselves, move freely and comfortably between different social settings. It also requires a curriculum that shows students how science impacts on the lives of all students, on the lives of their friends and families, and on the environment, both locally and globally," (Hodson, 1999: 226). In this regard, McKinley et al (1992) have noted that concern regarding the participation and achievement of Maori students in science education has led to considerations of their culture (beliefs, traditions, knowledge, heritage, experiences and values) and the Maori language in science lessons. They call for future research in science education to be directed at the interaction of language, culture and science education.

Jegede (1995) has developed the notion of collateral learning which refers to the cognitive cultivation of parallel frameworks of understanding, founded on a particular cultural system of values and beliefs, so that it becomes possible to hold and develop, for example, Western scientific thinking alongside traditional African knowledge and understanding (Jegede, 1995, 1997; Mundangepfufu, 1986). This would provide a process whereby the non-Western learner may not only construct knowledge rooted in Western culture alongside traditional cultural views, but one may strategically switch modes depending on the environment, or circumstance. The only problem I would perceive with this, is having to compromise the integrity of one's sociocultural framework, and system of beliefs and basic ethos, depending on the situation or setting. It appears to me that the actual construction and the subsequent adoption and utilization of a cultural system, or mode, which is inherently at odds with one's own sociocultural milieu of values, beliefs and etiquettes, is by its nature immediately in violation of one's personal sociocultural integrity. Yet, the response that is likely to be given would echo my earlier comments on residing in a multicultural society, where one must inevitably "check" certain cultural baggage "at the door". Moreover, collateral learning should
facilitate border crossings into alternate worldviews and permit a process geared towards enculturation within certain frameworks, without assimilation into the larger cultural domain.

Hence, a key thrust of multicultural science education is to ease those border crossings, from wherever students are, whether at home or in the wider community, into the subculture of science. Children from certain backgrounds find it easier to move into science culture because the language of science and the ways of thinking of science are quite similar to the language and ways of thinking of other sub-groups they are members of, and so they find it easier to "get in". Subsequently, it becomes fundamentally imperative to do whatever one can to make border crossings for other students easier. This easing might have to do with language, materials, or presentation. Critical reflection upon such matters should serve to better understand the challenges posed by educational enculturation and assimilation into a host culture, which should provide insight for science educators working toward an epistemology that allows for the personalization of knowledge and learning.

3.3 DEMYTHOLOGIZING THE SCIENCE ENTERPRISE

Another major thrust of multicultural science education is to demythologize the scientific establishment and science enterprise as being the paradigm of truth and in possession of superior knowledge, reinforced by the media, government, societal perceptions at large and current education. "Despite a major effort in recent years to direct the attention of teachers and curriculum developers to the importance of considerations in the history, philosophy and sociology of science, many school science curricula continue to promote deficient or distorted views of science. Apart from concern that a significant aspect of humankind's cultural achievement should be so poorly understood by students, there are clear indications that these distortions and falsehoods serve to exclude many girls and members of ethnic minorities from crossing the border into the culture of science," (Hodson, 1999: 228-229).
The science curricula currently taught in most schools, which cover only the achievements of the Western world and view technology as a panacea, fail to acknowledge the perspectives and achievements of other cultures as well as the dangers inherent in having blind faith in the Western scientific process (Hodson, 1993). In doing so, they present students with a narrow, biased, and ultimately limiting view of science which distorts the truth and alienates many students. Curricular changes must then be a part of any effort to inject multiculturalism into science education. The most effective changes in curricula involve efforts to show the limits of Western science and the contributions of people of all cultures while still maintaining a solid grounding in the dominant discourse of Western science.

The first facet of a multicultural science curriculum is that it must recognize the scientific contributions of people from non-Western cultures. Current science curricula often ignore the contributions of other cultures to the history of science, and in doing so imply that science is and has always been done solely by white males. The lack of attention to the multicultural history of science is especially puzzling given the fact that the Egyptians, Near-Eastern Muslims, and Chinese, among others, had thriving scientific communities centuries before there was any important science being done in Europe. For example, Muslim scientists had developed a heliocentric view of the solar system in the twelfth century, many years before Copernicus' theories (Hodson, 1993). In this light it becomes quite evident that current science curricula suffer from a myopic focus on the accomplishments of Westerners, and that the inclusion of the contributions of other cultures to the history of science is merely exposing reality.

Hence, a key thrust in demythologizing science is to illustrate its culturally diverse origins. Effectively one wants to demonstrate that the science which we currently know as Western science has its roots in non-Western cultures: in China, in India, Arab and Islamic science, African science, and to try to show what those roots have been. And, in addition, to recognize that other societies
practice other ways of knowing about the natural world which are dissimilar to Western science, and that there are alternative frameworks for understanding the natural world. Some of them are not that much different from science and some are radically different from science, but they are all ways of knowing about the natural environment. It is also important to show science and technology being utilized in diverse cultures at the moment, but in different manners.

However, it is insufficient to focus attention on the contributions of people of other cultures through scientific history. The contemporary multicultural face of science, where scientists from different cultural communities are making significant contributions to the science enterprise, should be reflected in the curricular materials employed. Many materials have racist undertones expressed in a variety of manners. One of the most common is that many textbooks depict only white scientists and students, or they depict scientists and students of other cultures performing subordinate roles to whites (Hodson, 1993).

Such curricular changes serve two main purposes. Firstly, images of multicultural scientists may serve as powerful role models for all students. Role models can serve to break the chain of negative thoughts concerning self-esteem, and educational and vocational aspirations, by showing them they can succeed (Rakow & Bermudez, 1993). Secondly, by teaching about the contributions of scientists of other cultures, and using anti-racist materials, all students, including whites, learn that the science enterprise is not just dictated by white people. This further leads to an appropriate appreciation for the contributions of other cultures.

Multicultural science curricula must also teach students the limits of the Western scientific process. While Western science is an adequate system for describing the world, and students need to become proficient in it in order to be well equipped for life, it is far from perfect, nor is it the only possible system. Unfortunately, in many of today's classrooms it is portrayed in a positivist light; that is, scientists are seen as objective observers performing reproducible experiments which
provide unambiguous support for theories which accurately describe the world (Stanley & Brickhouse, 1994). This belief obviously results in students placing a great deal of faith in scientific findings. Students can be given a more realistic, useful, and liberating view of Western science through a changed scientific curriculum.

Most fundamentally, in this regard, students should be able to recognize that science, because it is a human institution, is necessarily flawed, in all the ways that any human institution is flawed. Some of this may involve prejudice and stereotyping, principally sexism and racism. Science exhibits both of those characteristics. In what ways is science sexist or racist? One may look at science being misused for racist purposes, as in Nazi Germany, the Soviet Union and the Eugenics movement in the United States (Hodson, 1993). Moreover, one might examine the whole conceptualization and ways of proceeding that scientists use. Since science was developed largely by men, it necessarily implies, if there is indeed such a thing as masculine ways of thinking, that science is going to be it, par excellence. What are those characteristics? Can you change them and it still be science? Should you change them? How do you change them? Then, examining how science is being misused for racist and sexist purposes, such as with the recent publication entitled *The Bell Curve* (Herrnstein & Murray, 1994), which contends that low-income groups and African Americans possess inferior cognitive abilities to others as a result of an inherited disposition; and endeavouring to make students aware of such events and processes, and furthermore, allowing them to examine and critique the supporting arguments, underlying assumptions, and relating them to social and political contexts and agendas.

Furthermore, science students should be made aware that science and technology in the 20th century can behave in oppressive ways, especially towards the poor and the powerless. Curricula must begin to teach that technology and development that result from Western science have serious costs, as well as benefits, and that both resources and people are exploited. Lessons about economic
geology, for example, might involve discussions of the environmental damage inflicted by mining in third world nations, and physics classes learning about radiation might also discuss the problems of nuclear power, nuclear weapons and the issue of nuclear testing in Tahiti. As Hodson (1993) states, classes need to be taught to “recognize that issues of justice, equality and freedom are inseparable from the proper discussion of scientific and technological practice.”

If students can learn how the purposes of scientific activity have varied in different cultures and historical times, and how other cultures have developed sciences to meet these purposes, then they can also learn that the form of contemporary Western science is not universal, inevitable, or unchangeable. This kind of understanding is needed to encourage the critical thinking about the purposes Western science has served, and how these could be changed to create future sciences that better meet the needs of the diverse societies that support them. (Stanley & Brickhouse, 1994: 396).

3.4 POLITICIZING SCIENCE EDUCATION

Hodson (1999: 234-235) has noted that “politicization of science education can be achieved by the provision of opportunities for confronting a wide range of socioeconomic issues that have a scientific, technological or environmental dimension. By grounding curriculum content in socially and personally relevant contexts, an issues-based approach can provide the motivation that is absent from current abstract, decontextualized approaches and can form a base for students to construct understanding that is personally relevant, meaningful and important.”

Hodson (1993) notes that education for empowerment requires that science education assume a more overtly political flavour, which entails that the environment is not just a “given” but a social construct. “It is a social construct in two senses: (1) we act upon and change the natural environment, and so construct and reconstruct it through our social actions; and (2) we perceive it in a way that is dependent on the prevailing sociocultural framework. Thus, our concept of ‘environment’ itself is a social construct and could be different,” (Hodson, 1993: 705). Indeed, many
indigenous peoples do possess different perceptions (Knudson & Suzuki, 1992). Hodson (1993) has further remarked that by encouraging students to recognize the ways in which the environment is socially constructed, we can challenge the notion that environmental problems are natural and inevitable. In other words, if “environment” is a social construct, then environmental problems are social problems, attributed to societal practices and structures, and justified by society’s current values (Hodson, 1993). Consequently, addressing such problems means pursuing change in the social conditions responsible for them.

