Scientific & Technological Literacy Through TechnoScience2000+: An Approach for In-service and Preservice Training

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The Challenge of Scientific and Technological Literacy

Scientific and technological literacy (STL) is becoming one of the central planks for development through education on a global scale. Within this global thrust, design and technology in particular are gaining strength as curriculum components either as an individual subject or as contributors to a more broad and inclusive approach to learning (Growney, 2000). A declaration by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1994) recalls that our world is being increasingly shaped by science and technology, and that these key elements play a role in enabling us to cope with change, pursue development goals, make informed decisions (often with an environmental dimension), and expand investment in human development itself. Educational concerns, therefore, will need to focus on empowered citizens who can lead productive, high-quality lives and who are able to resolve the variety of societal problems stemming from issues such as population, health, nutrition, environment, and sustainable development at local and global levels (Holbrook & Rannikmäe, 1997).

The notion of *literacy* is seen as a mode of behavior rather than as a literal interpretation that concerns the utilization of written and printed information in order to function in society. This mode of behavior is itself complicated but may be one of the key indicators that STL is an appreciation of the *outcomes* of the application of scientific and technological activities. This may also have an environmental dimension, and may embrace notions of environmental literacy (Coppola, 1999). Since the mode of behavior concerns outcomes, and since outcomes affect our surroundings and ourselves, STL also has a moral and ethical dimension with values developed from a diversity of cultural and social settings.

STL, as a principal mechanism driving educational change, is becoming a beacon to which interested parties are drawn for guidance and inspiration. Beyond the rallying call to which groups may unite under the STL banner, Jenkins (1997) pointed out that like scientific literacy, technological literacy is a slogan, not a prescription for action. This is a useful cautionary note. Clearly there has to be some substance from which to turn well-directed but perhaps vague STL intentions into meaningful actions.

In this respect, some of the core questions driving the desire to increase STL may point towards purposeful prescriptions for action. What is the relevance of much of the content of science? Are scientific ideas accessible? What impact does science and technology have on society? To what extent can technology act as a contextual lead to science education? This link between science and technology is clear if science is perceived as a living discipline that can only be understood through experiencing the interaction of its concepts and processes in everyday life and, hence, through technology. In order to make science "real" and useful, it becomes necessary to reflect on the nature of technology that surrounds us. We are increasingly surrounded by consequences arising from our interactions with the natural environment through the construction of the made world. The great complexity of the made world can be seen as an over-arching summary of achievements (and failures) to apply technological ideas to perceived problems and attempts to elevate the living circumstances of the global population.

If STL is to become an effective component within global education, then the battle cry for change and development by educators will need to undergo a significant act of translation. It will need to be moved from a worthy but general intent to the implementation of active teaching and learning strategies in classrooms the world over. STL will need to become imbedded within the wider curriculum to the extent that teachers from elementary education upwards will understand and embrace its philosophy, formulate new goals, and facilitate effective classroom delivery. Clearly this is a massive challenge.

Significant changes will have to be made in the way preservice education is offered to intending teachers. Perhaps the biggest challenge will concern the vast pool of existing teachers for whom in-service education will be the principal route by which they can gain access to fresh approaches to teaching and learning.

In-Service and Preservice Education: The Dilemma of Delivery

Face-to-face modes of education delivery have been at the heart of the school and college-based curriculum for a very long time. The transfer of skills and knowledge by our cave dwelling ancestors was conducted on the basis of close personal contact. The hunting of bears, for example, would have required organizational skills coupled with a past knowledge of the behavior pattern of these animals when faced by a crowd of stone-throwing and stick-waving people. The transfer of skills and knowledge was conducted, perhaps, after a hunt over the glowing embers of a fire during the social act of sharing food. With the coming of the written word, the transfer of skills and knowledge has become decoupled from face-to-face interaction. Books, and increasingly a range of other media such as radio and television, have provided access to learning not only as a component of formal face-to face channels, but also via a powerful informal pathway.

