Technological Education and Environmental Sustainability, a Critical Examination of Twenty years of Canadian Practices and Policies

Leo Elshof, PhD.
Acadia University
Wolfville, Nova Scotia Canada

This paper will look at the last twenty years of technological education in Canada through a 'sustainability' lens. Technological education has a central role to play in helping young people develop the skills, knowledge and attitudes required to transform the term 'sustainable development' beyond mere policy rhetoric to one of embodied reality. The transformation of our built environment, our patterns and modes of consumption, transportation and energy use are all necessary in order to slow down and halt the degradation of the biosphere. This paper questions whether technological education programs in Canada have made substantive progress in addressing the problem of environmental sustainability. It will also offer a number of recommendations for transforming technological education to meet the global sustainability challenge. Selected secondary school technological education curricula from Alberta, British Columbia, Saskatchewan, Ontario and Maritime Canada were reviewed for this paper.

We live in what has been called the "Anthropocene", a geologic epoch in which humankind has emerged as *the* "potentially intelligent" globally dominant species, capable of virtually reshaping the face of the planet and its ecosystems through both intention and accident (Schellnhuber et al., 2004:1). This immense responsibility is unprecedented in human history; we have collectively become 'planetary engineers' in the sense that our ability or inability to manage our relationship with the Earth's ecosystems will have profound consequences for all living things. The UN predicts that world population will rise by 40% from the current 6.5 billion to 9.1 billion by 2050 (BBC, 2005), this fact alone will put an unprecedented strain on the ability of natural systems to meet human demands. Global energy consumption is growing at approximately two percent per year and is projected to double by 2035 and triple by 2055 (Friedmann & Homer-Dixon, 2004). In large developed countries upwards of 85% of this energy is derived from fossil fuels which when burned generate carbon dioxide and contribute to climate change.

It has been almost 35 years since the initial UNESCO call for an international 'Earth Day' to draw attention to the human impact on the planet Earth. The 1987 Brundtland Report followed by the 1992 Rio 'Earth Summit' injected the term 'sustainable development' into the popular consciousness. The Rio Earth Summit established the need for governments and their education systems to seriously address the nature of the need to address these issues. Chapter 36 of Agenda 21 "Promoting Education, Public Awareness and Training" clearly identifies the need to:

- reorient education towards sustainable development,
- increase public awareness of sustainable development and;
- promote training towards sustainable development (UNCED, 1992).

The last twenty years has witnessed the emergence of environmental sustainability as a prominent theme in public policy throughout the world. The 2002 Johannesburg World

Summit on Sustainable Development (WSSD) identified the need to educate young people from developed countries about issues such as Life-Cycle Analysis (LCA) as well as unsustainable patterns of consumption and production (United Nations, 2002:14). Numerous international studies point to the fact that environmentally unsustainable methods and levels of production and consumption in rich developed countries lie at the heart of the sustainable development conundrum (Meadows, 2004; Speth 2004; United Nations, 1992). The United Nations *'Global Environmental Outlook 3'* (GEO-3) stated that:

> The environment is still at the periphery of socio-economic development. Poverty and excessive consumption – the twin evils of humankind that were highlighted in the previous two GEO reports – continue to put enormous pressure on the environment. The unfortunate result is that sustainable development remains largely theoretical for the majority of the world's population of more than 6000 million people. The level of awareness and action has not been commensurate with the state of the global environment today; it continues to deteriorate" (United Nations Environmental Programme, 2002:2).

The health of global ecosystems over the last thirty years has been tracked by the World Wildlife Fund using a composite measure called the 'living planet index' (LPI). The LPI is the average of three separate indices measuring changes in abundance of 555 terrestrial species, 323 freshwater species, and 267 marine species around the world. The trend lines for the LPI over the last thirty years are distressing:

> While the LPI fell by some 40 per cent between 1970 and 2000, the terrestrial index fell by about 30 per cent, the freshwater index by about 50 per cent, and the marine index by around 30 per cent over the same period. These declines can be compared with the global Ecological Footprint, which grew by 70 per cent, and with the growth in the world's human population of 65 per cent, from 1970 to 2000" (WWF, 2004:2).

The Living Planet Report is blunt:

> In 2001, humanity's Ecological Footprint was 2.5 times larger than in 1961, and exceeded the Earth's biological capacity by about 20 per cent. This overshoot depletes the Earth's natural capital, and is therefore possible only for a limited period of time (WWF, 2004:1).

The nature of the technologies we design and use is inextricably connected to our lifestyles, our material and energy consumption levels, as well as the overall health of both our local and the global environment. Given this relationship and the disturbing trends emerging, we need to ask: *Has a coherent 'sustainability discourse' emerged from within the technological education community in Canada, a rich developed nation, and if not, why not?*

Canadians and their Environment

In terms of environmental sustainability performance Canada is falling behind other countries (Dion, 2004; Boyd, 2004; Statistics Canada, 2004). In a recent study by the Conference Board of Canada which looked at the environmental performance of 23 OECD countries, Canada dropped from a twelfth place ranking to sixteenth in 2003 (Commissioner of the Environment and Sustainable Development, 2004:2). Although

Canadians like to consider themselves 'environmental leaders' the actual performance of Canada on the environmental front is quite another story. North Americans have the highest regional ecological footprint on the planet (WWF, UNEP, 2004) and in aggregate at least, model an unsustainable consumer lifestyle lived at full throttle. Canadians have the eighth largest ecological footprint per capita on the planet, surpassed in North America only by the United States which has the second largest global footprint (WWF, 2004; Wackernagel, 2002). As Boyd explains:

> In Canada, over-consumption is the root cause of our environmental woes. As the North American Commission for Environmental Cooperation points out, our "prevailing emphasis on consumption – with high levels of waste, energy use, and greenhouse gas emissions – jeopardizes the capacity of natural resources and systems to support future generations." Consumption in this context refers not only to the energy and resources consumed by individual Canadians but encompasses the use of energy and resources by the entire industrial economy. Most Canadians see only the tip of the iceberg of the resources consumed to supply the goods and services required by current lifestyles. We are largely blind to the industrial activities that consume vast amounts of resources and cause extensive environmental damage (Boyd, 2004:5).

Canadians are also the second largest consumers of water in the world, and its emissions of CO_2 and other key air pollutants. On a per unit GDP and per capita basis are among the highest in the OECD (Dion, 2004). Overall emissions from Canadian industry increased 8.2 percent from 1990 to 2002; emissions per unit of fossil fuel consumed decreased 7.4 percent. Over the same period the fuel consumed for transport increased 13 percent and energy consumption in commercial buildings grew 31 percent while the floor space grew only 26 percent (Reguly, 2005). The "industrial material metabolism" of North American industry amounts to approximately twenty times body weight per day or one million pounds per year, globally the economy mobilizes a flow of half a trillion tones per year but only 1 percent of that flow gets embodied in a product and is still present 6 months after sale, the other 99 percent is waste (Lovins et al., 2005:31). Boyd estimates that Canadians use approximately 85,000 kilograms of resources per person annually or about 232 kilograms of materials per Canadian each day, or the equivalent of about 45 full shopping bags per person, per day (Boyd, 2004:4). The need to fundamentally re-vision the nature of our production-consumption systems also involves a restructuring of our economies as well:

> all of our economic arrangements today, from tax codes to mental models, derive from this effort to economize on the scarcest factor of production, skilled people, and substitute the use of seemingly abundant nature to supply resources and absorb pollution... today we have abundant people and scarce nature, not the other way around. This is not to say that commodities are scarce. What is increasingly limited is the ability of deteriorating living systems to provide the ecosystem services needed to sustain growing populations and economies." (Lovins et al., 2005:30).

