In Search of a Sustainable Future: An International Overview of the Contribution from Design and Technology Education

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RESEARCH

Introduction

In 1987 the World Commission on Environment and Development developed a definition of sustainability that was included in its report *Our Common Future*. This report stated that sustainable development 'meets the needs of the present generation without compromising the ability of future generations to meet their needs' (Brundtland, 1987, p. 40). Five years later, in 1992, the UN General Assembly asked for a report on progress and convened the United Nations Conference on Environment and Development (UNCED, 1992). The Rio Earth Summit declared that the right to development must be fulfilled in order to meet equitably developmental and environmental needs of present and future generations.

The purpose of this paper is to describe the extent to which design and technology education curricula in eight countries are teaching students to take into account, when designing and making products and services, the needs of the present generation without compromising a sustainable future. Do curricula emphasise sustainability? How effectively is sustainability addressed in schools within design and technology education?

The main body of the paper consists of contributions from the eight authors, who describe design and technology in their own country (or region) in terms of:

- its organisation;
- its core aims;
- the extent to which it encourages students to think about meeting the needs of the present generation without compromising a sustainable future;
- an example of good practice that relates design and technology education and sustainability and that could be adapted for use in other counties.

The reality is that internationally design and technology is diverse in all these aspects but, whether they have the backing of curriculum frameworks or not, design and technology educators in many countries are making significant efforts to help young people consider issues of sustainability when making decisions in the process of designing and making.

Australia

Organisation

In Australia the study of technology is guided by the generic term defined by UNESCO as 'the know-how and creative processes that may assist people to utilise tools, resources and systems to solve problems and to enhance control over the natural and made environment in an endeavour to improve the human condition'. Various titles have been adopted in different states (technology education, technological and applied studies, technology and enterprise) but they contain similar elements. Technology is defined broadly, and key common elements of the definitions include 'the application of knowledge and resources' and that it is used 'to extend human capabilities' (Williams and Kierl, 2001).

In New South Wales technology features in the curriculum for Primary level as Science and Technology (mandatory for students aged 5 – 11years), in Middle school as Technology (mandatory for students aged 12 – 16years) and to Higher School Certificate in Design and Technology (elective for students aged 17 – 18)

The term 'technology education' has many synonyms nationally. In most states of Australia, it is acknowledged that such a study is essential to operate in a technological future, where change is the norm and innovative thinking and flexibility are now required skills (Australian curriculum web sites, 2003).

Aims

The Australian Education Council (1989) set out *Common and Agreed National Goals for Schooling in Australia*. These goals give education systems and schools a common sense of purpose. Of particular relevance to technology programs are the following goals:

- To respond to the recurrent and emerging economic and social needs of the nation and to provide those skills which will allow students maximum flexibility and adaptability in their future employment and other aspects of life;
- To develop in students:
  - skills of analysis and problem-solving;
  - skills of information processing and computing;
  - an understanding of the role of science and technology in society with scientific and technological skills;
  - an appreciation and understanding of, and concern for, balanced development and global environment;

- a capacity to exercise judgement in matters of morality, ethics and social justice.

These goals were used in the development of *A Statement on Technology for Australian Schools* (Curriculum Corporation, 1994) All the educationally independent states and territories have established technology learning areas through the development of frameworks, curriculum and support material. The aims in each state, though worded differently, reflect the national goals.

An example – Schools For a Sustainable Future

The commitment to the Schools For a Sustainable Future (SFSF) project is directed by teachers seeing an opportunity to involve students in valuable experiences that reinforce student learning related to environmental sustainability.

As Design and Technology educators we take an ethical interest in the future we are going to create. Through the enthusiasm and hard work of their teachers and students, schools involved in the program have become environmental leaders. The task for the community now is to recognise their efforts and expand the vision for sustainable design projects.

SFSF aims to:

- support and promote schools working towards sustainability;
- support and promote business working towards sustainability;
- encourage sustainability to community, business, councils and schools;
- develop practical sustainability projects for schools that achieve educational (curriculum) and environmental goals;
- run projects in schools, providing 'hands-on' support for teachers.

In 1997 the Australian Catholic University became involved in the Schools For a Sustainable Future (2000) project through the 4th Year Environmental Education unit. The focus of this unit is Education for a Sustainable Future, and through the association with SFSF some of the pre-service teaching students were given the opportunity of working in SFSF primary schools, Figure 1, in partnership with teachers.

Figure 1: Oakleigh PS teacher Bev Clinton and ACU student Jonathan Auditore at Environmental partnerships in Action day ACU.

These pre-service teachers have been involved in a number of ways. For example, they have worked with teachers to develop waste reduction and energy audit programs, set up worm farms and developed a range of classroom activities with children from Prep to Grade 6. Their work in schools was integrated with their assessment for the unit whereby students kept a journal and reported on their involvement in the program.

All the students gained enormously from this hands-on experience in the schools. The schools also found the partnership beneficial as the student teacher was able to contribute to the class and share the load, rather than impose extra work on the teacher. The students were excited and encouraged by the enthusiasm of the children towards understanding and caring for the environment.

The Commonwealth Department of Environment, Sport and Territories funded a publication titled *Technology Education: An environmental perspective*. It stated 'Technology educators are in an ideal position to incorporate an environmental perspective into their teaching. One of the most effective ways to explore the environment is to use problem solving, the fundamental approach underpinning technology education' (King, 1997).

Botswana

Organisation

In Botswana, design and technology derives from contemporary developments in the UK. Separate courses in woodwork, metalwork and technical drawing were changed to 'Technology Studies' in 1988 and acquired the present title of Design and Technology in 1990 (Moalosi, 1999). It was then replaced by indigenous curricula and examinations (Botswana Ministry of Education, 1996, 2000) with the renovation of workshops and laboratories. Currently, optional course in design and technology enjoy an enviable status at 50 Junior Secondary Schools (JSS), being offered over three years to 5000 students and at 24 Senior Secondary Schools (SSS) over two years to 1500 students. This is a significant percentage in a country with a population of only 1.5 million, who are excited about its potential for enhancing development of the individual and society.