Even the linear pattern to learning, so well entrenched in activities such as the standard cover-to-cover reading of books and viewing of videotaped material, has been challenged. Modern learning can be nonlinear. Hypermedia resources have determined a fresh chapter in the story of learning. The learner is presented with choices, and the development of appropriate computer-based navigation skills can enhance the direction and pace of learning itself.

In many developed nations, in-service and preservice training of teachers has embraced much of the multimedia enhancement that modern information communications technology can achieve. Formal courses with reading-based components may have these distributed to learners through the Internet. This may be referred to as "distributed learning." The utilization of Internet-distributed texts or locally networked supporting media may be used to complement face-to-face delivery.

Nonetheless, aspects of such delivery generally require the learner to join other participants in a set place at a set time. While great advantages are to be gained from this social learning setting, participation is denied to those who cannot regularly travel to this fixed point at required times, and as a result such measures may become exclusive.

In developing countries, these factors may act as a brake on widening participation to a significant degree. As an over-arching theme, poverty not only reduces the ability to travel longer distances, but also affects both the reliability and security of such movement. Uncertain journeys induce a negative impact on regular, fixed-point, fixed-time social learning settings.

Widening Participation in STL

Clearly, the notion of disseminating the STL message will need to be open to a range of options if it is to be effective in the developed world and in developing countries.

Nonformal modes of dissemination in particular will have a part to play, including perhaps a reduction in face-to-face settings for learning. Bardowell (1999) outlined a variety of strategies for popularizing science and technology in the developing country setting of small island states in the Caribbean. As part of the evolution of education, an emerging "degathering" scenario is contrasted with one of traditional "gathering." This emerging "degathered" scenario identified by Bardowell is location independent, is learner directed, is lifelong or continuous, involves decision making and problem solving, and is of an interactive nature.

Degathering may be appropriately served by Internet-based learning measures. The personal computer is increasingly becoming location independent. Wireless communication can extend links to the Internet beyond the reach of telephone lines. Even solar-powered computers challenge our conception of the computer as a device that directly or indirectly gains electric charge from a conventional main source.

Hypermedia presentations can enable learners to direct the ways they wish to learn. Continuous or lifelong learning is well served by the computer. Progress in teaching and learning issues are matched by developments in both software and hardware. Learners embarked on the long haul to self-enrichment will be continually challenged by a tide of change. Even elements of problem solving can be effectively dealt with via Internet access modes that have the potential to provide a rich learning setting with text, moving and fixed graphics, and sound.

TechnoScience2000+: A Resource That Can Assist "Degathering"

The upgrading of scientific and technological background knowledge and confidence has long been seen as one of the major challenges facing the existing elementary teaching force.

Over 15 years ago, the following comment was made in the context of science in United Kingdom primary schools.

> The greatest obstacle to the continued improvement of science in primary schools is that many existing teachers lack a working knowledge of elementary science. Making good this deficiency is a long-term aim which calls for a range of provision within and outside the school. The main elements needed are: (a) Courses and materials which offer or consolidate a foundation of scientific knowledge which will give teachers the confidence necessary to teach science…. (Department of Education and Science/Welsh Office, 1985, p. 8)

The preceding quote must be seen in context. It is not just about science, but about technology also. It should be noted that within the curriculum of the 1980s, science for primary-age children in England and Wales was so closely linked to elements of technology that the two were seen as part of a continuum of experience.

Today, the challenge of providing materials to consolidate a foundation of knowledge in both science and technology is of significance far beyond the shores of the United Kingdom. It reaches into all countries. Development and education are inextricably linked. The key elements that still affect teachers in elementary school situations concern the development of a working subject knowledge and the confidence to deliver this to children. This challenge is being met by a generation of new materials, some with an Internet capability for distributed learning such as TechnoScience2000+.