The global market and a demand for higher environmental performance in goods and services is forcing Canadian business and industry to embrace:

environmental/sustainability reporting, environmental design and management processes, reduce greenhouse gas emissions, and to attend to concerns surrounding eco-efficiency, supply chain stewardship and the link between environment and value creation (Conference Board of Canada, 2003). As well, the recently ratified Kyoto Climate Accord on greenhouse gas emissions will widespread technological and social innovation if Canada is to meet its international Kyoto obligations and avoid an 'ingenuity gap' (Homer-Dixon, 2000). Current estimates place our greenhouse gas emissions in 2005 at twenty percent above that required to meet our Kyoto accord commitments. Enlightened thinking about the nature of waste and pollution in product design and manufacturing have moved beyond 'end-of-pipe' considerations in which pollution is considered as an afterthought, toward proactive *'Design-for-the Environment'* (DfE) and 'restorative' (Cunningham, 2002) approaches in which life-cycle costs are thoroughly considered in design. Proactive approaches to technological thinking related to sustainable production and consumption, extended producer responsibility, and product-service systems, has been more advanced in the European Union than in North America. The Canadian Minister of the Environment has warned that Canadians risk their quality of life if they ignore the imperative of a sustainability transformation within Canadian industry. He emphasizes that what he terms the "new industrial revolution"...as "one of the most important issues for our nation today" (Dion, 2004:2). Unfortunately Canadian technology education curricula over the last twenty years have reflected at best, a tepid response to promoting sustainable practices to address the sustainability crisis. In a number of provinces the curriculum remains out of step with the Canadian Government's stated industrial strategy which is guided by a vision of Canada as: "a leader in the development, commercialization and adoption of innovative sustainable development tools, practices and technologies throughout the economy" (Industry Canada, 2003:viii).

The need to address sustainability issues within technical education has been identified in a number of recent reports. Coll et al., (2003:173) identifies the importance of connecting education for sustainable development (EfS) to work so that:

- experiential learning in the workplace is seen as a critical context for educating for sustainability
- Students are exposed to EfS in the classroom first so that they may take these values into the workplace
- EfS integrates workplace-based knowledge with classroom learning.

The 2002 UNESCO report *"Technical and Vocational Training for the Twenty-first Century"*, identified a number of new lifelong directions for technical and vocational education and training in order to "meet the new demands of achieving the objectives of a culture of peace, environmentally sound sustainable development, social cohesion and citizenship of the world" (UNESCO & ILO, 2002:43). Further, technical education should "empower people to contribute to environmentally sound sustainable development through their occupations and other areas of their lives" (UNESCO & ILO, 2002:9). The report also urged that teachers of technical and vocational subjects in general education should not only be familiar with a broad range of technological specialties, but that they should develop the ability to relate these to each other as well as to the larger social, economic, environmental, historical and cultural context" (UNESCO & ILO, 2002:43).

Similarly, the 1999 Canadian Council of Ministers of Education report *'Educating for Sustainability the Status of Sustainable Development Education in Canada'* also identified the important role for technological competence in any consideration of sustainability:

> Any consideration of issues of sustainability must of necessity involve a discussion of the role of technology. What is meant by a "technological fix"; what constitutes appropriate technology; is a massive global technological transfer required to save the planet and its inhabitants; how might technology be used to acquire the information and make projections necessary to build a sustainable world; to what extent does a given societies' world-view predispose it to embrace technology, what are the ethical implications of certain technological developments? These are essential questions which students must explore (Council of Ministers of Education Canada, 1999:76).

The need for a sustainability literate workforce is becoming increasingly vital in terms of designing technological services and products which meet international environmental performance requirements. For example, international standards such as ISO 14000 for environmental management systems provide important general guidelines for 'greening' procurement and supply chains and improving environmental performance accountability. The importance of sustainability-related skills for Canadian workers is identified by Chienen:

> To protect ecosystem health, the Canadian workforce requires both specific knowledge and skills regarding how ecological systems and cycles work, as well as an understanding of the values that influence decisions and actions taken. Workers need to recognize that the resources of our planet are not infinite and to realize the need to use natural resources wisely to ensure a sustainable supply for future generations. They must become aware of major ecological problems as well as their cause and effects. Workers must also understand the importance of complying with environmental regulations and how they, as individuals can contribute to environmental problem solving and resource management. Having a systems view (taking into consideration environmental, social, economic factors) in all decision making and actions taken in the workplace will enhance the ability of future workers to think "outside the box" and simultaneously see themselves as part of a sustainable system. Sustaining the health of the planet for future generations is our ultimate challenge and goal (Chienen, 2003:12).

What is emerging is a clear indication that promoting sustainable technological practices not only make environmental sense, but economic sense as well.

A Review of selected Provincial Curricula and major Sustainability Themes

A content analysis of selected provincial and supporting curricula materials from Alberta, British Columbia, Ontario and Maritime Canada was performed to find evidence of the following sustainability-related themes:

- Product material Life Cycle Analysis (LCA): is LCA mentioned in the design of products with full consideration of all energy and wastes produced in all phases of manufacture-use?

- Waste-pollution elimination through Design: is waste considered something to be dealt with after the fact (end-of-pipe) or in the design process itself? (see Hoepfl, 2001)
- Design for Environment (DfE): are issues related or recyclability/reuse and industrial ecologies evident? (see Hoepfl, 2001)
- 'Energy- Efficiency' and Renewable Energy: are energy efficiency and renewable energy issues mentioned? (see Hill & Dewey, 2001)
- Material Consumption: is material consumption and consumerism treated as problematic? (see Petrina & O'Riley, 2001)
- Sustainability and Sustainable Development: are these broad thematics mentioned in connection to technological education?
- Climate Change: are any technological practices connected to this major global problem?

This choice of sustainability themes/topics examined is by no means comprehensive; rather the selected issues reflect those with significant environmental impact and close connection to technological practices. The documents were selected to provide a measure of comparison between provinces, but the reader should be aware that course names and curriculum organization vary significantly province to province. The results of this analysis appear in **table 1.**

Elementary and Secondary Education in Canada is a provincial responsibility and no national curriculum exists per se. The provincial ministers of education through their organizing body, the Council of Ministers of Education (CMEC) issue policy directives and statements concerning the state of Canada's educational system. Although the CMEC has developed a Pan Canadian science curriculum (CMEC, 1997), an equivalent in technological education has not to date been developed. Space permits only a brief exploration the situation in Alberta and Ontario.