Aims

The stated core aims of D&T for the JSS level are to develop sound knowledge, skills and values to assess real-life problems in the community and to apply problem-solving skills by creative thinking, communicating, designing, manufacturing and entrepreneurial skills. The rationale is to empower students to become resourceful, self-reliant and economic participants in their communities.

Living in harmony with nature, Fig. 2, creates a sense of appreciation for the exquisite designs in nature. This is used as a source of inspiration for better designs by humans.

The aims of the D&T programme at the senior secondary school level are to acquire knowledge, confidence and ability to solve technological problems through applying concepts and principles of systems including mechanical, electrical and electronics through an understanding of materials, manufacturing processes environment, communication and entrepreneurial skills.

Emphasis is placed on linking technology and the world of work so that students can make use of the Government's Citizen Empowerment Development Agency (CEDA) programme of loans to establish industries. A recent survey on the achievement of the stated aims shows shortfalls, which are attributed to lack of qualified staff, inadequate time for different topics and low motivation of students.

Present needs and a sustainable future

The government of Botswana is committed to the 'Vision 2016', formulated following countrywide consultations and discussions by a Botswana Presidential Group (1997), to work towards an educated, informed and self-reliant nation. This is with a view to reducing the over reliance on diamonds and beef, which currently contribute 60% and 20% respectively to the national income. The Vision document dwells on sustainable growth and diversification with special reference to environmental sustainability, e.g., renewable resources and wildlife preservation. The same long-term goals are duly reflected in the Revised National Policy on Education (Botswana Ministry of Education, 1999) and the Industrial Policy for Botswana (Botswana Government Paper, 1998).

Design and technology is considered to be the panacea for the country's economic development and prosperity. The present generation of students is characterised by a lack of exposure to mechanical toys and gadgets at home and are without experience of 'Do It Yourself' (DIY) tools. D&T is therefore an important means of making them technology-literate, computer-literate, and design-minded. Far from compromising a sustainable future, the subject sows the seeds of a sustainable future. The aims at JSS level include student ability to 'demonstrate an understanding and appreciation of the effects of technology on society and the environment' and 'exercise value judgement of a moral/aesthetic and environmental nature'.

Likewise, aims at SSS level include that students 'be environmentally sensitive as they design and make products for the real world' and 'be aware of the link between technology and the real world'.

Botswana has been producing JSS teachers with a Diploma in D&T Education from the Molepolole College of Education and for SSS teachers with a Bachelor's Degree in D&T Education from the University of Botswana since 1985. Innovations in the revised UB curricula (Tanna and Kumar, 2002) pays special attention to a sustainable future by offering courses on *'Design, Technology and Society', 'Design for Sustainable Rural Development', 'Ceramics, Glass and Stone Technology'* and *'Environmental Factors in Design'*. We have also been keeping pace with the latest technology for teaching and learning at schools. (Kumar, 2002)

An example

We organise a full-scale biannual National Design and Technology Exhibition, Botswana (NDETEBO) at the country's prestigious fairground in Gaborone. It is usually inaugurated by the President of Botswana or by a Senior Minister in order to make news.

For all projects, criteria of evaluation include sustainability alongside function, suitability, innovativeness, ergonomics, aesthetics and strength. An example of a 'Sweets for Cans' design of a Can Disposer is shown in Fig. 3. The best stall and the best demonstration are also awarded prizes and citation. The exhibition is open to the public free of charge. It helps in building a technological culture in society and encourages younger students to opt for D&T by making them aware of the excitement of creating new things and warning them about the risk and consequences of ignoring sustainability.

This year, a University student designed a standpipe by working on the theme *Design for Water Conservation*. In doing so, he toured the countryside to see how water is wasted in everyday life, as demonstrated by the video clip that will be shown at the oral presentation of this paper. This clip will also be played at next year's NDTEBO exhibition.

Fig. 2 A view of the Game-City complex in the vicinity of the Kgale Hill, seen in the background

Fig. 3 A 'Sweets for Cans' Design of a Cans Disposer by a D&T School Student in Botswana

Table 1: Sustainability in canadian technology education curriculum.

Province	Number of occurrences of the term:	
	sustainable	sustainability
Alberta		
Elementary	0	0
Junior and Senior High School	0	0
Atlantic Provinces Education Foundation (New Brunswick, Nova Scotia, Newfoundland, Prince Edward island)	0	0
British Columbia		
K-7 Fine Arts and Applied Skills	0	0
Grades 8-10 Applied skills	0	0
Grades 11/12 Carpentry and Joinery	0	0
Grades 11/12 Automotive Technology	0	0
Ontario		
Grades 1-8 Science and Technology	3	4
Grades 9-12 Technological Education	0	1

Canada (Ontario)

Organisation

Describing and characterizing technology education in Canada is no simple matter. First, each province has jurisdiction over its own curriculum, standards, program delivery, graduation requirements, and finances (Gradwell and Welch, in press). Hence there is considerable variation in the programs. Second, the relative importance of technology education varies, as does the degree to which it is viewed as a required subject (Gradwell, 1999). Furthermore, while curriculum documents provide guidelines for teachers, technology teaching as practised in the classroom often varies considerably from these official statements.

Aims

For Grade 1 – 8 students in Ontario technology education is compulsory as part of a combined science and technology curriculum (Ontario Ministry of Education and Training, 1998). The intended purpose is wide-ranging, including providing:

> The scientific and technological knowledge and skills that will enable [students] to be productive members of society…. To develop attitudes that will motivate them to use their knowledge and skills in a responsible manner…. [To] … develop … skills that are … important for effective functioning in the world of work … [and] learn to identify and analyse problems and to explore and test solutions in a wide variety of contexts. (p. 3)

Two curriculum documents describe technological education for Grades 9 – 12. For Grade 9 students a compulsory course titled *Integrated Technologies* 'enables students to understand the technological and computer concepts they will need in order to design, develop, and build usable products or to deliver services' (Ontario Ministry of Education and Training, 1999a, p. 8). At Grades 10 – 12 the program is divided into a series of discrete technical subjects (Communications, Construction, Health and Personal Services, Hospitality and Tourism, Manufacturing, Technological Design, and Transportation). According to the documents 'technological education focuses on developing students' ability to work creatively and competently with technologies that are central to their lives' (Ontario Ministry of Education and Training, 1999b, p. 2).