One of the purposes of multicultural and anti-racist education is to recognize that people in positions of power tend to come from the same sub-groups, and to recognize where power of decision is located and to see if it can be influenced so that alternative voices are heard. Its whole purpose is to try to change society to ensure that minority voices not only get heard, but that their views are acted upon by gaining access into positions of power and influence, and participation. Although, it is largely the case that people’s grievances are heard out of tokenism and rarely acted upon. However, the curriculum objective is to empower students with scientific knowledge through a personalized framework of learning and understanding, allowing them to perform proficiently with a political platform toward change.

3.5 CURRICULUM CONSIDERATIONS

The particular perspectives offered and explored essentially echo Dewey’s (1925, 1938, 1943) notions of learning achieved through an experiential process including both the individual continuity of experience and interaction with others. Tyler (1949) echoes this same philosophy when he states that “learning takes place through the active behaviour of the student; it is what he does that he learns, not what the teacher does. It is possible for two students to be in the same class and for them to be having two different experiences...The essential means of education are the experiences
provided, not the things to which the student is exposed,” (pp.63-64). Pedagogies derived from constructivist theory appear very much to reverberate a similar sentiment, where the teacher’s role is typically characterized as that of facilitating students’ investigations and explorations (Cobb, 1994). Such considerations need then be applied to actual curriculum formulation, where the aforementioned objectives outlined for multicultural science education should be further refined with explicit statements, and subsequently assessed.

It is in keeping with the spirit of such considerations that Reiss (1993) has engaged in a fairly thorough examination of science curricula for an ethnically and culturally pluralist society. One of his key concerns is teaching controversial issues in science, for which he explores three approaches. Firstly, there is the approach of *advocacy*, where the teacher might argue in favour of a particular position, perhaps personally held, although there is the danger of trampling on the student’s autonomy. Secondly, there is *affirmative neutrality* where the teacher presents as many sides of controversy as possible, without indicating personal support for any particular position, although there is difficulty in maintaining a balanced presentation and furthermore, the lesson may become very didactic, failing to engage the interest and involvement of many in the classroom. Lastly, there is *procedural neutrality*, where the teacher serves as a facilitator, eliciting different points of view from the students, without ever revealing his/her personal position. However, this might still require eventual intervention; for example, in a lesson concerning evolution, where a position must be adopted for the sake of proceeding further. Despite this problem, such dialogue does at least expose learners to diverse ways of thinking and understanding.

Education is necessarily “offensive,” that is one of its prime characteristics. Its purpose is not to underpin the beliefs that students come to the table with, but to question them and ask whether their beliefs are adequate/good/worthwhile? By presenting alternatives and requiring students to submit to a challenge, one might reinforce those beliefs, one might undermine them, or
even destroy them entirely. Though challenging may not be perceived as "doing violence", to borrow Hodson’s (1993) phrase, to belief systems, there are certain practices within the public domain that directly conflict with aspects of the sub-cultural domain – representing huge conflict, especially when the host culture teaches and reinforces certain values. Issues then are not really presented for debate but are presented with some predetermined stance, so that one may disagree with accepted practices and norms but the result is being marginalized, ostracized and cast in a negative light. Hence, a major curriculum consideration would have to be the presentation of a much greater range of options, level of flexibility and accommodation to different ways of thinking, acting, and believing. It is such curriculum considerations that are addressed by multicultural science education.

3.6 FINAL THOUGHTS AND REFLECTIONS

Stanley & Brickhouse (1994) have noted that among the questions raised by multiculturalists are: Whose culture are we teaching? Whose knowledge is of most worth? Who benefits and who is harmed by current approaches to curricula? The theoretical underpinnings of multicultural education are usually presented within the public education domain, seeking to accommodate people from various sociocultural backgrounds. However, what appears to be ignored is the possibility of a private domain of accommodation in a multicultural society. Efulmes (1989), in considering Muslim, Jewish, Christian, Hindu, and Afro-Caribbean perspectives on education, concludes that knowledge is variously defined and acquired quite differently through particular cultures. This realization subsequently directs one to a series of new questions.

To what extent is it indeed possible to accommodate “everyone” within the public domain, without offending anyone? If public education inevitably, and inescapably, involves the conveyance of various facets of the host culture, would not such concerns be more suitably addressed in private

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education? Certainly, the private domain would afford one the opportunity to provide a curriculum which fully integrates one's own personal sociocultural system of beliefs, values and ethos. Is this not the intended purpose of the Separate School System, in Ontario, to enculture and assimilate within a Catholic environment, allowing children to be inculcated with the Catholic cultural belief system? I believe this represents a tremendous concern and challenge for multicultural education within the public educational domain.

However, despite the domain of accommodation, the major thrusts of multicultural science education remain applicable, though it might be contextualized quite differently in the private education domain. Central to the core of multicultural science education is development of a personalized framework for learning, which involves knowledge, experiences, language and behaviours, which are socioculturally determined. Additionally, the curriculum objectives should include: demythologizing the science enterprise, so that learning and excelling in science are not intimidating to learners; and politicizing science, so that students become empowered with science knowledge which would serve them in the sociopolitical arenas of life. With scientific literacy for all as an accepted goal driving science education in a multicultural society, it becomes necessary to ensure equitable access and elimination of sociocultural marginalization of learners. Science educational instruction should be specifically aimed at integrating scientific processes and conceptual knowledge within a socioculturally personalized framework, geared toward fostering and developing scientific literacy for all students. By involving students, instead of excluding them, a firm educational experience of learning and understanding should be established, and successfully attained.
CHAPTER 4
ANALYSIS OF THE CURRENT ONTARIO SCIENCE CURRICULUM AND ITS SUPPORTING EDUCATIONAL POLICY

4.1 INTRODUCTION

In the spring of 1998, following a general public mood of disgruntlement and dissatisfaction directed toward the residing Conservative government of Ontario that had witnessed a series of mass public protests and strikes, there was anticipation and excitement in the air for a new provincial education initiative. It was in this climate that, at the end of March of 1998, then Minister of Education Dave Johnson stood on a podium at the Ontario Science Centre and unveiled the new provincial science and technology curriculum document for grades 1-8 (Small, 1998).

The newly promulgated Ontario science and technology curriculum seems to have won applause from some quarters (Hall, 1998; The Toronto Star, 1998a) for producing a more rigorous document, praised for its quality of content, and for being the first provincial science curriculum in Canada to fall in line with the goals and program of the Pan-Canadian protocols for science education of the Council of Ministers of Education of Canada (Council of Ministers of Education, Canada [CMEC], 1997). It has also been heralded for establishing for the first time a common uniform framework for teaching science and technology across Ontario (Hall, 1998; The Toronto Star, 1998a; Small, 1998), where previously each school board essentially set its own science program in line with provincial curriculum guidelines. Yet, it has also subsequently met some sharp criticism from other quarters, for being too prescriptive and constrictive in its presentation and delivery of science education, and for perpetuating a culture of conformity (Bencze, 1999). This thesis endorses remarks and endeavours to add another form of criticism of the Ontario science curriculum: that of being entirely negligent at responding to and accommodating the ethnic and cultural diversity which
pervades the provincial learning population, and for failing to provide multicultural and anti-racist curriculum content and objectives.

In the preceding chapters, this thesis sought to define scientific literacy in a multicultural domain, subsequently exploring and explicating the underlying philosophy, perspectives and objectives of the multicultural science education agenda. This chapter employs the objectives of multicultural science education, outlined in Chapter 3, as criteria for analysis and evaluation of the current Ontario science and technology curriculum documents and its supporting policy.

4.2 CURRENT POLICY AND PRACTICE IN ONTARIO REGARDING MULTICULTURAL EDUCATION

The current state of multicultural education policy and practice in Ontario was outlined in Chapter 1 of this thesis. To recapitulate, much criticism has been directed at the current government concerning the multicultural and anti-racist agenda, or lack of it (The Toronto Star, 1999). Educators and activists have rebuked the provincial government’s actions of dismantling the Ministry of Education and Training’s anti-racism unit, responsible for overseeing and reviewing the anti-racism and ethnocultural equity policy, programs, and practices, of the various school boards across the province. Critics have charged that the province has yet to provide any alternative body to act in such capacity. Moreover, critics charge that with the Ministry’s anti-racism unit removed, there is no way to enforce the Ministry’s policy memorandum, Policy Memorandum No. 119 (see Appendix 4 of Ministry of Education and Training, Ontario [METO], 1993a), which included legislation of a March 31, 1995, deadline for all school boards to submit their anti-racism and ethnocultural equity policies, or policy proposals, and implementation plans, for Ministry approval. The implementation of Ministry approved policies and programs was to take effect by September 1, 1995.
Such course of actions were interrupted, and essentially came to a halt when the Conservatives were elected to power in 1995. Instead, the Tory government legislated Bill 104 in April of 1997, effectively amalgamating 129 school boards into 72 (The Toronto Star, 1998b). Thus, whatever policy proposals were presented from those school boards lacking any official multicultural education policy, were effectively discarded and their efforts reversed, with the amalgamation of the various school boards. As a result, many school boards remain without any official policy or implementation scheme for anti-racism and ethnocultural equity, despite the fact that there may be some in various stages of formulating such particular policy and programs. Furthermore, the provincial government has failed to produce any new policy documents to buttress its new curriculum documents.