Alberta

The 1989 comprehensive expert paper *"Trends and Issues Affecting Practical Arts in Alberta Secondary Schools"* (Alberta Learning, 1989), was prepared to inform the design of an emerging Career and Technology Studies (CTS) curriculum development process in Alberta. The report identifies two broad categories, 'societal' and 'educational' trends, societal trends are broken down into demographic, economic and technological trends. The 56 page 'Trends and Issues' report contains 138 references but only mentions the word 'environment' once in terms of an emerging 'societal trend': "lack of worldwide stability: politically, economically, environmentally" (Alberta Learning, 1989:42). No mention is made of how this vague 'lack of stability' should inform the emerging CTS curricula beyond acknowledging that the "role of citizen [is] more complex" and the 'challenge' to "expand opportunities for students to build confidence, [and a] sense of empowerment" (Alberta Learning, 1989:42). The Alberta 'Trends' report endorses the work of Johnston and Packer (1987) who identify five technologies that they predict will have the greatest impact on society: information storage and processing, communications, advanced materials, biotechnology, and superconductivity. Drawing on these predicted trends, the report cites a "declining demand for natural resources" (Alberta Learning, 1989:12) as a technological implication to motivate more economic diversification.

The Alberta CTS program has a "vocational education color" when compared to the British Columbia (B.C.) technology education programs or those in Atlantic Canada (Yamakazi and Savage, 1998). CTS consists of 22 strands and over 650 courses. CTS provides opportunities for students to:

- make decisions regarding which procedures best suit the task at hand
- select and use available tools and resources in an appropriate manner
- assess and manage the impact of technology on self, others and the environment.

The Alberta curriculum incorporates a number of unique sustainability-related CTS modules dedicated to issues such as: sustainable agriculture systems, energy and the environment, conservation challenge, environmental law, protection and stewardship of forests, product life cycle in product development, eco-tourism and living environment – environment and interior design. Although one of the CTS product development modules makes one of the most comprehensive statements concerning life cycle issues of any of the curricula reviewed:

> Students describe the life cycle of a typical product from the time of introduction to its decline and consider the issues related to product disposal and/or recycling in the initial design stages of a product to minimize waste of materials

A number of important issues are not addressed consistently in related modules, nor is sustainability taken up as theme across any of the documents reviewed-see table 1.

Ontario

Gardner & Hill (1999a; 1999b) provide an extensive overview of the development of technological education in Ontario over the last 25 years. They observe that Ontario has retained a vocational orientation as a basis for organizing senior secondary technological education. The major development over the last 20 years in Ontario technological education has been the emergence of the 'broad based technology' (BBT) initiative. One of the major 'goals of education' for Ontario expected that all students: "develop respect for the environment and a commitment to the wise use of resources" (Ontario Ministry of Education, 1985:7). The 1985 curriculum made few specific references to environment and technological education beyond the claim that as one of the 'aims of technological studies': "students shall be given opportunities to develop understandings and attitudes [concerning] a commitment to the responsible use and conservation of the sources of energy that provide the motive power for sustaining a technological society" (Ontario Ministry of Education, 1985:7). The 1985 curriculum did however link values to technological practices:

> Values education occurs as an integral part of the school experience…in Technological studies programs teachers should provide regular opportunities to reflect upon the values and issues that arise from the subject matter, from the learning activities, and from the students' relationships in the classroom and the workplace (Ontario Ministry of Education, 1985: 20).

The last twenty years have witnessed enormous changes in the manufacturing industry in Ontario. The dynamic forces of technological change, globalization, financial deregulation, free trade and industrial restructuring have led to massive changes in the Ontario workplace. The need for the 'flexible skilling' of workers has reverberated as a major focus for technological education:

> Tomorrow's workplaces are seeking students who are mature, who can communicate well, and who hold appropriate attitudes to work and learning. Employers also point to the need for a wide range of workers who have problem-solving skills rather than simply a fixed body of knowledge, who have interpersonal skills and the ability to work in teams, who have a combination of skills rather than a single specialty, and who have the ability to keep learning new content and processes (Premiers Council, 1988:55).

The need for 'generic problem solvers' and not subject matter specialists was clearly set forth. This also meant:

> ...there is also a demand for employees who can implement and work with new management strategies designed to increase participation and create less hierarchical organizations... employers need and expect graduates with some common, recognizable knowledge and skill bases, but who are flexible and can be easily reallocated to new areas that require specific skills (Premiers Council, 1988:55).

An enrollment drop in traditional vocational education courses also accelerating the need to revamp technological studies in the mid 1990's. The number of individual technology courses taken by all secondary students in Ontario dropped from 481,000 in 1973 to 257,000 in 1996, while the overall student population had increased from 586,000 to 696,000 students (Smaller, 2000:17). The conservative provincial government from 1995-2003 instigated a period of unprecedented upheaval in the Ontario education system. In spite of their focus on economic issues, the neoliberal conservatives still did not find it necessary to make a technological education credit mandatory for the secondary students of Ontario. The BBT curriculum revised under the auspices the Conservative government's *"Common Sense Revolution"* effectively severed any connection between technological education and the subject of values and their clarification and further marginalized environmental and sustainability concerns (Elshof, 2000), the word 'values' is not even mentioned in the current BBT curriculum. The environmental and sustainability dimensions of technology design and use are inescapably value laden. When connections to values and values clarification processes are eschewed in the official curriculum, the word 'environment' may be construed as a very instrumental concept stripped of its intrinsic value. So construed, 'environment' becomes a 'placeholder' in the curriculum for 'environmental regulation' and consideration of 'the environment' essentially becomes a matter of ensuring that the minimum regulatory requirements concerning the proper handling of wastes and emissions from technological processes are adhered to. When this occurs pedagogical consideration of the broader value-laden issues related to the unsustainability of current technological practices and paradigms, along with the associated political and social justice dimensions of these issues are often left behind.

The Ontario Council for Technological Education (OCTE), the professional body representing technological studies teachers in Ontario presents the argument for technological education in starkly economic terms on their website:

> The Ontario Council for Technology Education (OCTE) believes that if we do not plan clear strategies for ensuring technological literacy, we risk our economic future. The talent to innovate, invent, create, maintain and build will go elsewhere. Our citizens will be ill prepared to deal with future changes in the global economic engines, such as the nascent biotechnology industry or hydrogen fuel cell economy. Our futures will be compromised, our economic survival conceded (OCTE, 2004).

This statement among other similar ones reflects a deterministic interpretation of technological education as/for 'economic survival'. The productivist 'fast capitalist' discourse is also evident in the OCTE definition of technological literacy:

> Technological literacy is about understanding how technology affects our society and our lives, and having the skills to utilize technology effectively. It is about being better-informed consumers and producers; it is about fulfilling the roles in the infrastructure that makes our society run; it is about ensuring our economic future. The consequences of a technological illiterate population are profound. Industry and businesses cannot find skilled employees. They leave, jobs are lost, and the economy suffers. Innovation goes elsewhere, and the best and the brightest goes where innovation lives. The right talent is not connected with the right career. Opportunities for the young in all destinations disappear; society lacks the means to maintain and grow (OCTE, 2004).

What is clearly missing from these 'vision' statements is the important role for technological education in helping young people understand the connections between our built environment, our lifestyles and our use of technology and the sustainability problem.