Present needs and a sustainable future

The terms 'sustainable' and 'sustainability' appear very infrequently in technology education documents in Canada. Table 1 shows the results of a search of web-based curriculum documents for a representative sample of provinces.

As shown above the term 'sustainable' appears only three times and the term 'sustainability' only four times in the lists of learning expectations for the Grade 1 – 8 course in Ontario. An introductory overview of the document states that 'students' understanding of the concept of sustainability is stressed in a variety of contexts' (Ontario Ministry of Education and Training, 1998, p. 5). These contexts include the 'sustainability of ecosystems' (p. 27), 'the importance of fresh and salt water to the sustainability of life on earth' (p. 103), and 'managing [the earth's water systems] for sustainability' (p. 103).

The terms 'sustainable' and 'sustainability' appear only once in the lists of learning expectations for the Grade 9 – 12 courses. This single occurrence appears in the Grade

10 Hospitality and Tourism Technology course, in which one learning expectation reads 'students will explain the challenges of environmental sustainability in ecotourism' (Ontario Ministry of Education and Training, 1999a, p. 35).

An example

Because sustainability is not emphasised in curriculum guidance, it is rare in technology education in Ontario. However, a three-year project based at the Faculty of Education, Queen's University has developed and recently made public curriculum materials designed to address this issue. The Elementary Science and Technology project (Welch et al., 2000) has developed a suite of curriculum units to help teachers acquire both subject and pedagogic expertise in science and technology. Each unit contains a section entitled *Looking at Values*, which encourages teachers to emphasise to students that making design decisions involves making value judgements (Welch, 2002). These judgements may relate to aesthetic, technical, economic, environmental, social and moral values factors.

England

Organisation

Design and technology was established as a foundation subject in the English national curriculum in 1990 as a required area of study for all students in maintained i.e. non-private schools between the ages of 5 and 16. From 2005 (Department for Education and Skills, 2003), design and technology will cease to be compulsory after the age of 14, but schools will still be required to enable these students to study it if they so choose.

Aims

The stated aims and rationale of design and technology (Department for Education and Skills, 2000) are:

> 'Design and technology prepares pupils to participate in tomorrow's rapidly changing technologies. They learn to think and intervene creatively to improve quality of life. The subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems. They combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices. As they do so, they reflect on and evaluate present and past design and technology, its uses and effects. Through design and technology, all pupils can become discriminating and informed users of products, and become innovators.'

The provision of design and technology is very variable. There are many examples of good practice; equally there are many primary schools that ignore design and technology and secondary schools with provision that is little more than handicrafts.

Present needs and a sustainable future

Over the last 40 years, major efforts have been made to improve and modernise design and technology and to extend it beyond its manual and domestic craft roots. These efforts have involved two (not always congruent) trends:

- modernisation of the process of design and technology, with an increased recognition of the importance (with both pedagogic and post-educational benefits) of design (Eggleston, 1988),
- modernisation of the content of design and technology with a growing emphasis on aspects such as Information and Communications Technology, systems and control and modern materials and processes.

The national curriculum does address the issue of sustainability. For example, students aged 11 to 14 are expected to be taught to:

> 'Identify and use criteria to judge the quality of other people's products, including the extent to which they meet a clear need, their fitness for purpose, whether resources have been used appropriately, and their impact beyond the purpose for which they were designed (for example, the global, environmental impact of products and assessment for sustainability).' (Department for Education and Skills, 2000)

The attainment targets (assessment framework) briefly mention 'the appropriate use of resources' as one criterion students are expected to consider in evaluating their own products. The reality in schools is that sustainability is not widely addressed in design and technology.

An example

The Intermediate Technology Development Group (ITDG) was founded in 1966 by Schumacher, the author of 'Small is Beautiful' (Schumacher, 1973). ITDG's Development Education unit produces a range of resources and support, notable among which is the Sustainable Technology Education Project (1999) web site. This site is mainly geared towards design and technology teachers in the UK who are looking for ways

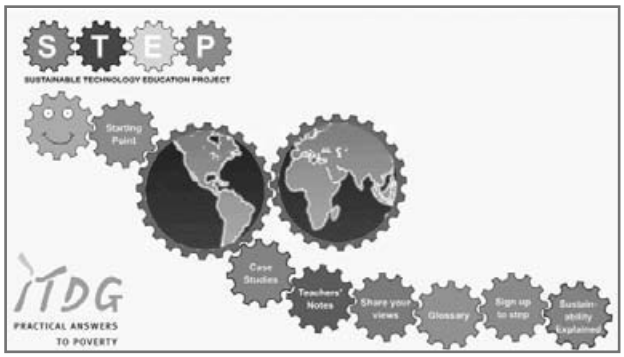


Fig. 4 A screen capture from the Sustainable Technology Education Project website

of stimulating students to think about sustainability in their work. The STEP web site currently attracts about 8,000 'hits' per month.

The web site includes 22 case studies, spread across the 'focus areas' of resistant materials, food technology, systems and control, graphic products and textiles technology. Each of the case studies follows a common format with:

- background information
- details of how people in a developing country have addressed the need
- a careful evaluation of the sustainability of the approach adopted
- ideas for classroom activities and projects, related to the case study
- hotlinks to websites with further information

Hong Kong Special Administrative Region, China

Organisation

Formal technical education in Hong Kong can be traced back to the 1920s. From the 1930s to the early 1970s, educational goals were simple. Students were trained in skills, in the form of apprentice training, which met the needs of local industry.