Hence, the last multicultural education policy document to be produced by the government was the Ministry’s guidelines for policy development and implementation (METO, 1993a), which was, as noted in Chapter 1, designed to work in conjunction with and further supplement “the principles, practices and outcomes of antiracist and ethnocultural equity education” as “enunciated in The Common Curriculum, Grades 1-9 and other ministry guidelines and resource documents,” (METO, 1993a: 5). The provincial policy manual was designed to serve as a guiding instrument for school boards responsible for not only formulating and implementing their own policy, but also to devise their own curriculum programs in line with the goals set out by The Common Curriculum. In 1993, the Ministry noted that “much of the traditional curriculum focuses on the values, experiences, achievements, and perspectives of white-European members of Canadian society and excludes or distorts those of other groups in Canada and throughout the world,” (p.13). Subsequently, it voiced a fervent concern that “students need to understand and respect cultures and alternative ways of living, and benefit from a knowledge of the experiences and contributions of people of other cultures and races other than their own,” (METO, 1993a: 13). Stemming from such an objective, the Ministry outlined a program for multicultural and anti-racist curriculum development and
selection "made on the basis of what a student requires to function effectively in a culturally and racially diverse society," (METO, 1993a: 14). The core objectives for such curriculum development and selection set out by the Ministry included the following: identifying "bias and discriminatory barriers in existing curriculum structures, policies, programs, and learning materials"; and ensuring that "all elements in the process of curriculum review, development, and implementation are consistent with antiracism and ethnocultural equity objectives"; and also enhancing "teachers' abilities to use biased materials constructively to develop students' critical thinking about racism" (METO, 1993a: 14). Just prior to the election of the Harris regime in Ontario, in 1995, the Ministry set about revising its 1993 curriculum, publishing *The Common Curriculum: Policies and Outcomes* (METO, 1995), which echoed the preceding core objectives, and emphasized that "implementation of the Common Curriculum must be linked to the development and implementation of policies on antiracism and ethnocultural equity", (p.4), drawing particular attention to the 1993 policy document (METO, 1993a) dealing with such matters.

However, with the arrival of the new curriculum documents in 1998 and 1999, which provide a uniform framework and curriculum scheme for the entire province, *The Common Curriculum* and all its associated documents have been discarded. Combined with the eradication of the Ministry's anti-racism unit, all power concerning official multicultural education policy and practice has fallen into the government's hands, which has yet to produce any significant initiative other than dismantling existing ones which served the multicultural education agenda in Ontario. No new provincial directive has been forthcoming. Indeed, the Harris government has stated that doing so would be an exercise in redundancy, pointing to recent policy documents, which (as argued here) have been rendered inert and impotent due to its educational reforms. To be fair, however, the Ministry has introduced multicultural and anti-racist content into select areas of the curriculum dealing with reading, history and social studies. Yet, such concern seems entirely absent from the science and technology curriculum, as will be discussed in the following text.

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4.3 ANALYSIS OF THE ONTARIO SCIENCE CURRICULUM FOR GRADES 1-8

In launching the new science curriculum for Ontario, in the spring of 1998, (former) Education Minister Dave Johnson commented that, “Our young people stand on the brink of the next millenium. It is our responsibility to make certain that they have acquired the scientific literacy they will need to help them understand our increasingly technological world,” (Small, 1998: A1). He, of course, boldly portrayed the new science curriculum as the remedy for what ails Ontario's students: inadequate scientific literacy, coupled with ill preparation for the future, due to deficient curricula employed in the past. The Ontario science curriculum for grades 1-8 (METO, 1998) prides itself on providing science educators with outcomes and expectations for scientific knowledge and skills which are “consistent with the goals of science education outlined in the Common Framework of Science Learning Outcomes, K to 12 (CMEC, 1997),” (p.3). The Pan-Canadian guidelines (CMEC, 1997) themselves have been heralded as ground-breaking, being developed over two years under the auspices of Canada's provincial ministers of education (Small, 1998: A18).

The CMEC guidelines for science education emphatically note that science activities “occur within a socio-cultural context, are interpreted within that context, and are designed to extend and challenge existing views” (CMEC, 1997: 7), that science itself is a socio-cultural construct that may vary across cultures and contexts. However, where the CMEC (1997) affirms such fact and provides concrete examples to confirm it, the Ontario science curriculum evades even acknowledgement of it, vaguely noting that “science and technology both exist in a broader social and economic context,” (METO, 1998: 4). Where the Pan-Canadian protocol for science curricula (CMEC, 1997) includes historical, sociological, philosophical dimensions in its discussion of science and culture, the Ontario curriculum (METO, 1998), which professes to be based on such guidelines, is completely silent on such matters, and is devoid of any content which meaningfully relates to the cultural diversity of its learning population.

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The Ontario science curriculum is organized along a three pronged offensive for disseminating science. Its purported "Goals of Science and Technology Education" (OMET, 1998: 4), which comprise the essential framework of the document, are to help students learn:

- 'Concepts'; i.e. "to understand the basic concepts of science and technology"
- 'Skills'; i.e. "to develop the skills, strategies, and habits of mind required for scientific inquiry and technological design"; and,
- 'Applications' (of the concepts learned); i.e. "to relate scientific and technological knowledge to each other and to the world outside the school"

It is the latter which presumably fulfills the expectations of the STSE (science, technology, society and the environment; recall Chapter 2) provisions foundational to the CMEC (1997) guidelines. It is here, within this particular domain, that the Canadian guidelines for science education (CMEC, 1997) presents its greatest provisions for multicultural science education, exploring the nature, relationships and contexts of science and the science enterprise. Yet, again, the Ontario curriculum fails to advance any such aims for science education. It also fails to make any substantial provision for the personalization of learning, demythologizing of science or politicization of science education.

4.3.1 ANALYSIS OF PROVISIONS FOR THE PERSONALIZATION OF LEARNING

The CMEC (1997) guidelines advocate an essentially constructivist approach to science education (recall Chapters 2 & 3) to promote the personalization of learning, noting that "student learning is affected by personal and cultural preconceptions and prior knowledge," (p.7). In its acknowledgement that "students learn most effectively when their study of science is rooted in concrete learning experiences, related to a particular context or situation, and applied to their world where appropriate," (CMEC, 1997: 7), the CMEC (1997) promotes a learning process of "linking newly constructed understandings with prior knowledge and adding new contexts and experiences to current understandings," (p.7).
Of the three goals set out by the Ontario curriculum, it is development of the skills set which presumably is in place to “empower learners to construct their own knowledge (e.g. laws and theories) and develop their own solutions to problems (e.g. inventions) and, thus, grow in directions unique to their strengths, needs and interests, rather than to those who would plan their education” (Bencze, 1999: 19). Bencze (1999) notes that while enshrining this “expectation” as policy may appear “quite progressive, quite liberal”, it is readily apparent that the government has, “although possibly unconsciously, taken steps to minimize creativity and choice” (p.19). He comments that,

As a rule, any skills students develop are to be limited to those of a ‘technician,’ rather than those of an ‘engineer.’ Knowledge invention is to be discouraged. Skills are to be used, primarily for the confirmation of the numerous ‘Concepts’ and ‘Applications’ students are expected to accept. Generally, this is to be accomplished through an illusion of scientific discovery. (Bencze, 1999: 19).

Hence, while advising science educators that the three aforementioned goals may “be achieved simultaneously through learning activities that combine the acquisition of knowledge with both inquiry and design processes in a concrete, practical context” (METO, 1998: 4), the Ontario curriculum is planned for students to conduct “scientific investigations” and “design” tasks which are to direct them, not toward conclusions and solutions evident to students, but rather, toward the concepts and applications prescribed (“expected”) (Bencze, 1999). “In other words, rather than ‘being like scientists’ and constructing non-prescribed ideas from evidence and argument, student thinking is to converge on preordained conclusions,” (Bencze, 1999:20).

Typical expectations from the “Concept” domain such as students being able to “identify, through experimentation, ways in which chemical energy can be transformed into electrical energy (e.g., build a circuit using a lemon or a potato)” (METO, 1998: 64), or being able to “determine, through experimentation, the mass-to-volume ratio of different amounts of the same substance (e.g. copper pennies)” (METO, 1998: 49), are likely to prove problematic. When students engage in their pseudo-experimentation, and do not accumulate data which coincides with the consensus of the scientific community, as frequently occurs, teachers will feel compelled to guide their discovery
efforts by instructing them in the correct method to achieve the desired results, or contrive their knowledge construction by suggesting the correct conclusion. Indeed, recent studies (Nott & Smith, 1995) expose teachers as often surreptitiously tailoring practical experiences, or experiments, to ensure that students arrive at the desired results. Such manoeuvres are clearly deceptive and misleading, especially in light of the understood “messiness” of science and experimentation (Hodson, 1996). Furthermore, students are likely to experience feelings of disempowerment when they have had findings and understandings apparent to them invalidated and overruled by an authority, usually the teacher. Indeed, students’ self-esteem is likely to suffer when, after having conducted investigations and design projects and arrived at conclusions which may deviate significantly from those of mainstream Western science and technology (Cobern, 1996; also recall Chapter 3), they are instructed to revise them to become commensurate with “the right answer”. Moreover, by continually attempting to eliminate and eradicate students’ “misconceptions” (METO, 1998: 12), the message students may receive is that they are only permitted to think and act as “expected” (or, more accurately, as prescribed by the curriculum).