The problematic dimensions of a narrow 'economic rationalist' approach to technical education are identified in the UNESCO-UNEVOC report *"Orienting Technical and Vocational Education and Training (TVET) for Sustainable Development"*:

> TVET in many countries remains locked into the role of being a supplier of skilled labour to industry and is, thereby, unable to respond effectively to the needs of the emerging Information Age. Some attribute this to the culture productivism in TVET which presupposes that economic growth is a permanent and necessary feature of human existence, regardless of its environmental impact and consequences...Giving precedence to economic interests, productivism can subordinate the needs of individual learners to those of industry and prioritizes work and employability over the non-economic outcomes of TVET. This has resulted in TVET being seen as training-for-growth and skills-for- work, two goals for TVET that are antithetical to the needs of the Information Age and the broader general education for personal autonomy, citizenship and sustainability that TVET also needs to serve (UNESCO-UNEVOC, 2004:13).

OCTE has also endorsed the ITEA's 'Standards for Technological Literacy' which according to the OCTE website includes: "An understanding [of] the cultural, social, environmental, economic and political effects of technology" (OCTE, 2004). It is significant to note that the Ontario secondary technology curriculum makes no reference to either the political or cultural dimensions of technology. Major questions involving public policy concerning technology and the environment are inescapably political and connected to our cultural construction of sustainable technology practices. Whether the public policy issue is related to subsidies for alternative energy generation and public transit or carbon taxes for large gas guzzling vehicles, the sociopolitical dimensions of technology are central to any discussion of sustainability.

Even the 'Ontario Curriculum Exemplars' a grade 9 resource document of 'exemplary work' to guide teachers in the assessment of students, provides no mention of any dimension of technology and the environment. Despite the 'sustainability deficit' of the official Ontario curriculum, some of the curriculum support documents produced by and for teachers have addressed some important sustainability related issues. For example, the Construction Technology Grade 12 College Preparation (TCJ4C) states:

> Students need to understand the impact that materials, old and new, have on the environment and their community... Students should be aware of product development and the use of "green" measures when renovating or creating new structures. It is important that they have a fundamental understanding of their role as stewards of the environment (Public and Catholic District School Board Writing Partnership, 2002).

The support curricula produced by the Public and Catholic District School Board Writing Partnerships (2002; 2001) and OCTE do address some important issues like renewable wind and solar energy, topics completely overlooked in the official provincial curriculum (see table 1).

Discussion

Sustainability 'blind spots' are evident in all of the curricula reviewed in table 1. For example, the energy consumption of buildings is one of the largest sources of greenhouse gases, and one of the areas in which education concerning energy efficient technology could make a substantial contribution to reducing greenhouse gases and saving money. Toward that end, the Canadian R-2000 home building standard developed in 1982 reduces energy costs by 26 percent compared to conventional new home construction (Boyd, 2003). The R-2000 standard also improves air quality, reduces maintenance costs and costs only 4-6 percent more than the average new home. Despite these obvious advantages fewer than ten thousand R-2000 homes have been constructed in Canada in the last 20 years and only about 0.6 percent of recent housing starts involve R-2000 construction (Boyd, 2003:89).

Only the Saskatchewan curricula mentions the R-2000 standard asking students to: "Discuss R-2000 homes in relation to energy efficiency. How are R-2000 building standards different from homes built to regular building standards today?"(Saskatchewan Education, 1999:40). The Saskatchewan curriculum is also the only one which mentions climate change (global warming) in asking students to, "speculate about and discuss the impacts of technology, global warming, societal changes, and changing family demographics on future housing design".

Petrina (2000) has argued that the conventional design, problem solving and technological methods employed in technological education embody an unsustainable technocentric political ecology. A neoliberal political ecology which emphasizes efficient production and consumption of globalized product forms at the expense of environmental and social justice remains for the most part unexamined and unchallenged within technology education. In fact, evidence suggests that technology curricula over the last twenty years in Canada has uncritically incorporated a number of business and industry imperatives related to efficient 'just-in-time' skills, themes situated in "competitive supremacy and conservative politics" (Petrina, 2000; Elshof, 2000). Technology education is losing ground to traditional industrial education in British Columbia (Petrina & Dalley, 2003) and some evidence indicates a similar trend may be occurring in the senior secondary years in Ontario.

Fundamentally absent within Canadian technological education is evidence of an engaged critique of postmodern product culture and its environmental impacts. The 'criticism of technology' is one of the fundamental interdisciplines that Petrina identifies within multidisciplinary technology education:

> Criticism of technology extends from 'internal' design criteria to social philosophies of technology dealing with values embedded in technological practices and their contexts. It deals with ethics, regulation, responsibilities, and our relations with technology and technoscience... Criticism links studies of technology with strategies and visions for improving the design and practice of technology within sustainable contexts. The critic of technology asks fundamental questions about what a technology offers (perception and description), what it means with its embedded values (analysis and interpretation), and the technology's worth (judgement) (Petrina, 1998:123).

Noticeably absent from all of the curricula are specific reference to the pollution generated in the production of technological raw materials like plastics, metals and composites. Only a few of the documents even mention 'green materials' and none mention 'green procurement' as an important goal in the production of a product. The de-linking of pollution from economic growth is fundamental to sustainable development, and requires more "ecological transparency" in technological design and use leading to an increased understanding of how all human activities, processes and patterns impact sustainable development (Heinonen et al., 2001). Improving ecological transparency within technological education requires improving awareness of the both the impacts of technological products and processes on the environment, as well as increasing skill levels and capabilities in eco-design to minimize these impacts before they occur.

None of the curricula examined address or even mention the concepts of sustainable production and consumption. Also noticeably absent is any mention of the 'precautionary principle' as a guiding principle for the design and deployment of new technologies. Although waste minimization is a theme in several curricula, many only deal with waste 'management' or disposal, a typical 'end-of-the-pipe' solution. The increasing aggregate societal level of material consumption and material throughput in the economy and embodied in technological products is not treated as problematic in technology education. Bauman's asserts that our consumer society "proclaims the *impossibility* of gratification and measures its progress by ever-rising demand" (Bauman, 2001:12). Because materialism as a signifier of success and social well being shows no sign of abating in rich developed countries (Schor, 2004), it becomes even more of an imperative that future technological products and systems designed to meet this ever expanding 'plasticity' of consumer needs, be ecologically smart both in the short and in the long term. It also follows that technological education cannot continue to treat sustainability principles and thinking as an 'add-on' or at best an afterthought as it is generally now, instead ecological design must become a deeply embedded operational principle in all facets of technological education.

Missing as well is any mention of the problematic 'rebound effect', a major factor mitigating against sustainability. The 'rebound effect' has been defined as "the subsequent erosion of the positive potential of technological innovation by increases in overall activities, and the concomitant increase in consumption of material and energy" (Birkeland, 2002:129). The rebound effect essentially means that although improved energy and material efficiencies in one type of product/system, can lead to lower costs which in turn allow for increased spending on more products etc., thus effectively negating any net benefit in reducing overall consumption, and pollution reduction. For example, the environmental benefits accrued through the design of more fuel efficient vehicles is effectively negated if individuals spend more time driving or if the overall weight of vehicles increases because of luxury features. The average North American pickup truck is a case in point; it has become 40 percent heavier in the last two decades and 11 percent less fuel-efficient (Hakim, 2005).