TechnoScience2000+ has had a long period of historical development. The open/distance learning structure found in TechnoScience2000+ was originally developed in the late 1980s as a text-based set of resources to assist teachers in upgrading their knowledge and understanding of science. Development financial aid was provided by two science-based organizations connected to the pharmaceutical industry, Pfizer and the Wellcome Foundation. The original texts were extensively tried, tested, and modified in the light of experience. As the curriculum in England and Wales accommodated the "new" subject of primary design and technology, so too did the forerunner of TechnoScience2000+.

Successful collaboration between an educational institution, Canterbury Christ Church University College, and British Nuclear Fuels Limited led to the production of a set of open/distance learning resources entitled "Success with Primary Technology" (Parkinson & Plimmer, 1995). At this stage in the development of open and distance learning materials, it was becoming clear that the Internet could not only have greater potential outreach than hard copy text, but could also be adapted to suit different purposes far more easily than a commitment to paper-based resources. With the switch to an electronic format, another industrial partner, the ICI Group, joined forces with Canterbury Christ Church University College to produce the united set of science and technology resources now known as TechnoScience2000+. TechnoScience2000+, then, is a set of electronic materials developed to provide flexible learning options for a variety of potential users. The materials are not presented as a formal course, although with adaptation, they could fulfill this function.

The essence of the TechnoScience2000+ materials is that they are a flexible resource in themselves. They are capable of being read online as an informal learning experience, capable of being downloaded as a file for reading as hard copy, and, crucially, capable of being altered, adjusted, and fundamentally rewritten to suit the needs of potential users.

TechnoScience2000+ can thus be utilized as a mechanism for professional development with advisors, teachers, and curriculum developers rewriting materials to suit their particular in-service or preservice delivery circumstances. This notion of localized development of resources is central to what Holbrook (1999) has defined as the “operationalization” of STL. With the use of TechnoScience2000+, such a mechanism enables participants in STL curriculum development initiatives to invent their own “curriculum wheels,” but from a basis of existing, appropriately shaped pieces rather than piles of raw materials.

The TechnoScience2000+ materials are being increasingly linked to initiatives by UNESCO. This situation has arisen due to the joint promotion of human and curriculum STL development by the ICI Group in association with UNESCO. As a global specialist chemical company, the ICI Group has been able to facilitate development workshops at company production and research and development facilities around the world. The provision of sites for development activity has linked exceptionally well to the strategic UNESCO objectives concerning the “training of trainers” (ICASE, SEAMEO-RECSAM & UNESCO-PROAP, 2001) to facilitate STL dissemination.

Two brief case studies concerning STL dissemination are outlined later in this account.

TechnoScience2000+: The Core Philosophy

As a mechanism for widening participation in STL, TechnoScience2000+ has incorporated the following elements into its foundations.

Science and Technology Content — A Partnership for STL

In terms of content, TechnoScience2000+ has been developed as a resource in which science and technology are seen as equal partners. No clear subject distinctions have been drawn. This reflects the view taken in some countries that clear distinctions between science and technology as curriculum subjects may be unnecessary. It also reflects a science/technology/society (STS) view that problems, questions, debate, probing, and conflict can be grounded in the science-technology continuum (Yager, 1996) and that STS can become a force to integrate these quintessential and persuasive characteristics of our culture into all the traditional learnings of society (Yager & Roy, 1993).

The Importance of Contexts

Recognition of the role of contexts is central to the development of TechnoScience2000+. This is achieved at two principal levels. First, industrial workplace-related situational contexts are used as introductory texts. These have a textual narrative delivered by the people directly involved. For example, an industrial safety officer indicates the problems of maintaining a safe working environment, wheras a materials scientist explains new approaches to the use of starch as a biodegradable material for foam packaging. These examples provide a perspective beyond school settings and help to establish the credibility of the resource itself. It is bonded to real people doing real jobs immersed in the research, commercial, and industrial culture of science and technology. This is a positive outcome arising from collaborative actions between industry and education.