The curriculum “Expectations” generally appear to be organized such that, for every “Concept” and its “Applications” to be developed by students, there is a corresponding “Skill” expectation promoting the guided discovery or contrived construction of that concept. Bence (1999) offers the following example: grade 7 students are to learn “how heat is transmitted [transferred] by conduction, convection, and radiation in solids, liquids, and gases” (METO, 1998: 66), the corresponding “Skill” expectation advises them to “formulate questions about and identify needs and problems related to heat (e.g., interactions involving energy transfers)...” (METO, 1998: 67). Other examples include: grade 8 students expected to learn the “Concept” of “how objects or media refract, transmit, or absorb light” (METO, 1998:68), with the corresponding “Skill” expectation advising them to “formulate questions about and identify needs and problems related to the properties and behaviour of light (e.g., interactions between light and different materials)...”
grade 3 students expected to learn the "various factors that affect plants and animals in a specific habitat (e.g., availability of water, food sources, light; ground features; weather conditions)" (METO, 1998: 21), with the corresponding "Skill" expectation advising students to "formulate questions about and identify the needs of animals and plants in a particular habitat" (METO, 1998: 21); grade 1 students expected to learn the "function of different structures (e.g., house, car, bridge, chair, umbrella, television, wheelbarrow)" (METO, 1998: 72), with the corresponding "Skill" expectation advising students to "ask questions about and identify needs or problems related to structures in their immediate environment (e.g., a toy bridge,...)" (METO, 1998: 72). Indeed, the Ontario science curriculum (METO, 1998) is replete with such examples.

Such an approach promotes an "intellectual dishonesty" through which "pupils are expected to explore phenomenon for themselves, collect data and make inferences based on it" and yet the "process is intended to lead to the currently-accepted scientific law or principle" (Driver, 1983: 3). Bencze (1999) condemns such "stage-management of student thought" noting that there is little authentic about such "inquiry and design." Furthermore, he argues, the "expectation" of students being essentially demoralized and defeated in order to subscribe to the curriculum tenets appears to border on fascism, with its veiled "mind control and behaviour management," (Bencze, 1999).

Despite whatever emancipatory illusions it may try to present, the Ontario science curriculum (METO, 1999) appears to be preoccupied with promoting, preserving and perpetuating a scientific culture of uniformity, where students are "expected" to be encultured and assimilated into what it defines as science, which in the absence of any socio-cultural considerations is inherently Western science (recall Chapter 3). While presenting a guise of concern for personalization of learning, the Ontario curriculum (METO, 1999), in fact, makes "provisions for many paint-by-number experiences in the province's elementary schools" (Bencze, 1999: 18). Bencze (1999) attacks the curriculum for serving as "a corporatist manifesto, and apprenticeship for consumership", where "rather than being allowed to 'construct their own knowledge,' they are taught to acquiesce, to faithfully accept
all claims, and to leave the 'meaning making' to experts," (p.19). Furthermore, with no provisions made to facilitate students' "border crossings" (recall Chapter 3) between contexts and cultures, all students, regardless of their various socio-cultural and ethnic backgrounds, interests, abilities and perspectives, students must strictly abide by and achieve the measurable standards, the more than one hundred "Expectations" the Ontario science curriculum (METO, 1998) catalogues for each grade, in order to be deemed "successful." The bottom line is that with little room to permit individual expression, creativity, and decision making, "students are being told precisely how to think and act in order to succeed in Ontario" (Bencze, 1999: 18).

4.3.2 ANALYSIS OF PROVISIONS FOR THE DEMYTHOLOGIZATION OF SCIENCE

The Canadian guidelines for science curricula (CMEC, 1997) attempt to demonstrate the tentative nature of science and technology and to inculcate a sense of demythologizing the science enterprise by seeking to inject content which reflects the history, philosophy and sociology of science. They seek to promote the notion that theories of science are continually "tested, modified, and improved as new knowledge and theories supersede existing ones," (p.9). The document seeks to communicate the fact that "scientific debate on new observations and hypotheses that challenge accepted knowledge involves many participants with diverse background. This highly complex interplay, which has occurred through history, is fuelled by theoretical discussions, experimentation, social, cultural, economic, and political influences, personal biases, and the need for peer recognition and acceptance" (CMEC, 1997: 9). Moreover, it attempts to convey the view that, "technology, like science, is a creative human activity with a long history in all cultures of the world," (CMEC, 1997:9), with its appearance and application taking many forms, from seemingly simple or primitive, to advanced and complex. Yet, despite being adamant about being faithful to such curriculum prescriptions, the Ontario science curriculum (METO, 1998) fails to incorporate even the slightest
discussion about the nature of science and technology, let alone include any content which projects
the history, philosophy and sociology of science as it relates to both cultures and contexts.

The Ontario guidelines (METO, 1998) appear to perpetuate the myth that science is the
paradigm of truth, with a fixed and highly regulated set of principles, processes and procedures,
which include a “commitment to accuracy, precision, and integrity in observation, experimentation,
and reporting; respect for evidence; concern for the observance of safety procedures; and respect for
living things and the environment” (p.9). Respect for the representation of culturally diverse
perspectives and individual expression does not appear to be part of the Harris agenda. This despite
the Canadian science guidelines (CMEC, 1997) prescribing curricula which include outcomes in
which students are inculcated with critical awareness: “realize that the applications of science and
technology can have both intended and unintended effects” (in terms of impacting on people’s lives
adversely, or with particular social, or cultural agendas in mind); “recognize that women and men of
any cultural background can contribute equally to science”; “be sensitive to and develop a sense of
responsibility for the welfare of other people, other living things, and the environment”; “appreciate
that the applications of science can have advantages and disadvantages”; and “appreciate and respect
that science has evolved from different views held by women and men from a variety of societies
and cultural backgrounds” (pp.30-31). Such prescriptions are completely absent from the current
provincial science curricula (METO, 1998).

Benceze and Hodson (1999) present several myths concerning scientific inquiry that were in
evidence in the previously employed Common Curriculum (METO, 1993):

- Observation provides direct and reliable access to secure knowledge.
- Science starts with observation.
- Science proceeds via induction.
- Experiments are decisive.
- Science comprises discrete, generic processes.
- Scientific inquiry is a simple, algorithmic procedure.
- Science is a value-free activity. (p.522)
Such mythical perceptions are evident in the current provincial curriculum (METO, 1998), pervading nearly every aspect of the document’s view of science and scientific inquiry.

While the Ontario curriculum understandably commits to presenting patriotic content wherever applicable or possible, concern should extend beyond Canada’s role or contributions to that of the roles and contributions of its culturally diverse populace and their global and international counterparts. Moreover, if the curriculum is to be deemed relevant from the perspective of this diverse audience, should it not also aim to incorporate themes to exploit the full history, philosophy and sociology of science, as it relates to cultural diversity? For example, the Grade 6 unit on “Space” could have been bolstered by making explicit mention of Canadians from diverse backgrounds contributing to space and technology in various supporting roles and industrial contributions, aside from highlighting prominent personalities such as Marc Garneau and Roberta Bondar (METO, 1998: 100). When the science curriculum directs students to “identify and describe past and present-day contributions of astronomy to the quality of human life (e.g., development of the calendar; prediction of events such as eclipses and seasons; provision of information about space and time)” (METO, 1998: 100), should it not make explicit reference to non-Western perspectives and contributions? In directing students to “demonstrate [an] understanding of factors that contribute to good health” (METO, 1998: 23), the focus should not be upon the established medical mainstream. What of injecting content the acknowledges alternative approaches to medicine practiced in different cultures (e.g. in a Canadian context, aboriginal medical practice)? When students are expected to comprehend “the basic needs of humans with the needs of other living things (e.g., the need for food, air, water, light)” (METO, 1998: 16), the curriculum could have been extended to include consideration of the various constraints which may serve to influence such needs, such as environmental, economic, social and cultural factors.

Unfortunately, the Ontario science curriculum (METO, 1998) fails to provide anything at all in the way of socio-cultural considerations for science. Instead of directing the content to
demythologize the science enterprise, it seeks to preserve and perpetuate the mythical perspectives inherent to Western science (recall Chapter 3). Moreover, it fails to address the CMEC (1997) directives to inject history, philosophy and sociology of science as it relates to matters of race, culture and individuality.

4.3.3 ANALYSIS OF PROVISIONS FOR THE POLITICIZATION OF SCIENCE

The Pan-Canadian protocol for science curricula (CMEC, 1997), includes provisions for the politicization of science (recall concept from Chapter 3), having students: "realize that the applications of science and technology can have both intended and unintended effects" (that sometimes personal agendas and benefits are at stake); "be sensitive to and develop a sense of responsibility for the welfare of other people, other living things, and the environment"; and that they "appreciate that the applications of science can have advantages and disadvantages" (pp.30-31). With regard to these matters, the Ontario science curriculum does endeavour to reflect CMEC guidelines in its content. However, where the CMEC (1997) guidelines ask for students to "be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment" to "project, beyond the personal, consequences of proposed actions" and to "appreciate that the applications of science and technology can raise ethical dilemmas", the Ontario curriculum (METO, 1998) does not seem to stray beyond the immediate and readily apparent implications and impact of actions or decisions directed by science. In other words, it is superficial in its concerns with politicization.