Confronting the value-laden issues of lifestyle choice and materialistic images of the 'good life' as technological consumers is also critical to any progress on the sustainability front, as Huesemann states:

> Any hard won improvements in eco-efficiency will soon be negated if growth in population and consumption is allowed to continue. Consequently, long-term industrial sustainability can be achieved only through a transition to a steady-state economy where the total throughput of matter– energy is kept at a constant and sustainable level. This requires not only improvements in eco-efficiency but also a reassessment of fundamental societal values that erroneously equate material consumption and economic growth with well-being and happiness (Huesemann, 2004:264).

Claims such as: "Their study of manufacturing technology will prepare students for change and for making critical decisions regarding the future" (Ontario Ministry of Education, 2000:105), are exposed as baseless if students are not also taught about the need to fundamentally change our relationship to material use and the design of our product systems.

While it is undoubtedly true that some consideration has evolved for environmental concerns in Ontario technological education, major fundamental concepts related to sustainable practices continue to be conspicuously absent. There is no evidence of students being introduced to any broad 'systems principles' or frameworks for supporting sustainable technological practices. For example, the 'Natural Step' framework adopted by a number of major businesses across the globe states that in a sustainable society, nature is not subject to systematically increasing:

1. concentrations of substances extracted from the earth's crust;
2. concentrations of substances produced by society;
3. degradation by physical means and, in that society. . .
4. human needs are met worldwide (Robèrt et al., 1999).

Frameworks such as the natural step provide guidance in terms of thinking about whether a technological invention or system moves us toward or away from sustainability.

For McDonough & Braungart (2005:119) conventional industrial design is fundamentally flawed because it: "developed in a time when few understood the dynamic relationship between economy and ecology, or the principles of the earth's natural systems".
They argue that today's traditional manufacturing is built on a "cradle-to-grave" model that "generates products designed for a one-way trip to the landfill and incinerator" (McDonough & Braungart, 2005:119). If ignorance of ecological realities was an excuse for the inappropriate design and manufacturing epistemologies of twenty years ago, it is certainly less defensible today. We know much more about the fate of chemicals in the environment, bioaccumulation, natural system dynamics and the actual and potential biophysical limits of the earth's ecosystems. Although we may acknowledge on an abstract level that is impossible to have a healthy economy without a healthy sustainable environment, we often fail to ask systematically consider how our technologies are working both for and against our health and sustainability interests. Persistent organic pollutants (POP's) emitted from industries in southern Canada and the U.S. are found in the breast milk of the Inuit people and in the wildlife in Canada's arctic at levels 8-10 times higher than those of other Canadians. Toxin concentrations are so high in the beluga whales of the St. Lawrence River that their carcasses are officially designated as 'toxic waste'; these animals also have the highest incidence of cancer in the mammalian world. The global spread of toxic pollutants is largely attributable to the manner in which we generate energy and manufacture and dispose of products at the end of their life. The transborder international shipment of toxic wastes from production processes is a global problem and so is 'e-waste' and the disposal of throwaway electronic products. Despite the importance of these issues the word 'recycle' does not appear in any of the Ontario grade 11 & 12 computer and information science and computer engineering curricula or in any of the support curricula produced by teachers. However, the curriculum in the much smaller province of Saskatchewan (and with a much smaller e-waste problem) states that computer recycling is an issue students need to understand (Saskatchewan Learning, 2003). There is no good reason why all technological education students should not be aware of the global e-waste problem and also be engaged in thinking about clean manufacturing and zero-waste processes and issues as part of the solution.

Tukker (2004:247) defines a 'product–service system' (PSS) as consisting of "tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs". The PSS is designed to minimize the life cycle costs of product use and achieve a factor 4-10 sustainability improvement by design which examines as a starting point consumer needs rather than the product filling the need (Tukker, 2004:248). Engaging young people in product service systems involves helping them understand the social and technical logistics involved in producing and marketing innovations, and developing new concepts of product use. Since 30-40% of all environmental problems in developed countries can be linked to private households and domestic consumption, these concepts are crucial to shrinking our ecological footprint (Hirschl et al., 2003). It reintroduces the adages 'repair instead of throw away and 'borrow instead of buy' as important ideas in replacing products with services and extending the useful life of products.

Preparing Teachers

It is incumbent upon pre-service technological teacher education programs to address in substantive ways the problematics concerning sustainability and technology. In general the current models assume an 'osmosis' process occurs when it comes to sustainable practices. It tacitly assumes that because everyone 'knows' what the word 'environment' connotes, appropriate considerations will be afforded 'environment' when it appears in the curriculum. For example, for some the consideration of the environment in building construction practices may merely mean that construction wastes find their way into a disposal bin for the appropriate 'management of waste'. For others, more considered thinking about the environment may include the embodied energy of building materials, life cycle considerations and building with recycled materials. There is every reason to believe that the complexities and evolving concepts concerning sustainability and sustainable technological practices still represent a 'blind-spot' within teacher education.

The curriculum documents reviewed reveal no evidence of the metaphors of sustainable technology practices: 'ecological footprints', 'resource streams' and the 'technological wakes' described by Petrina (2000). Teaching and learning activities which encourage students to reflect upon the values and beliefs involved in the social and environmental context of technological activities are an important part of developing critical technological competence(Conway, 2000). Technological education needs to be concerned with not only the design of technical systems but also with eco-technical and sociotechnical systems as well (Ropohl, 1997:70).

The technological education community like the business community (Welford et al., 1998) has found sustainable development difficult to operationalize. This work has found that a patchwork of relationships exist between environment/sustainability themes and technological concepts across provincial curricula in Canada. Banks et al. argue that the "active intersection of subject knowledge, school knowledge and pedagogical knowledge…brings teacher professional knowledge into being" (Banks et al., 2004:144). Establishing a coherent sustainability framework within Canadian technological education will require efforts in all these areas if sustainable practices are to take hold. The UNESCO-UNEVOC discussion paper *'Orienting Technical and Vocational Education and Training (TVET) for Sustainable Development'* clearly identifies the need to focus on pre-service education:

> Principles and practices of sustainability must be added to both pre-service and in-service TVET Teacher/Instructor training, preferably prior to their introduction in

> TVET curricula and training institutions. Unless the culture of the TVET Teachers/Instructors is changed, sustainability may not be sustainable (UNESCO-UNEVOC, 2004:26).

Important research questions include concerning the role of the socialization of technological teachers in various facets of business and industry and their understanding and commitment to technological education for sustainability. Are individuals who have experience with companies/industries publicly recognized for their environmental excellence more likely to incorporate sustainability themes into their classroom work than those who have not shared this background? As Boyd observes in Canada there is a "disturbing gap between our strong environmental values and our poor environmental record" (Boyd, 2004: viii), we might consider the extent and nature of such a gap within technological education. What factors mitigate for/against curriculum leadership in this critical area and how might faculties of education address this shortcoming? What areas do practitioners identify as areas requiring the most emphasis, subject knowledge, school knowledge or pedagogical knowledge to bring sustainable practices into more classrooms? Research is also needed into how socialization processes and teacher's existing subject matter knowledge are shaped by personal environmental worldviews and paradigmatic worldviews shared by the profession. No systematic research is available which measures the extent to which pre-service teacher education programs address sustainable practices.