Second, TechnoScience2000+ attempts to utilize everyday technological settings as contexts for exploring scientific ideas. This fluidity of approach is consistent with that of Johnsey (1999) who, as part of an alternative model for curriculum delivery, was concerned with “the integration of science and design and technology so that learning in each subject enhances the other” (p. 15). Venville, Wallace, Rennie, and Malone (1999) had a similar approach to curriculum integration based upon technological problem-solving contexts that direct participants towards abstract scientific concepts through engaging, technologically-based practical tasks.

The technological settings sketched out in the TechnoScience2000+ resource embrace engagement with scenes actively surrounding the learner. A gaze from a window to the scene outside or a "thought experiment" becomes the link to wheeled transport and thus leads to notions of motion and mechanism. Examination of the building materials that may surround the reader can lead to questions of the appropriateness of substances in the made world for certain purposes.

Employment of Innovative Elements in the Resource Text in Order to Engage Users

TechnoScience2000+, although portrayed as an Internet resource, is based largely upon a flow of text, which can be either considered as an on-screen display or printed hard copy. Text, of course, is a symbolic medium that can convey information to the reader. Success in conveying information to the reader is dependent on reader skills and attitudes related to factors such as comprehension, reading speeds, and attention levels. Motivation to read is a further significant factor. One of the factors that influences motivation is the appeal of the text itself. Research into this domain (Hidi & Baird, 1988; Schank, 1979; Shimoda, 1993) has suggested that text embracing important life themes and vivid details, especially when written in a narrative format, increases the intensity and effectiveness of the reading experience. TechnoScience2000+ has been written with this in mind. It has a narrative style and attempts, as far as possible, to reach out to the learner with situations communicating "interesting" sets of circumstances (Plimmer, 1996).

Learning in the Workplace

As part of teacher in-service education, learning in the context of the school has many strengths. TechnoScience2000+ has been developed upon the premise that teaching situations can provide appropriate platforms for enhanced contextualized learning. Barnes (1976) made a distinction between two strands of knowledge. "School knowledge" is seen as knowledge presented by others and tested in formal settings, but it is characterized by being "outside" individuals because it is not seen to be useful for personal purposes. This contrasts with "action knowledge" that becomes incorporated within mental schemata and serves everyday actions. By placing learning through TechnoScience2000+ within the context of the workplace, the acquisition of relevant action knowledge should play a significant role.

The action-knowledge perspective of Eraut (1994), which underpins the development of knowledge in the context of real-life classroom situations, supports such a view.

Central to the hypothesis of Eraut is the notion that as well as learning taking place prior to knowledge use, learning also takes place during knowledge use.

TechnoScience2000+ with its wealth of classroom-related situations can form an appropriate base from which action-knowledge can be developed. Subsections of the text are punctuated by "In your classroom" scenarios that encourage the user to reflect and use knowledge gained from the learning materials.

Acknowledgement of the Social and Environmental Context of Technological Applications

An attempt has been made to highlight links between technological actions and social/environmental consequences. This link embraces the notion of "Bildung" (Hansen, 1994) by augmenting STL with aspects of character development and moral autonomy. Such a reflective attitude should enable users to question aspects of their own lifestyle, uncomfortable as that may often be, so they may engage fully with the Big Ideas that will exert increasing pressure on the environmental agenda for the new millennium.

Where May TechnoScience2000+ Be Used?

It may be used anywhere. It is a misconception to believe that electronic resources can only bear influence via the modern setting of an Internet terminal. TechnoScience2000+ materials can be downloaded as files and printed out. They can thus be employed as a "traditional" paper-based resource remote from the point of Internet origin.