Some examples may serve to illustrate this last point. Consider the "expectation" that students "describe ways in which humans can affect the natural world (e.g. urban development forces some species to go elsewhere and enables other species to multiply too rapidly; conservation areas can be established to protect habitats)" (METO, 1998: 22). What of humans affecting the lives of other humans? What about the practice of scientific progress impacting on human life? What of
urban development forcing people to relocate, or even to be eradicated? What of species being eradicated altogether, rather than merely fluctuating in population size or relocating? What happens when conservation areas are not established? Or when they are, if they are violated? While the "extinction of a plant or animal species" is acknowledged as affecting "the rest of the natural community and humans" (METO, 1998: 22), there is no mention of the continued extinction of human ethnic groups as a consequence of the actions and practices of others, whether directly or indirectly.

Consider the curriculum "expectation" of asking students to be able to select common forms of energy and to "predict the effect on their lives if it were no longer available" (METO, 1998: 54). No mention is made of directing students' concerns to the effect on other peoples' lives in order to furnish such energy. Is energy furnished at the expense of others? What of pollution, radioactive waste, or electrical powerline radiation, adversely affecting both the natural environment and settled environments where people reside? What about the economic, social, cultural and ethical issues that may be raised?

Finally, consider the prescription for students to "recognize that clean water is an increasingly scarce resource in many parts of the world and that the water we use is part of our environment and should be used wisely (e.g., taps should be turned off while brushing teeth; toxic substances such as paint should not be poured down the drain)" (METO, 1998: 92). Where is the mention of the underlying reasons contributing to, and causing, such a situation? Which practices are permitted (such as corporate dumping of certain "allowable" levels) and which are not (pouring paint down the drain)? Who decides? Why? Based on what considerations? Who benefits? Who is harmed? Is there anything for critically aware citizens to do about it? When the provincial curriculum directs students to "analyse factors that affect the productivity and distribution of animal species in marine and fresh water environments (e.g., water released from a nuclear plant, oil spills)" (METO, 1998: 104), what of the impact on humans under similar circumstances? No mention is
made of man-made disasters such as Hiroshima, or Chernobyl. Is science not capable of behaving in very powerfully destructive ways, as demonstrated by the preceding examples?

Hence, while the Ontario curriculum (METO, 1998) does seek to make some provisions for the politicization of science, it appears to have mandated a superficial treatment of it. There seems to be a deliberate intent to distance students from engaging in any critical and reflective questions, or from debating moral, ethical and political dilemmas. The curriculum fails to politically charge any issues, subsequently failing to foster any sense of civic or political participation, or to seek remedies or rectification of perceived social, moral, cultural, or environmental injustices. Instead, it appears content to offer students an opportunity to be informed of issues and consequences, on a non-probing, politically inert level, where focus tends to highlight the immediate and obvious impact that the practice of science and technology may have on the environment. There is no sense of inculcating students with critical awareness, providing insight to the socially, economically, or culturally contrived agendas which may direct the practice of science and technology, or to politically charge and empower them. Instead, it appears to preserve the status quo of power structures in society. Again, in this regard, the Ontario curriculum (METO, 1998) fails to fully comply with the CMEC (1997) guidelines, and fails to incorporate the multicultural science agenda.

4.4 ANALYSIS OF THE ONTARIO SCIENCE CURRICULUM FOR GRADES 9-10

Public response to the unveiling of the provincial science curriculum for grades 9 and 10 (METO, 1999) was in stark contrast to the anticipation and applause which greeted the curriculum for grades 1-8 (METO, 1998). Trepidation and uncertainty greeted the grades 9 and 10 science guidelines (METO, 1999) with concern that it was being rushed in terms of both publication and implementation (The Toronto Star, 1998c). Nonetheless, the structural organization of the grades 9 and 10 curriculum (METO, 1999) remained intact. It preserved its three domains of science education – “Concepts”, “Skills” and “Applications” – explicated earlier in this text. The only major
difference is the division of the content of each grade into "Academic" and "Applied" streams. Otherwise, the format remains unchanged.

Since the grade 9 and 10 curriculum (METO, 1999) follows the same formula for its curricula, it is subject to a similar critique. Hence, for the sake of avoiding redundancy, and for brevity, suffice it to say that the grade 9 and 10 curriculum (METO, 1999) suffers from the very same deficiencies as the antecedent grades 1-8 guidelines (METO, 1998) and thus, the same barbed criticisms apply.

Special mention should be made of certain "Specific Expectations" which do endeavour to introduce some socio-cultural considerations, although quite sparsely, to reflect the CMEC (1997) expectations of students being able to "appreciate and respect that science has evolved from different views held by women and men from a variety of societies and backgrounds" and to "value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds" (p.31). With students "expected" to "demonstrate an understanding of the historical development of reproductive biology and outline the contribution of the microscope to knowledge in the field" (METO, 1999: 8), it is a question of whether that would include non-Western history and scientific contributions, especially since both items of concern have roots in non-Western science.

The "expectation" to have students "relate the beliefs of various cultures concerning celestial objects to aspects of their civilization (e.g., aboriginal beliefs, Greek mythology, Mayan civilization)" (METO, 1999: 21) while a commendable start to introducing facets of multicultural science, falls into the trap of being concerned more with viewing cultural peculiarities or superficial customs than viewing the impact that such beliefs and customs have had in contributing to contemporary understanding. Similarly, the "expectation" to have students "describe ways in which the relationships between living organisms and their ecosystems are viewed by other cultures (e.g., First Nations)" (METO, 1999: 24) fails to extend understanding far enough. What about such views
translating into scientific practice, whether indigenous or contemporary Western? What about comparing and contrasting the merits of each paradigm of practice? What about presenting other paradigms of practice as being credible forms of scientific practice in their own right?

Hence, while the grades 9 and 10 curriculum (METO, 1999) essentially reflects the structural framework, organization, format and, hence, deficient qualities of its predecessor (METO, 1998), it does offer some concrete socio-cultural considerations. However, these few items are relatively insubstantial and insignificant in the context of the entire curriculum. In short, the content in question is woefully superficial and suggestive of tokenism.

4.5 CLOSING COMMENTARY

Premier Harris and his cohorts may claim to be following the Royal Commission’s recommendations (Royal Commission on Learning, 1994), yet they dismally fail to comply with any of the recommendations for equity considerations directed at introducing greater multicultural and anti-racist. Without any governing multicultural and anti-racist education policy document, provincial science curricula can certainly not be expected to offer a program of multicultural science education. Indeed, as pointed out earlier, the Ontario science curricula (METO, 1998, 1999) skirt the major issues and fails to abide by the guidelines set out by the CMEC (1997) for personalization, demythologization and politicization – three essential elements in multicultural science education.

While the Harris government may pride itself on abiding by the Pan-Canadian protocol (CMEC, 1997), it does so only in terms of the “literal science” subject content. It would not at all be an exaggeration to state that the Ontario curricula (METO, 1998, 1999) fail to make any provisions for multicultural science education, failing entirely to abide by the socio-cultural considerations of the CMEC (1997) science curriculum guidelines or to include its corresponding content. Indeed, while the CMEC (1997) outcomes include significant historical, philosophical and sociological dimensions for science education, the Ontario curriculum is entirely devoid of such
content. The Ontario science curricula (METO, 1998, 1999) fail on several fronts, by: providing far too much content "expectation", where the content itself may be too difficult and too abstract; providing little (essentially, no) attempt to deal with philosophical, historical, social, economical, moral, cultural and ethical issues; providing little integration of the sciences and few interdisciplinary endeavours; paying little (again, essentially, no) attention to the individuality of learning needs; and providing few (if any) critical and reflective dimensions. They fail to provide any true personalization of learning, demythologization of science, or politicization of science, and, in consequence, as such are negligent and deficient in their capacity to provide multicultural science education.

However, the establishment of multicultural science education does extend beyond the formulation of appropriate curricula to other factors and issues. It is these other factors and issues, related to multicultural science education, which serve as the focus for the next chapter.
CHAPTER 5
FURTHER REFLECTIONS ON INTRODUCING A MULTICULTURAL SCIENCE EDUCATION PROGRAM IN ONTARIO

5.1 INTRODUCTION

The institution of a multicultural science education program in Ontario must be predicated on two principal interrelated and interacting foundations: curriculum and pedagogy. Certainly, for any science curriculum (or any curriculum at all) to establish its educational objectives with any sustainable viability, it must support, and be supported by, appropriate and efficacious pedagogical practice (as explicated in Chapters 2 and 3). To echo an earlier assertion (made in Chapter 2) the disparity between the "intended" curriculum and the "implemented" curriculum may be a consequence of a number of factors: availability of resources (professional expertise, time, energy, finance, curricular materials, etc.), teaching context, available support (public, governmental, or institutional), teacher beliefs and ethos, etc. An additional contributing factor is an approach to curriculum development which fails to identify and engage teachers as the key agents of change, and ignores the uniqueness of educational settings. It is clear that a comprehensive, critically reflective scientific literacy will not be achieved without a curriculum, which balances the various emphases in science education, reconciles competing interests (recall Chapter 2), and displays an appropriate pedagogy. This also requires that the curriculum has content and resources that favour critical pedagogical practice and that teachers adhere to and promote such curriculum directives.