To promote creativity in students a new subject, Design and Technology, was introduced in mid-1975 and implemented concurrently with conventional technical subjects for secondary level students (aged between 11 and 17 years). There is no formal design and technology subject for primary level students. In 1975, D&T was offered to Secondary Four students who had taken Woodwork and Metalwork, and as a new subject to Secondary One students. The subject has been offered until now, although the syllabus has been revised several times (Siu, 2002).

D&T is not a compulsory subject in Hong Kong. Schools can determine their curriculum under the School-Based Management (SBM) arrangement, in which the Education and Manpower Bureau delegates authority to schools. Thus, 'recommended subject' would be a better description for D&T. Today, about half of secondary schools (225 schools) offer D&T in Secondary One to Three, and 43 schools offer the subject at the senior level.

Advanced Supplementary Level D&T is available in Hong Kong for Secondary Six and Seven students in four prevocational and technical schools. To provide a different D&T curriculum to suit the needs of different types of schools, the D&T (Alternative Syllabus) is now offered in 22 schools. This curriculum is more technology-oriented in that more advanced facilities are required, and schools have the freedom to opt for it if they can provide the resources and facilities. The implementation of the curriculum started in 2000 and the outcome is still being reviewed.

Aims

The core aims of D&T in Hong Kong are to foster and develop the creative, intellectual, and technical abilities of students through the use of materials and the application of technological knowledge (Hong Kong Examinations and Assessment Authority, 2002a, 2002b).

Design and Technology is expected to enable students to achieve technological literacy through the development of:

- technological knowledge and understanding,
- communicating and problem-solving capabilities,
- technological capability, and
- an understanding and awareness of the relationship between technology and society.

The technological design process is considered central to such development (Hong Kong Examinations and Assessment Authority, 2002a, 2002b).

Before the 1980s, teaching and learning activities in many of the schools offering this subject focused on the technical aspects. Due to a revision of the curriculum and the examination syllabus, as well as to new teacher training methods, more attention has been put on the design and thinking elements (Siu, 1997, 2000). Activities are more flexible and more variety is provided for the students.

Present needs and a sustainable future

'Sustainability' has not been a key concern in the D&T curriculum in Hong Kong, although some teachers assign projects related to the topic and some extra-curricular activities are conducted to arouse environmental awareness in students.

The syllabi for Design and Technology contain hints of concern over environmental issues. For example, students are required to explore the characteristics of different kinds of materials and their influence on the environment, as well as the environmental impact of modern technology on society, and describe ways in which technological advances may be accompanied by negative side effects (Curriculum Development Council, 2000a, 2000b). They are also asked to consider the importance of 'design for the environment/green design' (Curriculum Development Council, 2000b), and relate the design and make process to the impact of technological development in society as well as the environment (Hong Kong Examinations and Assessment Authority, 2002a, 2002b, 2002c). However, as no concrete requirements and detailed suggested elements are provided in the curriculum and because it is also difficult to make the study of the environment a compulsory examination requirement, many teachers are not serious about requiring their students to pay attention to this issue.

Nevertheless, in recent years, there have been some positive changes. Some questions in the public examinations have placed an emphasis on 'environmental concerns.' This, in turn, is causing teachers and students to pay more attention to this issue.

An example

There are no particular regular content or activities that schools in Hong Kong have to include in the curriculum to encourage sustainability. Some teachers try to increase awareness by requiring students to engage in projects related to environmental issues; for example, projects about environmentally friendly shopping bags, holding creative design competitions by using used materials and/or rubbish, and holding energy-conserving mobile toy-car races. The positive implication of these kinds of activities is that students enjoy 'design-and-make oriented' activities. Through these activities, students can gain insight into and experience of the importance of sustainability.

However, these activities are still insufficient to cultivate broad and in-depth levels of understanding, investigating, designing and evaluating. Moreover, as mentioned, all of these activities are still conducted in quite a piecemeal manner. Public examinations also do not make sustainability a compulsory topic in the syllabus, although individual examiners will sometimes set questions related to environmental issues.

The author of this section of the paper was the Chief Examiner of the D&T design paper (AS and CE levels). His experience indicates that making sustainability one of the design and project elements in the examination syllabi (including CE, AS and Alternative Syllabi) will certainly encourage, even force, teachers and students to spend more time considering the issue. This kind of compulsory requirement can also foster a habit in students of showing concern for their future living environment in their design assessments and projects.

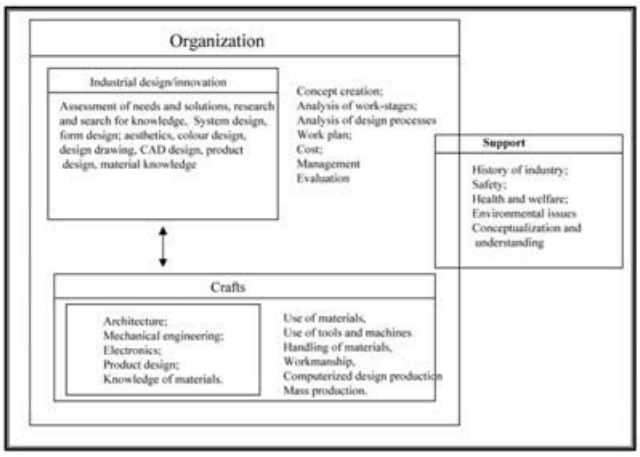


Fig. 5 A schematic of the curriculum components of Design and Craft.

Iceland

Organisation

The Ministry of Education re-established the old Icelandic Craft subject as a new subject in the National Curriculum in 1999 and called it 'Design and Craft.' The National Curriculum Guidelines came into full effect during the school year 2002-2003 and 'Design and Craft' became an obligatory subject.

The subject Design and Craft is subdivided into four areas: Planning and Organization, Design and Innovation, Hand Crafts and Technical and Support. For each age level, students are supported within these four main areas. Throughout Iceland, Design and Craft is a compulsory subject for all Grades 1 – 8 students but is optional for Grades 9 – 10.