Resources such as this can be used by local teaching associations as vehicles for curriculum and professional development. This has already occurred in Jamaica, where materials related to the prototype for TechnoScience2000+ were employed at the local teaching level and the national level by the government Core Curriculum Unit to inform the emergence of a new curriculum (Parkinson & Swire-Walton, 1997). At a recent UNESCO-supported workshop in Kingston in September 2001, the latest generation of TechnoScience2000+ CD-ROM materials were provided for Jamaican teachers. This occurred in conjunction with an island-wide initiative to provide all government-funded elementary schools with personal computers. Such an initiative was timely, since teachers now have CD-ROM resources at their fingertips, both as an on-site resource to assist in STL matters and also as a means of motivation to utilize the technology of computer access that so many of us take for granted.

In Nigeria the materials were employed by local subject-based teaching associations as a means of supporting local Project 2000+ initiatives. The Early Learning Science Series for Africa is one such initiative in which science and technology, along with environmental education, plays a leading role (Bajah, 1999). TechnoScience2000+ should become an appropriate in-service tool to assist in the teaching of a core curriculum for primary science, since it is founded upon science-with-technology themes embracing technological capability for the world of work, energy, health, and environment (Federal Ministry of Education, 1991).

For a UNESCO-supported workshop held October 2001 in Argentina, the materials were translated from the original English text into Spanish. Since the addition of a second world language, global penetration by the TechnoScience2000+ materials has been massively increased.

UNESCO development workshops held in the Far East during 2002 will lead to a Chinese version of TechnoScience2000+ in 2003.

A Cautionary Note on Virtual Learning Environments

As a contribution to global STL, the role of TechnoScience2000+ has to be seen in perspective. Within education via information communication technology, there has been rapid progress towards the creation of learning situations based entirely upon a flow of computer-based information, assessment activities, and simulations or, as these are sometimes called, "virtual learning environments" (VLEs). Such virtual settings are perhaps the ultimate form of degathering.

Hopefully, TechnoScience2000+ will not become some fragment within a totally degathered virtual learning framework to promote technological literacy. TechnoScience2000+ is ultimately about people and for people. VLEs may offer exciting possibilities in terms of the distribution of learning materials and measures for the monitoring of student performance; however, the displacement of all face-to-face social learning may be seen as a retrograde step. The quality of a learning experience depends upon the interaction of a range of variables, including the prior experiences and attitudes learners carry with them and the characteristics of the task environment in which learning will take place. Research by Richardson and Turner (1999) suggested that a significant number of learners increasingly imbedded in VLE settings find themselves isolated and needing the forces of external motivation that only face-to-face situations can supply. It is hoped that TechnoScience2000+ will become part of a new generation of hybrid delivery systems that acknowledge the value of some aspects of face-to-face social learning while taking advantage of the enormous opportunities for dissemination offered by the Internet.

The Electronic Future

Opportunities for electronic dissemination are increasing all the time. The merging worlds of computers and telecommunications have a habit of leapfrogging perceived barriers to the widening of participation in the information communication technology arena. At one time, disadvantaged communities cited the lack of hard-wired infrastructure as a barrier to progress. Wireless communications are rapidly re-writing the telecommunications infrastructure chapter in a way that could not have been imagined 10 years ago.

Broadband communications are set to have a similar effect in terms of the density of information transfer that can be accommodated on the Internet. Perhaps, in time, the blisteringly hot data transfer rates we have seen on hard-wired systems will become part of the wireless scene also.

Through the scale of recognition now offered by UNESCO, TechnoScience2000+ will be part of this ongoing educational electronic revolution. Interestingly, one way of judging the "success" of the ability of the resource to interact with educational training systems will be to see how it is progressively taken and reconstructed by users. In, say, 10 years time TechnoScience2000+ may well become a diverse resource that has used elements of the original core text, yet modified this as local communities of curriculum and resource developers make adaptations to suit local needs.

The translation of the resource into Spanish in Argentina is the most dramatic indicator of this drift toward local adaptation and change. This, of course, is not simply a change of language, but within it are hidden all the subtle subcontexts and meanings bound up with language and culture. In many ways, this is a symbolic act.

The operationalization of STL both through and for an electronic age is truly underway.

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