A curriculum which aims to foster and achieve a critically reflective scientific (and technological) literacy must be embedded within a paradigm of curriculum development which aims to engage teachers, with encouragement and support, in becoming critically reflective and critically literate about their own educational practices (Pedretti, 1994). The multicultural science education paradigm has been presented here as being a curriculum model which seeks to accommodate such
provisions. The intention of this chapter is to supplement the concepts and perspectives presented in the preceding chapters by reflecting and expounding upon related issues of concern which affect curriculum and pedagogy, as it relates specifically to the implementation and delivery of a multicultural science education program in Ontario.

5.2 PROVIDING SUPPORT FOR APPROPRIATE PEDAGOGY

The capacity to implement appropriate pedagogical practice commensurate with a particular curriculum program is dependent on the level of support provided. There are three main fronts to be considered: pre-service teacher education, continued professional development programs, and other supportive measures provided by administrative initiatives (at the levels of ministry, school board, and local school). The emphasis in this chapter is on supportive measures for a multicultural science education curriculum, with little attention afforded to the actual pedagogical practice which should accompany it. Explication of appropriate pedagogical response has already been offered in Chapter 2, and in greater detail in Chapter 3. Hence, for the sake of brevity, and to avoid much redundancy, focus will be largely limited to proposed supportive measures.

5.2.1 MEASURES FOR PRE-SERVICE TRAINING

With the teacher playing such a central and influential role in curriculum delivery and implementation, the training with which they are provided assumes fundamental focus as a vital venue for inculcating appropriate attitudes, beliefs, philosophy and perspectives, as it relates to their pedagogy. Indeed, pedagogical training must equip teachers to serve in a productive capacity, with their practice echoing the perspectives and objectives entailed within whatever curriculum program is administered. In Ontario, the university pre-service teacher education programs are a foundational site for socializing prospective educators into the profession, and hence, inculcating them with the knowledge, values, and skills set deemed appropriate. Within the realm of
multicultural science education, this would require adequate pre-service preparation on two fronts: multicultural (and anti-racist) education and science education; both of which appear to be inadequate, as shall be elucidated in the proceeding text.

Rezai-Rashti (1995) contends that most who seek entrance to the teaching profession arrive with little or no training in race relations, with little change, if any, effected through a pre-service teacher program. She further asserts that the faculties of education offer nothing significant, in terms of courses, to train teachers critically concerning the roles which schools play in perpetuating inequalities based on aspects such as race, gender and class. “The furthest that some teacher training institutions might go is to offer courses on cross-cultural communications. However, in most cases, this is done to provide extra qualification to those teachers who are interested in teaching English as Second Language courses,” (Rezai-Rashti, 1995: 12).

If preparation prior to entrance to the classroom is inadequate, as being suggested here, with learning opportunities to foster critical thinking in race and ethnic relations quite sparse, there is little chance that these graduates once among the professional ranks of teachers, will realize and appreciate the gravity of such relations, and their impact, in everyday classroom experiences. Rezai-Rashti (1995) comments that while it may be commonplace for practitioners to hear teachers insisting that they do not require race and ethnic relations training, since “they treat every child fairly”, a serious problem confronting teachers is their inability to recognize and negotiate their own biases, as suggested by Tator (1987/88) and Lee (1985). This is more likely to be apparent with recent arrivals in the profession who have yet to mature with their pedagogical philosophy, perspectives and practice. Although, for the same reason of professional immaturity, they offer a prime target to effect meaningful change in pedagogical practice, by steering them along a critically reflective avenue.

The vast majority of elementary teachers possess a relatively weak background in science, and are often overwhelmed by science, “regarding it as a body of complex and conceptually difficult
knowledge properly understood only by experts” (Bencze & Hodson, 1999: 528). Such trepidation is certainly compounded by inadequate pre-service training, where elementary teachers lacking a strong science background would find themselves feeling ill-prepared to contend with the science curriculum. Consequently, the best perceived recourse would be to engage in a very didactic and formulaic approach to science education, to simply translate the curriculum for students, a contention supported by the findings of Bencze & Hodson (1999).

With regard to a multicultural science education program, training elementary or senior science teachers would also require supplementation with significant elements of history, philosophy and sociology of science. However, as Bencze & Hodson (1999) note, despite the abundance of literature that has become available, and the greater prominence attached to the history and philosophy of science in many pre-service teacher education programs, many teachers persist in a practice locked in the philosophical mindset of the 1960s and early 1970s, where science governs with precise procedure, infallibility and objectivity. This suggests that, even where pre-service programs do accommodate such elements, sufficient time and attention is not being afforded to them. Research by Bencze & Hodson (1999), Pedretti & Hodson (1995) and Pedretti (1994) would seem to suggest that such aspects of pre-service training are largely absent in Ontario. Indeed, Pedretti (1994) urges those with responsibility for pre-service teacher education programs (in Ontario) to afford greater prominence to both critical competence in science education and elements of history, philosophy and sociology of science, as well as providing greater resources and training to such ends. These remarks suggest that curriculum guidelines and resources in Ontario do not place any significant emphasis on such elements of science education, otherwise they would be reflected more prominently, not only in pre-service training, but also in in-service programs of professional development. Hence, professional development programs would serve as another venue of support for the desired pedagogy.
5.2.2 MEASURES FOR PROFESSIONAL DEVELOPMENT

In-service teacher professional development programs constitute a means to build upon the foundations laid in pre-service programs, to bolster competency and functionality in curriculum delivery, but also to incorporate innovative ideas and methodology in teacher practice. Professional development aimed at reinforcing particular pedagogical practices is crucial to sustain desired and efficacious curriculum implementation and delivery schemes. Again, concern here is directed to two fronts: multicultural (and anti-racist) education, and science education.

On the multicultural education front, Rezai-Rashti (1995) takes aim at current staff development programs for raising teachers' awareness of racial and ethnic issues in the classroom, referring to the present situation as abysmal. She comments that ongoing in-service programs in this domain are almost nonexistent. "Currently, staff development programs for teachers take the form of one-shot sessions, and participation in them is voluntary. This kind of staff development training is referred to by some North American consultants as "hit and run" or "flash and dash", which highlights the marginal nature of these programs within the school" (Rezai-Rashti, 1995: 13). Not surprisingly, many educators in the United States are now refusing to participate in such professional development programs (Sleeter, 1990).

Rezai-Rashti (1995) refers to her own experiences as a practitioner, commenting that much of these one-shot programs are concerned more with creating some measure of sensitivity and tolerance among teachers, as well as informing them about certain salient features from different cultures, rather than aiming to affect change in teaching strategies or pedagogy. "Not surprisingly, in time some of the teachers who had participated in these staff development programs simply turn themselves off by believing that they had learned everything that is to be learned about multiculturalism, and that the field has little more to offer to them. They distance themselves from ethnic and race relations activities, completely oblivious to the fact that they failed to grasp the
pervasiveness of institutionalized racism, both within the educational system and in society at large,” (Rezai-Rashti, 1995: 13).

Two factors are cited for the present situation: attitudes of educators and the lack of priority attached to multicultural education programs. Rezai-Rashti (1995) points to a needs assessment survey conducted by one of the (former) boards of education within Metropolitan Toronto, focussing on sections of the race and ethnic relations policy. The teachers’ responses indicated that many were not only opposed to anti-racist education, but also to the milder policies of multicultural education, preferring to advocate the outdated ideology of cultural assimilation, an ideology explicitly rejected by Canadian legislation (Rezai-Rashti, 1995). Hence, teacher attitudes serve as a major impediment contributing to the lack of priority attached to such professional development programs. Yet, this is a problem further compounded by the lack of financial resources allocated to supporting such in-service programs, both at the ministry and school board levels, again a consequence of the prevalent attitudes (Rezai-Rashti, 1995).

On the science education front, with the recent introduction of the new Ontario science curriculum documents (METO, 1998, 1999), much criticism has been directed at the government's eradication of in-service programs designed to aid teachers in becoming fully conversant and competent with the newly introduced curricula (Small, 1998; The Toronto Star, 1998a, 1998c). Concern has emanated not only from critical quarters, but also from supporters of the new curricula, including one of the chief architects behind the new science curricula, Graham Orpwood, a professor at York University's Faculty of Education, who has warned that a firm ongoing government commitment will be required to get educators up to speed on the new curriculum (Small, 1998). Orpwood has noted that such commitment will require much more than the three months of teacher training which was proposed by the Ontario government: “It’ll take three years” in his estimation (Small, 1998). Instead, many teachers have found themselves ill-prepared to administer the curriculum in their classrooms. Compounding the problem is school boards having
to scramble to reallocate priorities concerning in-service programs, many of which have been eradicated due to provincial initiatives aimed at streamlining the finances and organization of education in Ontario.

Within whatever sparse in-service programs are still available, focus will no doubt be fixed firmly on measures to cope with the new curricula and just being able to implement it with some level of competence, leaving no time or concern for critical reflection, or introducing elements of science history, philosophy and sociology. Pedretti (1994) has expressed concern over the lack of in-service programs in Ontario geared toward an STS focus, which entails considerations not only of history, philosophy and sociology of science, but also issues of science and culture. Recent research findings by Bencze & Hodson (1999) seem to support such a contention, with their own voices added to echoing similar concerns. With the lack of attention paid to socio-cultural considerations, and the lack of provisions for critical reflection within in-service science education programs, the prospects for an effective multicultural science education are grim. Moreover, with teachers’ current preoccupation with becoming functional with the new science curricula, the situation is not likely to change in the immediate future.

5.2.3 OTHER SUPPORTIVE RESPONSES

Measures for supporting appropriate pedagogical practice commensurate with the curriculum objectives must extend beyond teacher training, through pre-service and in-service programs. Supportive administrative responses are essential from all levels of the educational system: ministry, school board and local school. The current non-supportive environment can only result in the further demoralization of educators contributing to ineffective curriculum implementation, and increasing mismatch between the intended and implemented curriculum.

While the current Ontario government has provided a political and economic commitment for its recently introduced science curricula, the agenda appears entirely preoccupied with ensuring
complete conformity to its curriculum directives. Advocates of the new science curricula, such as one of the principal players responsible, Graham Orpwood, maintain that the curriculum does not mandate explicit pedagogical practice. Rather, teaching and learning methods are left to the discretion of individual teachers and their board appointed trainers, so that any existing approaches to teaching particular content which remain relevant to the new curriculum content, may persist (Hall, 1998). However, provincial Ministry initiatives appear to contradict such contention.

Any teachers wishing to facilitate a more open-ended science program, such as that proposed by multicultural science education, are likely to experience numerous barriers to its implementation (Bencze, 1999). “Chief among these is the sheer volume of curriculum ‘content’; that is, the number and complexity of the Specific Expectations for the ‘Concepts’ and ‘Applications’ domains. Effectively addressing these can completely use up any time that might be available for students to conduct authentic inquiry and design projects, which generally require proportionately more time than more predictable content lessons” (Bencze, 1999: 27). Indeed, until the government reduces its curriculum expectations, teachers will have little choice but to strictly abide by the prescribed content, restricting students’ scientific and technological activities to those requiring little creativity and imagination (Bencze, 1999), and completely curtailing any significant effort to engage in critical reflection. At present it is a struggle simply to cover the expansive material within the allotted time frame of the school year.

With the provincial government’s legislative initiatives aimed at increasing centralization of authority and accountability, the downsizing of school boards and general elimination of localized powers, school boards and local schools are rendered helpless and themselves obliged to abide by the Ministry directives. In the process, teachers’ preparation time and in-service professional development programs have been greatly curtailed. The Harris government’s demands for greater proficiency from Ontario’s educators has largely cast teachers in an unfavourable light, where, as Bencze & Hodson (1999) contend, the personal practical knowledge of teachers and their ability to
exercise sound judgements concerning appropriate learning experiences and assessment/evaluation activities for particular students in particular learning contexts are ignored. Instead, "the failure of curriculum innovations can and will be blamed on teachers" (Bencze & Hodson, 1999: 524). Recent provincial proposals to require regular evaluation and appraisal of teachers and their level of familiarity and competence with the currently employed curricula, in order to maintain their professional certification, has only served to aggravate teachers further. The Ministry's attempts to drive curriculum change by means of linking notions of accountability and assessment has resulted in the introduction of standardized testing of students at particular stages of their scholastic careers. This has served to send teachers into a frenzied panic, to ensure that the curriculum expectations are extensively covered, driven by the desire to produce favourable results. With the public dissemination of such data, the Ministry only fuels public opinion and its impact on the culture of the school and the expectations placed on teachers and schools. In the process, the government achieves a sense of public accountability for educators. Teachers become coerced by the many constraints confronting them, and the only available recourse is to subscribe to the particular pedagogical practice prescribed by the curriculum, despite its undesirability or inappropriateness. "Within this climate, the implementation of standardized testing of students at particular stages of school careers as a means of providing data for a performance-based teacher appraisal scheme linked to merit pay, promotion and contract renewal cannot be far away" (Bencze & Hodson, 1999: 533).

Hence, the introduction of a multicultural science education program, or any of the innovations to curriculum development advocated here, would require a drastic change in direction, contrary to the course which the provincial government is currently steering. With teachers overwrought, overworked, demoralized, having to contend with time, energy, fiscal, resource, and in-service training constraints, it appears that the Ministry has succeeded in providing anything but a supportive environment. Indeed, the Ministry has fostered support for an environment of high
pressure and paranoia, with the sword of Damocles dangling perilously over teachers' heads. Any notions about introducing innovative curriculum development or pedagogy which stray from the prescribed provincial program are likely to be perceived by educators as far too precarious a professional path to tread. In other words, the Ministry has fostered an educational environment predicated by, and preoccupied with, conformity to its curriculum directives, permitting little room for deviation or innovation. Instead of providing supportive responses to teacher concerns, the provincial government has forcibly instituted reforms that squash any protests by educators and suppressing all urgent pleas to the contrary.

5.3 ISSUES RELATED TO CURRICULUM

As stated earlier, curriculum and pedagogy serve as the principal foundations to facilitate institution of an educative program, whether that of multicultural science education or any other. Considerable attention has already been directed to the curriculum framework for multicultural science education (recall Chapter 3), and to the requisite responses related to supporting an appropriate pedagogy, in the preceding text. Consequently, this chapter provides a brief insight into other considerations deemed significant to supporting multicultural science education initiatives in Ontario. Its principal concerns are: an examination of textbooks currently employed with science curricula; introducing alternative assessment schemes; exploring culturally centered curricula to enhance current content; and eliminating implementation constraints.

5.3.1 TEXTBOOK CONCERNS

To reassert a contention made in Chapter 3, science textbooks often present a predominantly Eurocentric, male view of science, ignoring the accomplishments and roles that people from diverse cultural backgrounds have achieved and continue to achieve (Hodson, 1993; Reiss, 1993). Furthermore, textbooks often portray only white scientists and students, with any
depictions of scientists or students from other cultures casting them in roles subordinate to whites (Hodson, 1993). Similarly, McCarthy (1998) comments that textbooks serve as the primary vehicle for conveying Eurocentric biases in the curriculum and in the classroom. McCarthy (1998) charges that the textbook, which serves as the centrepiece of the school curriculum in North America, frequently perpetuates the supremacy of white, European achievements and those of their (North) American counterparts over those of all other, non-white cultures. In the process, achievements from other cultures come to be seen as immaterial and inconsequential, with inferior status. Consequently, he contends, (North) “American schoolchildren come to know the world as one made by European ancestors and white people generally”. At the same time, they come to know “a world over-populated by minorities and third-world people”, a world portrayed as having been brought to ruination by “these people of other lands,” (McCarthy, 1998: 111).

Reiss (1993) suggests four main reasons for the biased (and prejudicial) presentation found in textbooks. Firstly, textbook authors may not be cognizant of the contributions of other cultures. Secondly, some areas of learning which are of importance to women and persons from other cultures are often excluded from the usual definitions of science, despite curriculum initiatives such as Benchmarks for Science Literacy (AAAS, 1993) or the Pan-Canadian science curriculum guidelines (CMEC, 1997) encouraging a broader view of science. Thirdly, textbooks fail to address the discrimination against women and people of colour, which may have prevented many of these people from obtaining an adequate education in science or ensured that contributions by women and scientists of colour were not reported. Finally, Reiss (1993) comments that science textbooks also fail to represent the factors which influence or determine the topics scientists choose to study. For example, science textbooks rarely cover the effect of power struggles and race relation on sickle cell anaemia research, and yet sickle cell anemia is usually discussed in biology textbooks.

All of this serves to underscore the need to examine and review science textbooks employed in Ontario. Moreover, all other science curriculum materials and resources should undergo a similar
evaluative review. The purpose of such examination and review of textbooks is to identify and replace all offensive and racially stereotypical curriculum materials. To reiterate the emphasis from Chapter 3, the objectives and content of multicultural science education should be reflected in the curricular materials employed, with particular attention paid to textbooks, which serve as a fundamental instrument for curriculum implementation in the classroom.

5.3.2 ALTERNATIVE ASSESSMENT SCHEMES

The new approaches to science teaching and science curriculum construction being advocated by this thesis, require a fresh approach to assessment and evaluation, one that differs very significantly from the standardized testing and assessment schemes the Ontario government has served to introduce alongside its new curricula. The problematic nature of standardized assessment schemes, and their inherent biases, is well established in the educational literature, with emphasis placed on the failure of such assessments to measure what students really know (Luft, 1998; Barba, 1998). Many have advocated alternative assessment schemes which seek to provide a holistic approach to evaluation in science education (Barba, 1998; Gough & Griffiths, 1994; Tippins & Dana, 1993; Luft, 1998; Pedretti, 1994). Moreover, assessment should be deemed context dependent; it should reflect the nature of the subject matter; and it should address the unique cultural aspects of class, school and community (Tippins & Dana, 1993). Such perspectives would be in keeping with the provisions sought by multicultural science education to facilitate the personalization of science learning and knowledge, while maintaining sight of socio-cultural considerations.

While the explicit criteria of such alternative assessment schemes may be subject to different interpretations and emphases (Luft, 1998), there is some agreement as to what such alternative assessment schemes should entail (Barba, 1998; Gough & Griffiths, 1994; Tippins & Dana, 1993; Luft, 1998). Briefly, this includes incorporating such schemes as: cooperative learning and group
assessment, where students must engage in a dialogue which requires them to construct and negotiate a shared meaning of their science learning, and in the process come to understand and appreciate socio-cultural differences; journal writing, where opportunity is afforded for students to foster connections between experiences and theory, and to engage in personal scientific discourse, allowing for greater familiarization of scientific vocabulary and the articulation of their thought processes; concept mapping, which requires students to share, discuss, negotiate and agree upon meanings; and portfolios, which should serve to provide a developmental record of growth in conceptual understanding for both teachers and students, and would include concept maps, written journals, records of oral interviews and cooperative group work, and the like (Tippins & Dana, 1993; Barba, 1998; Gough & Griffiths, 1994). "Any discussion of assessment must be linked to understanding what we teach, how we teach, and why we teach. A multiethnic and multiracial science curriculum and learning environment, as well as culturally relevant assessment strategies, can enable teachers to better prepare their students for the multicultural society in which we live" (Tippins & Dana, 1993: 47).