Aims

The main feature of Technology Education is that it is inter-disciplinary; the emphasis is on problem solving and the acquisition of techniques and working methods that students can use as tools.

The purpose of Design and Craft in Iceland is wide-ranging, but includes developing in students:

- an understanding of the nature of modern technology, how it is used in our society, its meaning and influence on the environment;
- a positive attitude towards innovation and its use;

- enterprise, initiative, courage and inventiveness to solve problems and find solutions to daily needs.

Present needs and a sustainable future

The national curriculum for Design and Craft puts emphasis on environmental sustainability. The main focus is on using technology to modify the environment through innovation. Working with their ideas builds up the student's initiative, creativity and power of creation and the children discover themselves to be the creative power in their environment (Thorsteinsson, 2000). The student should understand the importance of human cooperation and social responsibility when solving environmental factors, such as pollution and safeguarding nature.

In the rationale for the subject of Design and Craft we see the following:

> 'In Design and Craft the student will be trained to bring his ideas to material reality with traditional technology and knowledge that already exists in the subject. This procedure builds on a classical skill that every generation must have. This means proper use of the material world that shapes the environment. By making our ideas come true in the material world we adjust the environment to our common needs. The subject Design and Craft is therefore an excellent way to get the student to think about and care for their environment through real work.'
> (A_alnámskrá grunnskóla, 1999)

An example

Entrepreneur sustainability in human life is a major concept in the national curriculum. Through creative work we can maintain the initiative and creativity that is necessary to sustain the quality of human life for the future. We need a strong economy kept up by entrepreneurs and people ready to support society with their creativity in a humanistic manner.

The Young Inventors Competition became an annual event in 1991. The main theme of this competition has been to encourage young students to tackle work within the framework of innovation. Another goal has been to point out the benefits of innovation to the grade schools with a view towards future graduates and their career options. The Innovation Competition is advertised yearly in all the grade schools and introduced to the students. Participating students send in a drawing and a description of their idea. These are subsequently categorized and judged by a special previewing panel. The panel is made up of specialists in the field of invention and design. The emphasis on chosen entries is on those ideas that have originality, are of value to society and appear to have potential market value. The Association of Design and Craft teachers has set up a show of all the prototypes, posters and models the students have made in school for the competition. Over the last few years over 3000 ideas have been entered from children all around the country, and many prototypes have been displayed (Thorsteinsson, 1998, p303-323).

Israel

Organisation

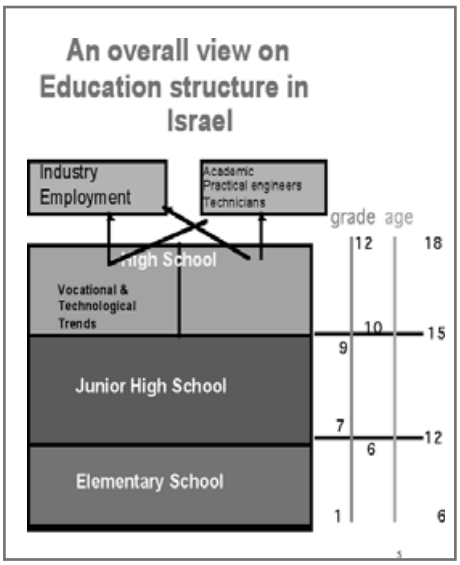


Fig. 6 An overall view

There is wide agreement in Israel that scientific and technological literacy should be provided to every student at each level of his or her education. Accordingly, *technological literacy for all* is implemented as an integrated subject with science, aimed at 1.3 million students in Israel from kindergarten to grade 12. The curricula for elementary, middle and high schools are based on relationships (co-ordination/collaboration/integration) between science and technology and emphasize an STS approach.

In addition, a *technology education* framework exists in high schools (grade: 10 – 12 age: 16 – 18) aimed at specializing in technology-related subjects (electronics, mechanics, management and others). Approximately 40% of students in high school study in a vocational framework.

Aims

> 'The new integrated curriculum (Science and Technology) reflects the connection and mutual impacts between science and technology in modern society. Collaboration between science and technology is essential because of the growing linkage between scientific

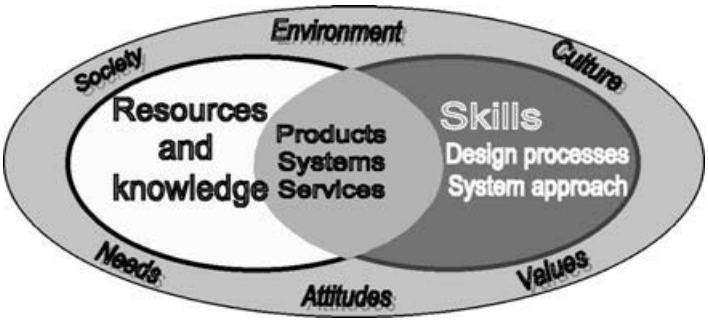


Fig. 7 The technology literacy space

> subjects and relevant technologies and also because of the unclear borders between them.' (Ministry of Education, 1996)

The seven main subjects of the science and technology curriculum for junior high school are: materials, energy, technology systems and products, information and communication, earth and the universe, creatures and life, and ecology systems.

Based on the rationale and the subjects mentioned above, and in order to implement such collaboration, we illustrate the technology literacy space in Figure 7.

It is quite difficult to evaluate on a national level the extent to which these aims are achieved since no assessment processes on a national level had been published.

In many schools students study the topics: design, and systems in 7 and 8 grade (using textbooks, laboratory activities and websites).

In spite of being an 'integrated subject' (science and technology), implementation faces many difficulties. In most schools science and technology are taught as separate subjects (there are some schools in which technology education does not exist at all). In a few schools teams of science and technology teachers are developing there own collaborative curricular materials, some with a scientific literacy orientation, a few with a technology literacy orientation.