Advancing a discourse of sustainabilism within technological education and a coherent ecologically and socially reconstructive path toward changing the status quo will require the participation many stakeholders. John Dewey argued that technical education should emphasize:

> The development of such intelligence, initiative, ingenuity and capacity as shall make workers as far as possible, masters of their own industrial fate. ... The kind of vocational education in which I am interested is not one which will 'adapt' workers to the existing industrial regime ... but one which will alter the existing industrial system and ultimately transform it (quoted in Smaller, 2000:8).

In this spirit, the transformation of existing technological knowledge, skills, attitudes and practices toward more sustainable ones requires a new Pan-Canadian 'Eco-tech' initiative involving teachers, provincial education stakeholders, environmental groups, industry and faculties of education. Young people need to learn and internalize a new eco-technological perspective concerning the nature of the technological products, systems and built environment they produce. In short, young people need to be active participants in learning how technology can accelerate the transition from a linear waste intensive economy toward a more eco-efficient, cyclic and holistic 'eco-economy' (Brown, 2005).

It is important to emphasize that this overview is by no means exhaustive and that environmentally progressive and enlightened components exist in all the curricula examined. Some progress has been made toward incorporating sustainability thinking within technological education in Canada. However, relative to the magnitude of the sustainability problem we collectively face, the response over the last twenty years has been inconsistent, and fragmentary. While some important technology-sustainability issues have been addressed in some areas, there is little evidence to suggest that sustainability principles/thinking have been widely infused into the curriculum as a whole.

Much work remains to be done within Canadian technological education circles to help this process become reality. As the historian of technology Thomas Hughes points out we don't often grasp the large range of possibilities for creative action that technology offers:

> we are satisfied to see it used mostly for consumer goods and weaponry, not realizing that we are unconsciously and unthinkingly also using technology to create a human-built physical environment. We do not take responsibility for the aesthetic characteristics and quality of life in this human built world. In short, we do not understand the range of technology and our responsibilities for it (Hughes, 2004:153).

Bibliography

Alberta Learning (1997). Design Studies Career and Technology Studies. Edmonton, Government of Alberta.

Alberta Learning (1997). Enterprise & Innovation Career and Technology Studies. Edmonton, Government of Alberta.

Alberta Learning (1997). Management and Marketing Career and Technology Studies. Edmonton, Government of Alberta.

Alberta Learning (2004). Career and Technology Studies Strand and Course Descriptions. Edmonton, Government of Alberta.

Alberta Learning Curriculum Design Branch (1989). Trends and Issues Affecting Practical Arts in Alberta Secondary Schools. A Review of Research. Edmonton, Alberta Learning Government of Alberta.

Atlantic Provinces Education Foundation (2001). Foundation for the Atlantic Canada Technology Education Curriculum. Halifax.

Atlantic Provinces Education Foundation (2001). Foundation for the Atlantic Canada Technology Curriculum. Halifax, Atlantic Provinces Education Foundation.

Atlantic Provinces Education Foundation (2001?). The Atlantic Canada Framework for Essential Graduation Learnings in Schools. Halifax, Atlantic Provinces Education Foundation.

Banks, F., D. Barlex, et al. (2004). "DEPTH- Developing Professional Thinking for Technology Teachers: An International Study." International Journal of Technology and Design Education 14(2): 141-157.

Bauman, Z. (2001). "Consuming Life." Journal of Consumer Culture 1(1): 9-29.

Bauman, Z. (2004). Wasted Lives. Cambridge, Polity Press.

Bawden, R. (2004). Sustainability as Emergence: The Need for Engaged Discourse. Higher Education and the Challenge of Sustainability: Problematics, Promise and Practice. P. B. Corcoran and A. E. J. Wals. Dordrecht, Kluwer: 21-32.

BBC (2005). World population 'to rise by 40%'. BBC World News. London.

Birkeland, J. (2002). Design for Sustainability. London, Earthscan.

Boyd, D. R. (2001). Canada vs. the OECD: An Environmental Comparison. Victoria, Eco-Research Chair in Environmental Law and Policy. Available at www.environmentalindicators.com.

Boyd, D. R. (2003). Unnatural Law, Rethinking Canadian Environmental Law and Policy. Vancouver, UBC Press.

Boyd, D. R. (2004). Sustainability within a Generation: A New Vision for Canada. Vancouver, David Suzuki Foundation.

Brown, L. (2005). An Eco-Economy in Harmony with Nature. Environmentalism & the Technologies of Tomorrow. R. Olson and D. Rejeski. Washington, Island Press: 20-28.

Chinien, C. (2003). Skills to Last- Broadly transferable Sustainable Development Skills for the Canadian Workforce. A Technical Research Report Human Resources Development Canada. Winnipeg, National Centre for Workforce Development.

Coll, R. K., N. Taylor, et al. (2003). "Using Work-based Learning to Develop Education for Sustainability: a proposal." Journal of Vocational Education and Training 55(2).

Commissioner of the Environment and Sustainable Development. (2004). Report of the Commissioner of the Environment and Sustainable Development to the House of Commons. Ottawa, Office of the Auditor General of Canada.

Conference Board of Canada. (2003). Environmental Practice and Performance of Canadian Business and Industry. Ottawa, Conference Board of Canada.

Conway, R. (2000). "Ethical Judgements in Genetic Engineering: The Implications for Technology Education." International Journal of Technology and Design Education 10: 239–254.

Council of Ministers of Education, C. (1997). The Common Framework of Science Learning Outcomes, Pan-Canadian Protocol for Collaboration on School Curriculum. Toronto, Council of Ministers of Education, Canada.

Council of Ministers of Education Canada (1999). Educating for Sustainability: The Status of Sustainable Development Education in Canada. Toronto.

Cunningham, S. (2002). The Restoration Economy. San Francisco, Berrett-Koehler.

Dion, S. (2004). Environmental Action for Economic Competitiveness: Will Canada lead the new Industrial Revolution? A speech delivered to the Calgary Chamber of Commerce September 10, 2004. Ottawa, Environment Canada.

Elshof, L. (2000) Technological Education for Critical Citizenship or Consumerism? ‘Orbit’ ‘Science, Math & Technology Learning for All' Volume 31, Number 3, 25-29.

Elshof, L. (2000) Worldview Research with Technology Teachers unpublished Doctoral Thesis, University of Toronto.

Friedmann, S. J. and T. Homer-Dixon (2004). "Out of the Energy Box." Foreign Affairs 83(6): 72-83.

Gardner, P. L. and A. M. Hill (1999). "Technology Education in Ontario: Evolution, Achievements, Critiques and Challenges Part 2: Implementation and Evaluation." International Journal of Technology and Design Education 9: 201–239.

Gardner, P. L. and A. M. Hill (1999). "Technology Education in Ontario: Evolution, Achievements, Critiques and Challenges Part 1: The Context" International Journal of Technology and Design Education 9: 103–136.

Government of Canada. (2002). A Framework for Environmental Learning and Sustainability in Canada. Ottawa.

Hakim, D. (2005). Big Pickup Trucks Eclipsing S.U.V.'s. New York Times. New York.

Heinonen, S., P. Jokinen, et al. (2001). "The Ecological Transparency of the Information Society." Futures 33: 319-317.

Hill, R. B. and G. Dewey (2001). Moral and Ethical Issues Related to Appropriate Technology. Appropriate Technology for Sustainable Living, 50th Yearbook Council on Technology Teacher Education. R. C. Wicklein. New York, Glencoe McGraw-Hill: 78-91.