5.3.3 EXPLORING CULTURALLY CENTERED CURRICULA

To return to an earlier discussion in Chapter 3, the private domain of education would afford greater opportunity to provide culturally centered curricula which fully integrate one’s own personal sociocultural system of beliefs, values and ethos. Fleras & Elliot (1992) offer the example of native-controlled education, whose aims are twofold. Firstly, it seeks to impart those skills which children will require to succeed in the outside world. Secondly, it aims to immerse children in an environment that is resolutely aboriginal in content, style and outcome.

With the recent emergence of First Nations schools (Greene, 1998), significant efforts have been undertaken to formulate culturally centered curricula. The development of such curricula appears to have contributed to the heightened awareness and credence of aboriginal scientific
knowledge and practice (Ho, 1999). Another notable example is the Kurakaupapa Maori initiative in New Zealand (see Hodson, 1993), which aims to present Maori perceptions of the natural environment alongside those of Western science, and reinforced by a preferred Maori pedagogy. Such culturally centered curricula, whether First Nations or for other cultures, could also provide valuable references and resources for a multicultural science education program. With private schools steadily on the increase in Canada, largely centered around culture and religion (Fleras & Elliot, 1992), greater culturally centered curricula are likely to be produced, providing a possible valuable resource pool for multicultural science education, and ensuring a more accurate representation of the scientific philosophy, history, perspectives and practice of various cultural groups.

5.3.4 IMPLEMENTATION CONSTRAINTS

As already noted, any curriculum is subject to implementation constraints, including: lack of support on a governmental, school board, public or local institutional level; lack of economic resources or commitment, lack of provisions for time, energy and resources for teachers to facilitate efficacious curriculum delivery; lack of supportive initiatives for appropriate pedagogical practice; lack of supportive environment for teachers; and lack of supportive environment for the curriculum, on the part of educators, politicians (seeking reform), or the public. Indeed, closing the divide between the intended and implemented curriculum is dependent on the ways in which these are addressed. It almost goes without saying that such matters should be afforded a much higher level of priority.

5.4 FINAL REFLECTIONS

Multicultural science education may mean many things to many people, with relative emphases varying between countries, regions, schools and classrooms (Hodson, 1993). In Ontario,
the needs of urban students will contrast with those of students from rural Ontario, where there are different degrees of exposure to diverse cultures, peoples and backgrounds. Indeed, the priorities in schools with a highly mixed ethnic population will significantly differ from those in schools in which the student population is largely drawn from the dominant culture. Some might argue that the needs and provisions for multicultural science education should be commensurate with the degree of exposure to and interaction with ethnically heterogeneous populations. In other words, such provisions are more important and required for large urban areas or in communities which exhibit visible diversity. However, this ignores the fact that Ontario's population is ethnically and racially diverse, reflective of the diversity which pervades Canada. Schools do not exist in isolation but rather, each comprises a component of the wider spectrum of society. Consequently, with students going on to further education, job training and employment, they must be equipped to participate effectively in broader society, where there is a marked need for multicultural (science) education initiatives, regardless of the composition of their immediate community or school environment. Indeed, some contend that such initiatives may prove more valuable in homogeneous learning environments dominated by white children, in order to combat the prejudices and biases likely to accrue without such socioculturally diverse exposure (Mann, 1991). Hence, multicultural science education would seek to foster a critically reflective scientific literacy for all students, regardless of their sociocultural backgrounds, not merely for ethnic minorities.

In surveying the various considerations for responsive provisions related to curriculum and pedagogy, for the institution of a multicultural science education program in Ontario, it must be stressed that there is a danger in adopting a view which is too prescriptive, or too narrowly and rigidly defined (Hodson, 1993), a quality which the Ontario science curricula (METO, 1998, 1999) have in abundance (recall Chapter 4). Sufficient breadth of perspective can be achieved through the presentation of the philosophy, objectives and perspectives underlying the three main thrusts of multicultural science education, outlined in Chapter 3: the personalization of science learning and
knowledge, the demythologization of the science enterprise, and the politicization of science. This chapter has sought to elaborate the full scope and magnitude of introducing a new science curriculum program for Ontario, outlining obstacles that exist and problems which must be remedied in order to ensure that multicultural science education curriculum is buttressed with the appropriate supportive provisions. In the final chapter, attention is directed at synthesizing recommendations for policy and practice reform in Ontario to reflect the goals of multicultural science education.
CHAPTER 6
RECOMMENDATIONS FOR SCIENCE CURRICULUM POLICY AND PRACTICE
REFORM IN ONTARIO

6.1 RECOMMENDATIONS FOR REFORM

This thesis has sought to engage a discourse for what it proposes as an improved science curriculum program. Toward this end, multicultural science education has been presented as a curriculum development program which aims to accommodate sociocultural factors, acknowledged by educators as impacting on learning. Furthermore, concern for such a program has also been directed at engaging teachers in a critically reflective pedagogical practice, inculcating critically reflective skills among science students, and fostering a critical and comprehensive scientific literacy within a multicultural domain. Subsequently, analysis of the current policy and practice for multicultural and science education programs in Ontario was undertaken, with curriculum evaluation conducted under the criteria of multicultural science education defined in Chapter 3, delineating several deficiencies in terms of the Ministry's provisions. Chapter 5 sought to reflect further upon provisions which should be considered in supporting and sustaining a multicultural science curriculum paradigm, with focus directed on two fronts: measures related to supporting appropriate pedagogy and issues related to curriculum implementation.

This thesis has aimed to provide an undercurrent of critical reflection in its presentation of multicultural science education for Ontario. It is with this same objective that the presentation of the various considerations, related to curriculum policy and practice in Ontario, has been offered. The entire focus of this thesis though, has been directed at establishing the foundation for providing recommendations for science education reform in Ontario.

It is proposed that the Ministry of Education and Training examine current provisions for multicultural science education contained in current curriculum policy and practice in Ontario in the
light of current research findings and academic debate, as presented in this thesis. In particular, attention should be directed to the following considerations.

- The Ministry of Education and Training for Ontario should formulate a policy concerning multicultural (and anti-racist) education, to influence curriculum development and practice in Ontario, with directives for the school boards across the province to formulate their own particular policy and program initiatives within the Ministry's mandate.

- Science curriculum provisions should be made to incorporate the three domains of multicultural science education: the personalization of science learning and knowledge, the demythologization of the science enterprise, and the politicization of science education. This may achieved by: affording prominent attention to the individuality of learning needs; promoting appropriate pedagogical practice commensurate with the objectives of facilitating border crossing for students; promoting appropriate pedagogical practice which seeks to enculture students to the manners and methods of authentic scientific investigation and procedure without assimilating them culturally; affording prominence to sociocultural considerations in science education; deploying historical, philosophical and sociological dimensions of science; infusing content which encourages critical and reflective questions and exercises; addressing issues which require moral, ethical and political debate; fostering a sense of participation and empowerment for students.

- The Ministry should administer measures to provide a supportive environment for appropriate pedagogical practice by ensuring the following provisions: bolstering pre-service teacher education programs for multicultural (anti-racist) education, science education and multicultural science education; the re-introduction of greater, and
improved, in-service professional development programs for the same; enacting administrative initiatives responsive to the multicultural science curriculum mandate for teachers and their needs, which implies re-introducing adequate fixed time for teacher preparation, diminishing the volume of curriculum expectations assigned to each grade so that teachers can manage the curriculum more proficiently, providing greater curriculum resources and training to facilitate improved implementation, and providing an environment where teachers are not compelled to conform or face continuing pressure over retention of professional accreditation and employment.

- The Ministry should administer the following measures in support of implementing a multicultural science curriculum: review all textbooks and other curriculum materials with the aim of identifying and replacing all offensive or racially stereotyped content; introduce alternative assessment schemes aimed at providing a holistic evaluation of science students; examine and explore the possibility of introducing culturally centered science curricula to enhance curricular dimensions of culturally diverse history, philosophy and perspectives; and eliminate implementation constraints related to pedagogy, resources and administration.

6.2 TOWARDS A MORE RELEVANT AND CRITICALLY REFLECTIVE SCIENCE CURRICULUM

Multicultural science education has been presented in this thesis as a paradigm for curriculum development to furnish a science curriculum deemed more relevant to the culturally diverse learning population of Ontario. To re-emphasize an earlier contention (from Chapter 3), multicultural science education would still fundamentally preserve the scientific process of investigation, examination and discovery. Since there must be some common forum for science
communication, process, evaluation and dissemination. However, it would allow for sociocultural factors which might affect perspectives on process, results and interpretation to be recognized. Its goal would be focused on seeking to enculture students with the science process without socioculturally assimilating them. In this regard, particular emphasis would be afforded to fostering critical reflection amongst students.

How science education proceeds in Ontario should reflect our concerns and expectations for achievement and accomplishment by our students. It is widely argued that success in today’s world is dependent on one’s capacity to access and negotiate the socio-cultural diversity of the global village. If this is true, do students not require a science curriculum which is firmly grounded in diversity? Only then, will they be fully conversant and functional in today’s global village. Given the paradigm of multicultural science education presented here, my response is a resounding, “yes.” Anything less, would be cheating their future.
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