Present needs and a sustainable future

Science and Technology is an integrated subject based on a STS approach. 'Environment and sustainability' themes are part of the curriculum. The following are examples of statements from the national curriculum (Ministry of Education, 1996):

> 'This approach (STS) shall be applied as an approach to defining human-social needs and problem solving in order to improve quality of life'
>
> 'Developing awareness and capability to preserve the environment'
>
> 'Understanding human involvement with the environment and nature'

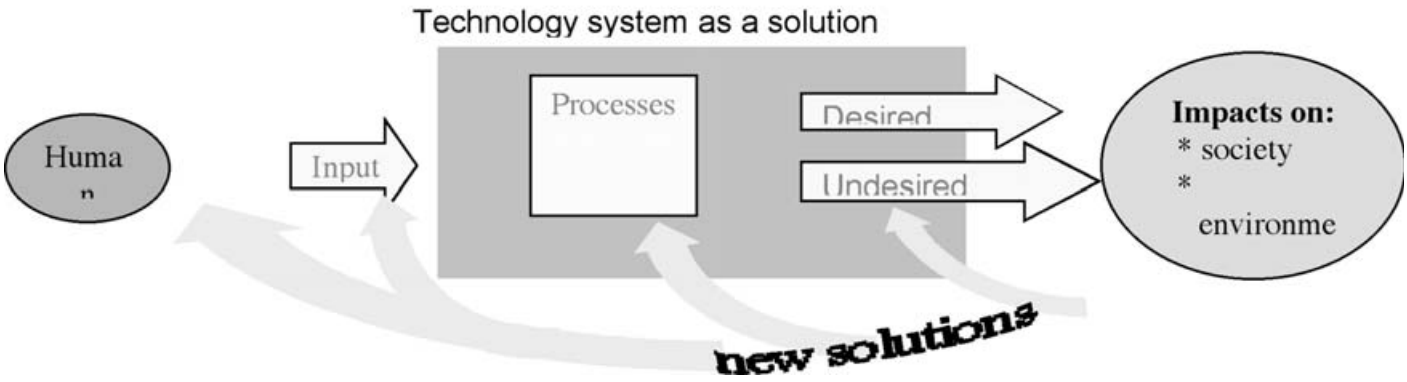
As part of implementing these aims, we (in the ORT – Organization for educational Resources and Technological training – development centre) developed a methodological approach – the system approach (Figure 8).

This approach serves as a curriculum organiser for learning about technology systems, as well as understanding the relationship between society and technology.

An example

Through learning about transportation and manufacturing as a technological system, the students (grade 8 – 9) are challenged to think about the impact of these systems (air and water pollution, health problems, noise, recycling materials). Focusing on pollution,

Fig. 8 A conceptual framework for teaching technology-society interaction.



Desalination system

Water power station

Fig. 9 Examples of simple technological systems

students have the task of designing a car that does not pollute and have to evaluate different solutions. With regard to manufacturing systems, students evaluate the impact of different power stations (grade 6) and use recycled materials for designing packages (grade 8).

Scotland

Organisation

Linguistic confusion surrounding terminology matches the uncertainty concerning the exact nature of Design and Technology education in Scotland. The Scottish Consultative Council on the Curriculum's 1996 document, which forms the bedrock of the curriculum in Scotland, refers to the subject as Technology Education. HMI on the other hand, writing three years later, refer to Technical Education. Within the literature it is referred to variously as Technology Education (Bain, 1999; Learning and Teaching Scotland, 2000) or Technical and Vocational Education (Clark and Munn, 1997). This is no mere semantic quibble: the perception of technical education is largely functional, occupational and about the development of craft skills; whilst technology is viewed as future orientated, inventive and about the creation of a sustainable future.

This confusion is manifest in the fact that Design and Technology Education in Scotland is taught as a range of discrete subjects and modules in two departments. Craft and Design, Graphic Communication, Technological Studies and Practical Craft Skills are all taught in the 'Technical Department', whilst the study of food and textiles is taught in Home Economics.

It is important to note that the curriculum in Scotland is not prescribed, but rather, based upon National Guidelines. Head Teachers and Principal Teachers can thus design the curriculum based upon what they perceive local needs to be. On the downside, however, not all subjects need be taught.

Aims

The core aims of technology education are grounded in a perceived need to 'develop a motivated, flexible and highly skilled workforce' (Scottish Consultative Council on the Curriculum, 1996, p. 1). Within the curriculum the four areas of technological perspective, confidence, sensitivity and creativity, constitute the concept of Technological Capability (Scottish Consultative Council on the Curriculum, 1996). The development of young people's Technological Capability is considered a major aim of technological education (Her Majesty's Inspectors, 1999) and is defined as:

- an understanding of people's material needs and wants;
- imaginative and enterprising application of knowledge and skills;
- an understanding and engagement in design processes, evaluation, decision making, planning, manufacturing and marketing;
- an ability to cope creatively with complexity and conflicting demands and constraints such as economic, aesthetic, political, ethical and environmental, as well as ergonomic, technical and scientific.

These aims should be realised through the 'design – make – evaluate' sequence of processes. Students should gain direct experience of the design process through active engagement (Her Majesty's Inspectors, 1999). Thus the philosophical basis of technological education in Scotland is based upon the principle of learning through activity (Engeström, 1999).

Present needs and a sustainable future

For primary aged children in Scotland, technology education falls within the curricular area of Environmental Studies, which includes social subjects as well as the sciences. However, there is a dichotomy between policy and practice here.

Whilst the rationale behind technology education seeks to actively involve students in understanding the multifarious ways that technology affects society by making, '…better informed decisions and act[ing] in ways that are sensitive to environmental issues and consistent with the idea of sustainable development' (Learning and Teaching Scotland, 2000, p.3), the practice tends towards practical craft skill procurement. (Dakers, 2001; Dakers and Dow, 2001).

An example

A Scottish Government initiative on formative assessment based upon the Black and Williams 'Inside the Black Box' research (Black and Williams, 1998) is currently being piloted in some schools. This will provide an opportunity for technology departments to move assessment away from the current system where emphasis tends to be given to teaching and measuring craft performance, on to a system which sees learning goals as the way forward (Dweck, 1999). Here, more emphasis will be given to developing informed attitudes where technology education's role will be seen as 'fostering

young people who are reflective, caring, and aware of their responsibilities as citizens and as stewards of a sustainable global environment.' (Learning and Teaching Scotland, 2000, p. iii)

General thoughts and reflections

Given the diversity of the international picture it would be dishonest to pretend that we are able to reach clear conclusions based on well-tried and extensive experience. The following thoughts are offered partly on the basis of our varied experiences and partly on the basis of (hopefully realistic) conjecture.

Sustainability is a dynamic condition that requires a basic understanding of the interconnections and interdependency among ecological, economic and social systems.

Both the Brundtland and Rio reports stressed that if sustainable development is to be successful, the attitudes of individuals with regard to our current lifestyles and the impact they have on the environment will need to change. Achieving sustainability will require technological and social change. Technology Education can make a significant contribution to enacting this change. Making design decisions, a central activity when students are designing and making products and services, involves making value judgements. Making these judgements is an ongoing process that will permeate students' work. Teachers should engage students in thoughtful discussion that will help them make decisions that are important to them and eventually to society. By balancing technical, economic, aesthetic, environmental and moral criteria, students will be able to make decisions based on issues of sustainability. Personal, social and cultural priorities will impact these value judgements students are making.

A democratic society requires each student to become an informed citizen who will use his or her knowledge and value system when making decisions about technology in settings outside the school. Students must be helped to conceptualise what values are and how these values might impact their life, both now and in the future.

In the authors' views, key priorities for strengthening the contribution of design and technology education to sustainability are:

1. The issue of sustainability needs to be addressed in national/regional curriculum frameworks and assessment specifications.

Probably the most striking pattern to emerge from the short summaries of the situations in various countries is that sustainability is being addressed most widely in those countries/regions where it is highlighted in curriculum frameworks.

2. Teacher education needs to be reinforced in this area.

Addressing sustainability in anything more than a superficial manner requires knowledge and thought on how to enable young people to appreciate the relevance of the issues; it therefore implies teacher education.

3. As an international community of design and technology educators, we should adopt the slogan 'Think globally, act locally' by implementing activities and resources designed to relate students to their communities and technological systems and choices.

Young people are most likely to respond to issues of sustainability that they can see as relevant to their own communities. While the general issues are global, many of the examples cited above focus on specific local needs and problems.

4. Design and technology does not have a monopoly over sustainability in the curriculum; links and collaboration with geography, science etc. are important.

Sustainability, more than almost any other issue, is 'holistic' in the sense that it relates to a wide range of educational, economic, life-style issues and values.

5. At suitable points in their design and technology education students should be exposed to activities where sustainability is highlighted – it should not be simply a minor afterthought in all activities, with token recognition.

Necessarily, there is a wide range of issues that young people need to consider when designing and making. It is unrealistic to address all of them simultaneously in significant depth.

6. Sustainability should be a 'standard agenda item' for design and technology education conferences.

We will only move to a sustainable future by sustained long-term effort, both individually and collectively.

A key element in securing a sustainable future is teaching students the knowledge and skills essential for their role as caretakers of the environment for future generations.

The authors of this paper welcome the opportunity for international collaboration.

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References

A_alnámskrá grunnskóla (1999) *Hönnun og smí_i*, Menntamálará_uneyti_

Australian curriculum web sites (2003):
New South Wales www.boardofstudies.nsw.edu.au/writing_briefs/index.html;
Queensland education.qld.gov.au/public_media/reports/curriculum-framework/html/download.html;
South Australia www.ssabsa.sa.edu.au;
Tasmania www.tassab.tased.edu.au;
Victoria www.vcaa.vic.edu.au/csfcd/;
Western Australia www.sea.wa.edu.au/pages/framework/framework11.htm

Australian Education Council (1989) www.curriculum.edu.au/mceetya/discpap.htm

Bain, M. (1999). *Technology education.* In T. G. K. Bryce, and W. H. Humes (Eds.), *Scottish education* (pp. 562-567). Edinburgh: Edinburgh University.

Black, P., and Williams, D. (1998). *Inside the black box: Raiding standards through classroom assessment.* London: King's College, School of Education.

Botswana, Government Paper (1998). *Industrial Development Policy for Botswana*, Government Paper No. 1 of 1998, Ministry of Commerce and Industry, Gaborone, Botswana.

Botswana Ministry of Education (1996). *Design and Technology: Three-Year Junior Certificate Programme*, Curricula Development Division.

Botswana Ministry of Education (1999). *Excellence in Education for the New Millennium, A* Comprehensive Report on the Implementation of the Revised National Policy on Education, Ministry of Education, Gaborone, Botswana.

Botswana Presidential Group (2000). *Botswana Generla Certificate of Secondary Education Teaching Syllabus, Design and Technology,* Curriculum Development Division, Gaborone, Botswana.

Botswana Presidential Group (1997). *Vision 2016: Towards Prosperity for All, Long-Term Vision for Botswana,* Presidential Group, September 1997, Gaborone, Botswana.

Bruntland, G. (1987). *Our common future: The World commission on environment and development.* Oxford: Oxford University.

Clark, M. M., and Munn, P. (1997). *Education in Scotland: Policy and practice from pre-school to secondary.* London: Routledge.

Curriculum Corporation (1994) *A Statement on Technology for Australian Schools.* Curriculum Corporation, Melbourne.

Curriculum Development Council. (2000a). *Syllabus for Secondary Schools Design and Technology (Secondary 1-3).* Hong Kong: Curriculum Development Council.

Curriculum Development Council. (2000b). *Syllabus for Secondary Schools Design and Technology (Secondary 4-5).* Hong Kong: Curriculum Development Council.

Dakers, J. (2001). *Primary teachers confidence in delivering technology education.* In C. Benson, M. Martin and W. Till (Eds.), *Third International Primary Design and Technology Conference* (pp. 50-54). Birmingham: University of Central England.

Dakers, J., and Dow, W. (2001). *Attitudes of secondary teachers of technical subjects and home economics towards curricular continuity at the transition between primary 7 (11 years) and Senior 1 (12 years).* In C. Benson, M. Martin and W. Till (Eds.), *Third International Primary Design and Technology Conference* (pp. 46-49). Birmingham: University of Central England.

Department for Education and Skills (2000). *The National Curriculum for Design and Technology.* London: Her Majesty's Stationary Office and www.nc.uk.net

Department for Education and Skills (2003). *14 – 19 Opportunity and Excellence,* London: Her Majesty's Stationary Office and www.dfes.gov.uk/14-19/

Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality and development.* Philadelphia: Psychology Press.

Eggleston, J. (1988). *The best of craft, design and technology.* Stoke-on-Trent: Trentham Books.

Engeström, Y. (1999). *Activity theory and individual and social transformation.* In Y. Engeström, M. Reijo, and P. Raija-Leena, (Eds.), *Perspectives on activity theory.* Cambridge: Cambridge University.

Gradwell, J. B. (1999). *A Canadian perspective on vocational education and training.* In A. J. Pautler (Ed.), *Workforce education: Issues for the new century*, (pp. 241–252). Ann Arbor, MI: Prakken.

Gradwell, J., and Welch, M. (in press). *Technology education in Canada: A mosaic. Canadian Journal of Science, Mathematics and Technology Education.*

Her Majesty's Inspectors. (1999). *Effective learning and teaching in Scottish secondary schools: Technical education.* Edinburgh: Her Majesty's Inspectors of Schools.

Hong Kong Examinations and Assessment Authority. (2002a). *Design and Technology Syllabus, CE Level (2004-CE-D&T).* Hong Kong Examinations and Assessment Authority.

Hong Kong Examinations and Assessment Authority. (2002b). *Design and Technology, CE Level, Alternative Syllabus (2004-CE-D&T (ALT)).* Hong Kong Examinations and Assessment Authority.

Hong Kong Examinations and Assessment Authority. (2002c). *Syllabus: Design and Technology – Advanced Supplementary Level.* Hong Kong Examinations and Assessment Authority.

King, Julie (1997). *Technology Education: An Environmental Perspective*. Technology Education Federation of Australia (TEFA) Web site www.pa.ash.org.au/tefa/TEFAdest.html

Kumar K.L. (2002). *Impact of New Technology on the Teaching and Learning in Technology Education,* DATA International Research Conference, 2-5 July, 2002.

Learning and Teaching Scotland. (2000). *Environmental studies: Technology. 5-14 National Guidelines*. Dundee: Learning and Teaching Scotland.

Moalosi R. (1999) *A Historical Perspective of Traditional Technical Subjects in Botswana*. The Journal of D&T Education, Vol. 4, Number 2, 1999.

Ministry of Education (1996). The Israeli National Curriculum for Science and Technology, p. 5

Ontario Ministry of Education and Training. (1998). *The Ontario curriculum Grades 1-8: Science and technology*. Toronto: Queen's Printer.

Ontario Ministry of Education and Training. (1999a). *The Ontario curriculum Grades 9-10: Technological education*. Toronto: Queen's Printer.

Ontario Ministry of Education and Training. (1999b). *The Ontario curriculum Grades 11-12: Technological education*. Toronto: Queen's Printer.

Schools For a Sustainable Future (2000) web site: www.sfsf.com.au

Schumacher, E. F. (1973). *Small is beautiful.* London: Blond and Briggs.

Scottish Consultative Council on the Curriculum. (1996). *Technology education in Scottish schools: A statement of position from Scottish CCC*. Dundee: Scottish Consultative Council on the Curriculum.

Siu, K. W. M. (1997). Criticism and theory studies in design and technology teacher education programs. *Curriculum Forum,* 7(1), 49-58. Hong Kong: The University of Hong Kong.

Siu, K. W. M. (2000). A comparative study of relay thinking activities in degree and secondary level students. Educational Research Journal, 15(1), 45-68.

Siu, K. W. M. (2002). *Impact of new technology on teaching and learning in technology education: Opportunity or threat?* (Keynote Address). In E. W. L. Norman (Ed.), *DATA International Research Conference 2002* (pp. 29-37). Wellesbourne: The Design and Technology Association.

Sustainable Technology Education Project (1999) the Sustainable Technology Education Project (STEP) web site: www.stepin.org

Tanna N.J. and Kumar K.L. (2002). Curriculum Innovations in Design and Technology at the University of Botswana, Southern Africa, *The Journal of D&T Education*, Vol. 7 Number 1, 2002.

Thorsteinsson, G. 1998. *The Innovation Project in Icelandic Grade schools. Development of Technology Education* – Conference -98. University of Jyväskylä. The principles and Practice of teaching 33, 303-323.

Thorsteinsson, Gisli. 2000. *Skolen i idéernes tidsalder.* Vi i Norden/Entreprenörskab (2).

United Nations Conference on Environment and Development. (1992). *Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity.* New York: United Nations.

Welch, M. (Ed.). (2002). *Playful puppets in the Savannah*. Kingston, ON: Queen's University.

Welch, M., Barlex, D., Christie, C., Mueller, A., Munby H., Chin, P., and Taylor, J. (2000, August). *Teaching elementary science and technology in Ontario.* In P. H. Roberts and E. W. L. Norman (Eds.), *IDATER2000: International Conference on Design and Technology Educational Research and Curriculum Development* (pp. 180-185). Loughborough, UK: Loughborough University of Technology.

Williams, P.J and Kierl, S (2001) *The status of teaching and learning of technology in primary and secondary schools in Australia.* In IDATER2001: International Conference on Design and Technology Educational Research and Curriculum Development. Loughborough, UK: Loughborough University of Technology.