Hirschl, B., W. Konrad, et al. (2003). "New concepts in product use for sustainable consumption." Journal of Cleaner Production 11: 873–881.

Hoepfl, M. (2001). Design Criteria for Developing Appropriate Technology. Appropriate Technology for Sustainable Living, 50th Yearbook Council on Technology Teacher Education. R. C. Wicklein. New York, Glencoe McGraw-Hill: 92-112.

Homer Dixon, T. (2000). The Ingenuity Gap. Toronto, Random House.

Hughes, T. P. (2004). Human-Built World. Chicago, University of Chicago Press.

Industry Canada. (2003). Sustainable Development Strategy 2003–06. Ottawa, Industry Canada.

Lovins, A. B. and L. H. Lovins (2005). A New Age Resource Productivity. Environmentalism & the Technologies of Tomorrow. R. Olson and D. Rejeski. Washington, Island Press: 29-37.

McDonough, W. and M. Braungart (2002). Cradle to Cradle. New York, North Point.
Meadows, D., J. Randers, et al. (2004). Limits to Growth: The 30 Year Update. White River Junction, Vermont, Chelsea Green Publishing.

Meadows, D., J. Randers, et al. (2004). Limits to Growth. White River Junction Vermont, Chelsea Green.

Natural Resources Defense Council and S. C. o. Canada (2002). America's Gas Tank: The High Cost of Canada's Oil and Gas Export Strategy. Ottawa.

Ontario Council for Technological Education (2004). Real Knowledge. Real Skills. Real World. Campaign for Technological Literacy for All Students of Ontario. Ottawa.

Ontario Council for Technological Education (OCTE) (2001). Grade 11 TDJ3E Technological Design (Workplace Destination) Unit 3, Activity 2: Investigating the Life Cycle of a Product.

Ontario Council for Technological Education (OCTE) (2001). Grade 11 TMJ3E Manufacturing Technology (Workplace Destination) Unit 1 Activity 3 & 4 Project Management: Material Selection & Planning Production.

Ontario Council for Technological Education (OCTE) (2001). Grade 11 TMJ3E Manufacturing Technology (Workplace Destination) Unit 2 Activity 2: Conveyors – The Gumball Machine. Toronto.

Ontario Ministry of Education (1985). Technological Studies Intermediate and Senior Divisions, 1985 Part A Policy for Program Planning. Toronto, Ontario Ministry of Education.

Ontario Ministry of Education (1990a). Technological Education Consultatation Paper. Toronto.

Ontario Ministry of Education (1990b). The Way Ahead- a Working paper. Toronto.

Ontario Ministry of Education (1995). Ministry of Education Resource Documents. Toronto, Faculty of Education University of Toronto (FEUT) Technological Studies.

Ontario Ministry of Education (2000). The Ontario Curriculum Grades 11 and 12 Technological Education. Toronto, Government of Ontario.

Ontario Ministry of Education (2000). The Ontario Curriculum Exemplars Grade 9 Technological Education. Toronto, Government of Ontario.

Ontario Ministry of Education (1985). Technological Studies Intermediate and Senior Divisions: Part A Policy for Program Planning. Toronto, Ontario Ministry of Education.

Petrina, S. (2000a). "The Politics of Technological Literacy." International Journal of Technology and Design Education 10(2): 181-206.

Petrina, S. (2000b). "The Political Ecology of Design and Technology Education: An Inquiry into Methods." International Journal of Technology and Design Education 10(3): 207-237.

Petrina, S. and P. O'Riley (2001). Economics of Appropriate Technology. Appropriate Technology for Sustainable Living, 50th Yearbook Council on Technology Teacher Education. R. C. Wicklein. New York, Glencoe McGraw-Hill: 22-55.

Petrina, S. and S. Dalley (2003). "The Politics of Curriculum Reform in Canada: The Case of Technology Education in British Columbia." Canadian Journal of Science Mathematics and Technology Education 3(1): 117-144.

Public and Catholic District School Board Writing Partnerships (2002). Construction Technology Grade 12 College Preparation TCJ4C. Toronto, Government of Ontario.

Public and Catholic District School Board Writing Partnerships (2002). Course Profile Technological Design Grade 12 University/College Preparation TDJ4M. Toronto, Government of Ontario.

Public District School Board Writing Partnership (2001). Integrated Technologies Grade 9 Open. Toronto, Ontario Ministry of Education.

Public District School Board Writing Partnership (2001). Course Profile Integrated Technologies Grade 9 Open Units 3, 4, and 5. Toronto, Ontario Ministry of Education Government of Ontario.

Rees, W. E. (2002). "Globalization and Sustainability: Conflict or Convergence?" Bulletin of Science, Technology & Society 22(4): 249-268.

Reguly, E. (2005). Consumers should bear the brunt of Kyoto. Globe and Mail. Toronto: B2.

Robèrt, K.-H., J. Holmberg, et al. (1999). "The Ecological Footprint from a Systems Perspective of Sustainability." International Journal of Sustainable Development and World_Ecology **6**(1): 17-33.

Ropohl, G. (1997). "Knowledge Types in Technology." International Journal of Technology and Design Education 7: 65-72.

Schellnhuber, H. J., P. J. Crutzen, et al. (2004). Science for Global Sustainability. Earth System Analysis for Sustainability. H. J. Schellnhuber, P. J. Crutzen, W. C. Clark, M. Claussen and H. Held. Cambridge Mass, MIT Press: 1-28.

Schor, J. B. (2004). Born to Buy. Toronto, Scribner.

Smaller, H. (2000). Vocational Education in Ontario's Schools: Past, Present- and Future? North York Ontario, York University Labour Education and Training Research Network Centre for Research on Work and Society.

Speth, J. G. (2005). Creating a Sustainable Future: Are We Running Out of Time? Environmentalism & the Technologies of Tomorrow. R. Olson and D. Rejeski. Washington, Island Press: 11-19.

Speth, J. G. (2004). Red Sky at Morning, America and the Crisis of the Global Environment. London, Yale University Press.

Statistics-Canada (2004). Human Activity and the Environment: Annual Statistics 2004 16-201-XIE. Ottawa.

Statistics-Canada (2004). Environment Industry Survey Business Sector 2002. Report 16F0008XIE. Ottawa, Statistics Canada.

Tukker, A. (2004). "Eight Types of Product Service System: Eight Ways to Sustainability? Experiences from SUSPRONET." Business Strategy and the Environment 13: 246–260.

UNCED United Nations Conference on Environment and Development (1992). The Earth Charter. United Nations Conference on Environment and Development, Rio de Janeiro, Brazil.

UNESCO United Nations Educational, S. a. C. O. and ILO International Labour Organization (2002). Technical and Vocational Training for the Twenty-first Century. Paris, UNESCO Section for Technical and Vocational Education, Paris, Available online at : http://www.unesco.org/education/.

UNESCO-UNEVOC (2004). Orienting Technical and Vocational Education and Training (TVET) for Sustainable Development. A Discussion Paper Prepared by the UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training Bonn, Germany UNESCO International Experts Meeting Bonn, October 25-28, 2004 Learning for Work, Citizenship and Sustainability. Bonn.

United Nations Environmental Programme (UNEP) (2002). GEO 3 Global Environmental Outlook. Available online at: http://www.unep.org. Nairobi, Kenya, United Nations Environmental Programme.

United Nations. (2002). Report of the World Summit on Sustainable Development Johannesburg, South Africa, 26 August- 4 September 2002, United Nations.

Wackernagel, M., N. B. Schulz, et al. (2002). "Tracking the ecological overshoot of the human economy." Proceedings of the National Academies of Science **99**(14): 9266–9271.

Welford, R., W. Young, et al. (1998). "Towards Sustainable Production and Consumption: A Literature Review and Conceptual Framework for the Service Sector." Eco-Management and Auditing 5: 38–56.

WWF, World Wildlife Fund, United Nations Environmental Program. UNEP, et al. (2004). *The Living Planet Report*. Gland, Switzerland.

Yamazaki, S. and E. Savage (1998). "Views of Technology Education in Canada and the United Kingdom." Journal of Technology Studies Winter/Spring.

Table 1- Frequency – Context of Sustainability Issues within selected Canadian Curricula

	Product material Life Cycle Analysis (LCA)	Waste-pollution elimination In Design	Design for Recyclability	Climate Change	Energy-Efficiency and Renewables	Material Consumption and Consumerism as problematics	Sustainability and Sustainable Development
Ontario Grade 11 &12 Technological Education (2000)- 208 pgs	Not mentioned	21- 19 of which focus on 'management & disposal' issues not reduction or elimination - Pollution mentioned once	Not mentioned	Not mentioned	1-Solar Photovoltaics 0-(PV) 0-Wind Energy 1-Energy efficiency 7-Energy conservation-	Not mentioned	Not mentioned
Ontario Grade 9&10 Technological Education (1999) - 58 pgs		21-19 of which focus on 'management & disposal' issues not reduction or elimination. - Pollution not mentioned	1- "identify local systems that deal with recycling in the transportation industry"	Not mentioned	3-Energy efficiency 3-Energy conservation- 0-Solar 0-PV 0-Wind Energy	Not mentioned	Not mentioned
Foundation Document for Atlantic Canada Technological Education (2000) 48 pgs	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Three times

	Product material Life Cycle Analysis (LCA)	Waste-pollution elimination in Design	Design for Environment and/or Recyclability	Climate Change	'Energy-Efficiency' and Renewable Energy	Material Consumption and Consumerism as problematics	Sustainability and Sustainable Development
Alberta CTS Design Studies (1997) 283 pgs	Not mentioned	24 -emphasis on "minimizing" material waste	Not mentioned	Not mentioned	0-Solar 0-PV 0-Wind 0-Energy efficiency- 0-Energy conservation-	Not mentioned	Not mentioned
Alberta CTS Fabrication Studies (1997) 369 pgs	1-"select a manufacturing system based on life cycle and durability of a product".	11-Waste, 10 of which emphasize "minimizing"of waste	4-Recycling	Not mentioned	Not mentioned	Not mentioned	Not mentioned
Alberta CTS Construction Technologies (1997) 407 pgs	Life cycle- 2 "describe the life cycle of a typical product from the time of introduction to its decline"	17-Waste- "minimizing"of waste	4-Recycling	Not mentioned	1-Solar- "solar orientation" of buildings Wind energy- 0-PV 46-Energy efficiency-	Not mentioned	Not mentioned
Saskatchewan Design Studies 10, 20 Curriculum (2000) 56 pgs	Not mentioned	1-Waste	Recycle- once "Environmental impact should be considered when making choices: use of recycled materials"	Not mentioned	1-Solar Energy 1-efficiency 1-Energy conservation	Not mentioned	Not mentioned

	Product material Life Cycle Analysis (LCA)	Waste-pollution elimination in Design	Design for Environment and/or Recyclability	Climate Change	'Energy-Efficiency' and Renewable Energy	Material Consumption and Consumerism as problematics	Sustainability and Sustainable Development
Saskatchewan Housing 30 Curriculum (1999) 59 pgs	Not mentioned	1-Pollution- - "concern for the environment with land use, energy, pollution"	3- Recycle "Explore the changes in natural, manufactured, and recycled building materials"	1-"To speculate about and discuss the impacts of technology, global warming, societal changes... on future housing design."	37 -Energy efficiency & conservation-	1-Energy consumption	Not mentioned
Saskatchewan Construction and Carpentry 10, 20, 30 Curriculum (2000) 74pgs	Not mentioned	1- "To dispose of waste products in an environmentally sensitive manner".	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned
British Columbia Technology Education 8 to 10 *Integrated Resource Package* (1995) 160pgs	Not mentioned	22-minimizing waste: "examining processes and procedures used to minimize waste and to reuse products"	12- "Ask questions that lead students to consider minimizing waste and recycling material."	Not mentioned	8-energy efficiency & conservation 14- solar "Have students design and construct energy efficient devices 7-wind energy	2-consumerism	4- "Studies that integrate environment and sustainability themes provide students with opportunities to identify their beliefs and opinions, reflect on a range of views, and

	Product material Life Cycle Analysis (LCA)	Waste-pollution elimination in Design	Design for Environment and/or Recyclability	Climate Change	'Energy-Efficiency' and renewable energy	Material Consumption and consumerism as problematics	Sustainability and Sustainable Development
							ultimately make informed and responsible choices."
British Columbia 11 &12 Industrial Design *Integrated Resource Package* (1995) 157pgs	Not mentioned	13- waste reduction (8) Waste management (3)	2-"suggest possible methods of recycling or reusing Materials"	Not mentioned	4- "Have students interview field technicians who are responsible for energy efficiency in their companies, then make brief oral reports to the class" 3-wind energy	Not mentioned	7- "The term *sustainability* helps to describe societies that "promote diversity and do not compromise the natural world for any species in the future."
Course Profile Technological Design Grade 10 Open 102 pgs	0	5 Waste management Pollution (0)	4-Recycled "Students first build a prototype from recyclable materials in order to ensure their solution is viable."	Not mentioned	Not mentioned	Not mentioned-however some facet of meeting the needs and demands of the "consumer" in design is mentioned 28 times	Not mentioned
Technological Design	Not mentioned	13 -waste management (5)	1		25 71-Solar	Not mentioned Meeting	Not mentioned

Grade 11 University/College TDJ3M 59 pgs		Waste minimization (8)				demands of the "consumer" 17 times	
	Product material Life Cycle Analysis (LCA)	**Waste-pollution elimination in Design**	**Design for Environment and/or Recyclability**	**Climate Change**	**'Energy-Efficiency' and renewable energy**	**Material Consumption and consumerism as Problematics**	**Sustainability and Sustainable Development**
Course Profile Technological Design Grade 11 Workplace Preparation TDJ3E 56 pgs	7 Students are assessed on their ability to access and find information on the life cycle of a product	4 waste reduction Pollution 0	1	Not mentioned	Not mentioned	Not mentioned	Not mentioned
Course Profile Construction Technology Grade 10 Open (2000) 100pgs	Not mentioned	Not mentioned	10	Not mentioned	1Energy efficiency 1 energy conservation	Not mentioned	Not mentioned
Prince Edward Island Intermediate Industrial Technology Education Curriculum (2003) 42 pgs	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned