Technological literacy: A realisable goal or a chimera?

Dr Bev France, Principal Lecturer,
Centre for Science Education, Auckland College of Education

Abstract

Technological literacy is the aim of the New Zealand technology education curriculum. It is proposed that the components (technological knowledge, technological capability and an awareness of societal relationships) equally contribute to the development of this technology education goal. Is the full realisation of technological literacy possible in classroom programmes or is this an unrealistic fantasy which, for some teachers, can become a chimera?

Technological literacy has a range of interpretations. Is the view of technological literacy proposed in 'Technology in the New Zealand Curriculum' (Ministry of Education, 1995) achievable in New Zealand classrooms? This paper describes and analyses a range of teachers' classroom interpretations of this goal and debates whether such a goal is feasible.

Introduction

These days scientific and technological literacy is a hot topic in educational circles. The publication of the sixth volume of 'Innovations in science and technology education' (Jenkins, 1997) provided an opportunity for educationalists to explore a variety of perspectives of scientific and technological literacy as well as report on its implementation via case studies. This publication had its roots in the declaration by the UNESCO 'Project 2000+' that there was a need to develop a citizenry that were scientifically and technologically literate. This issue was taken up in the United States by the American Association for the Advancement of Science's (AAAS) 1997 recommendation that issues of education for science/technology literacy need to be re-examined. Similar issues have been discussed in England in the Nuffield Seminar Series 'Beyond 2000: Science Education for the Future' with the committee recommending that the science curriculum from 5-16 years should focus on enhancing general scientific and technological literacy (Driver & Osborne, 1998).

Throughout these discussions there has been the assumption that science and technology were inexorably linked. Hurd (1998) comments that the direction of modern science is determined by technological instrumentation and modern science is often referred to as 'applied technology' or technoscience. When science is given this focus more attention is given to the functional aspects of science and technology as it relates to strategic research. The assumption that there are common issues in science and technology means that discussion of education for scientific literacy provides a corollary that technological education may provide similar issues for discussion.

Pacey’s (1983) analysis of the technological process, Staudenmaier’s (1989) reflections on the specific nature of technological knowledge and Layton’s (1993) translation of such ideas into classroom practice formed the basis of the world-wide reform of technology education throughout the 1980’s and 1990’s. Views of technological literacy have been discussed in terms of educational goals (Lewis & Gagel, 1992) and translated into educational programmes that reflected the economic, social and political needs of each country.

It was at this point in the discussion that I felt rather smug about New Zealand technology education for it had followed that route (Jones & Carr, 1993). As a consequence 'Technology in the New Zealand Curriculum' (Ministry of Education, 1995) proposed that technology education should be focussed on the development of technological literacy for all students. I felt that not only had these issues been worked through at the curriculum development stage but also classroom-based research had provided evidence that teaching programmes were being developed that took into account these goals (Jones, Mather & Carr, 1994; France, 1997).

However my smugness hasn’t lasted long. Recent discussion about education for science/technology literacy has been accompanied by papers critiquing the New Zealand interpretation of technological literacy (Burns, 1997; O’Neill & Jolley (1996/97)). Both papers provided the impetus for my re-examination of the research data gathered during 1992 and 1993/94 that analysed teaching programmes which used biotechnology as a context to explore the concept of technological literacy (France, 1997).

This re-examination of the data inspired more questions than answers. Was the goal of technological literacy attainable in New Zealand classrooms? Did these teaching programmes explore the dimensions of technological literacy? Were teachers able to provide an opportunity for students to fully experience the societal influences on technological solutions? I wondered whether the goal of technological literacy could be likened to the fantastic fantasy of a chimera where a fabulous fire spouting monster with a lion’s head, goat’s body and serpent’s tail could ever be realised in the 'real' world.

Is technological literacy a realisable goal in New Zealand technology education classrooms? This paper will:

- discuss recent views of technological literacy
- describe a way of expressing technological literacy within a biotechnological context
- analyse the classification of these teaching programmes in terms of technological literacy
- debate whether the goal of technological literacy is realisable in New Zealand classrooms
- propose some ideas to enhance the development of technological literacy in New Zealand schools.

Recent views on technological literacy

Initial discussion in technology education focussed on defining and characterising the subject. Views of technology ranged from a technological determinist standpoint that saw technology as a pervasive force with its own momentum that was largely uninfluenced by human intervention (Barnett, 1995); a perspective that saw technology as a form of human knowledge that was developed within a particular historical and social context (Watkins, 1991); to an applied science view of technology (Lewis & Gagel, 1992).

These perceptions of technology influenced education for technological literacy worldwide. Programmes that had a technological determinist focus emphasised knowledge and skills development that aimed to provide students with an ‘insiders’ view’ (Jenkins, 1997). Even though this view has largely been discarded during this latest wave of curriculum reform (France, 1997) perhaps in the drive to develop technological capability some classroom programmes may unintentionally focus on this perspective.

When technology is viewed as a form of human knowledge then its educational expression should acknowledge the variety of influences on its development. These may include political, social and economic influences (Watkins, 1991). Recent discussion also identifies additional influences for example morals and ethics and environmental considerations (Scott & Oulton, 1998; Cross & Yager, 1998).

Earlier proponents of applied science view of technological literacy made technology a sub-branch of science (Lewis & Gagel, 1992). The hybridisation of technology and science that occurs during strategic research projects has led to contemporary science being described as applied technology (Hurd, 1998). Jenkins (1997) describes technology and science as two intersecting social systems. This analysis not only opens up the potential for exploring the social interactions that occur in science but also provides a parallel but different focus for technology education. This view of two different but intersecting systems frees technology education to exhibit its particular characteristics and ways of working.

There is a diagram in the New Zealand technology curriculum document (Ministry of Education, 1995, p.8) which depicts technological literacy as a circle where the strands of technological capability, technological knowledge and technology and society having equal space. This depiction could indicate that the writers had a view of technology as a form of knowledge that is set within and influenced by the practice and influences of our culture. Recent critique in New Zealand has questioned this assumption. O'Neill & Jolley's (1996/97) analysis ascribes a technocratic rationale to this curriculum. These authors back up their claims by looking at the implementation examples, which they assert, illustrate a rationalistic, explicit and systematic approach to technological development.

Burns (1997) argues for a liberatory technological literacy discourse that provides an opportunity to critically examine one discourse in terms of the values and beliefs of another discourse. As a result of this analysis the values and belief systems of each discourse can be clarified. She comments that such an analysis of the New Zealand technology curriculum document shows that the learning and assessment examples focus on the impact of technological developments rather than societal influences. She argues that this emphasis on a technical organisational aspect of technological literacy supports a technological determinist view of technology. Burns also comments that there is a need to look at the technological process and its interactions on society from a social, political, economic, cultural and historical viewpoint as well as from the position of the stakeholder.

These views contributed to my re-examination of how education for technological literacy had been interpreted and implemented in this research project that used biotechnology as a context (France, 1997). During the research period the following definitions and explanations were developed to describe biotechnology literacy.

Technological literacy expressed within a biotechnological context

Biotechnology education is the focus for this research. It provides an opportunity for me to explore a definition of biotechnology within a framework of the New Zealand curriculum document's expression of technological literacy and monitor the development and implementation of some teaching programmes set within this context.

Although the definition of biotechnology that appears in the curriculum document acknowledges the complexity of a biotechnological process by indicating a range of agents, the variety of products produced and the processes involved it does not identify the complex interrelationship of factors that influence the endpoint of a biotechnological solution.

> Biotechnology involves the use of living systems, organisms or part of organisms to manipulate natural processes in order to develop products, systems, or environments to benefit people. These may be products, such as foods, pharmaceuticals, or compost; systems such as waste management or water purification; or environments such as hydroponics. Biotechnology also includes genetic or biomedical engineering.
>
> (Ministry of Education, 1995, p.12).

Because of the inherent limitations of a written definition a model is more efficacious in demonstrating these interacting factors. Pacey (1983) proposed a useful model for technology in action where he identified cultural, technical and organisational aspects of technological practice that are set in user and expert spheres. Pacey’s ‘culture of expertise model’ (Pacey, 1983, p.49) provides an operational view of technological practice and gives an indication of the complex feedback interactions that take place during technological activities. However, it is not appropriate for use in a technology education context because the components of technological literacy that appear in the curriculum document are not easily identified in his model.

I developed a model (Figure 1) that not only identified the components of technological literacy as proposed in the curriculum document but also gave the expression to their application in a biotechnological problem-solving situation. The model is made up of the following parts:

- skills and knowledge (biotechnological knowledge)
- the application of biotechnological knowledge in a particular situation (biotechnological capability)
- factors that may affect the resolution of the best solution for that situation (some of which may be attributable to societal influences) (France, 1997).

All of the components of technological literacy can be found in this model and its organisation demonstrates not only the interdependence of these components but also the importance of societal factors influencing technological solutions. These factors ranged from finding out what the recipients need and want from a biotechnological proposal to its acceptability of such a solution from an economic, social, cultural viewpoint.

CLASSIFICATION AND ANALYSIS OF TEACHING PROGRAMMES IN TERMS OF THE TECHNOLOGICAL LITERACY MODEL

The model of technological literacy (Figure 1) provided a framework for analysis of the components of technological literacy when it was applied to a teaching situation that used a biotechnological context. Teaching programmes were developed and implemented by teachers in the research group using this model of technological literacy during two intervention periods in 1992 and 1993/94 (France, 1997). Data about these teaching programmes was collected from interviews (semi-structured and unstructured) with teachers and students (group and individual), classroom observations and teacher's lesson plans and diaries. Flow charts were used as one of the tools of analysis, and in the second phase of the project, these teachers also constructed them both as a method of planning their programmes and as a focus for their evaluations.

The data was analysed and, to ensure the veracity of the 'story', respondent validation techniques were used during reporting sessions when teachers provided video records, samples of their students' work and publicly evaluated their teaching programmes. The lengthy time frame allowed for repeated observation of classroom programmes which contributed to the reliability of the research findings (Merriam, 1998).

The teaching programmes were analysed and given a classification (A-F) that is identified in the following way. Teaching programmes that:

- had a scientific emphasis (A)
- had a bias towards technical skill development (B)
- used biotechnology applications as their framework and focus (C)
- demonstrated technology problem-solving in a limited way (D)
- reached limited technological outcomes (ie some of the aspects of the technological process were identified and followed through) (E)
- worked through the technological process and reached a technological outcome (F).

This analysis revealed that in 1992 no teaching programmes were classified as (F) (Appendix 1) but during the 1993/94 research period seven out of the seventeen teaching programmes were given an (F) classification i.e. the teaching programme had provided an opportunity for these students to experience all aspects of technological literacy (Appendix 2).

However, both this analysis and the subsequent classification deserves closer attention. Even though an (F) classification should indicate that attention had been paid to the societal strand, further examination of the teaching programme flow charts, teaching plans and transcripts of classroom observations show that this component was given limited attention. In most teaching programmes societal impacts of technological solutions were limited to students finding out what the consumer required. In other situations the social aspects were examined when links were made with biotechnological communities to research the restrictions that a biotechnological operation might encounter.

Further analysis of the flow charts revealed that teaching programmes where societal aspects of biotechnological solutions were examined (notably *Programme 5 Beer Making and Related Health issues, Programme 8 Cottage Cheese Production* in 1992 and *Programme 17 Individualised Solutions* in 1993/94) could not be classified in the (F) category as they did not provide opportunities for students to develop the other components of this concept of technological literacy, that is technological knowledge and technological capability (Ministry of Education, 1995, p.8).

Even though these teaching programmes were not given an (F) classification subsequent analysis shows that these teachers provided an opportunity for their students to explore the societal aspects of the technological process (Appendix 3, 4 and 5). This exploration enabled students to go beyond the needs of the consumers and the restrictions imposed by and on the biotechnological community that had been identified as a common societal focus. Instead these teachers had provided their students with an opportunity to explore the effect of these biotechnological solutions on the wider society. For example *Programme 5* examined the values promoted by the beer industry via their advertisements. This class also looked at the consequences of beer consumption on their employees as well as their customers. *Programme 8* extended this examination of the cottage cheese industry to the processed food industry and the class took part in a spirited debate on the merits of processed foods where the debaters assumed the role of producer, health food specialist, consumer, and medical researcher. This session provided time for these students to explore these alternative views as well as an opportunity to state their own position. *Programme 17* involved students researching problems that were specific to individuals and the teacher provided opportunities for the class to talk to people with experience of similar problems (for example a diabetic and a veterinarian).

Is technological literacy a realisable goal in New Zealand classrooms?

Subsequent analysis of all these teaching programmes showed that teachers either gave less attention to the technology and society strand, or did not have time to develop technological capability amongst their students when they explored the societal strand. The questions continue. Why were there so few programmes that provided opportunities for their students to develop a deeper understanding of technological literacy? Why were the societal aspects of these programmes so superficially developed?

The blame cannot be laid with the teachers. All of these teachers were experienced and very competent classroom practitioners. They had developed teaching programmes that reflected their emerging understanding of technological literacy. Their classroom programmes reflected their sophisticated teaching skills and the awareness that they needed to provide students with a wide range of resources and learning experiences. They accessed appropriate communities of practice (Lave & Wenger, 1991) and created learning situations where students explored the development 'real solutions' to 'real problems'. Yet this second analysis in terms of a broader view of technological literacy demonstrates that the societal aspects of the programmes that were given an (F) classification were still superficially developed.

Is the expectation that all aspects of the technological literacy can be explored during a technology problem-solving situation unreasonable? Certainly when the expectation for a real working solution is paramount, there is little time for detailed analysis of the societal implications of such a process, product or environment. However I suspect time is not the only reason for the lack of attention to the societal aspects of technological literacy. Other contributing factors may have been a teacher-driven focus on capability, when there was a pressure to develop 'real' problem-solving situations within a restricted time frame. In addition teachers' unfamiliarity with this technological area, and their inexperience at organising programmes that involved a considerable community input as well as their limited view of societal impacts on technological solutions may have influenced the focus of these teaching programmes.

Examples of time being a constraint were noticeable. In some cases the teacher abandoned the capability part of the programme and instead concentrated on developing their student's awareness of societal issues. For example in *Programme 5 Beer Making and Related Health Issues* the students did not make their specialised beer but instead followed a beer making recipe and produced posters identifying the societal aspects they had identified. During the unit *Programme 8 Cottage Cheese Production* the students made cottage cheese from a recipe but did not proceed with the production of a market-niche cottage cheese because they ran out of time. In *Programme 17 Individualised Solutions* students did not have the opportunity to trial their solutions with their subjects and consequently their prototypes were presented without opportunity for modification.

Other teachers in this research programme concentrated their effort on creating a situation where students could develop and work through 'real' problem-solving situations. Because the teachers gave more attention to the capability and knowledge strands they allocated considerable time to develop their students' skill level while providing opportunities for the development of appropriate scientific concepts.

Because all teachers in the research project were new to technology education, let alone biotechnology, their inexperience at appreciating the ramifications of biotechnological products and processes on society was understandable. For example *Programme 16 Plant Packaging* identified the range of packages appropriate to the preservation of these plant products but conservation packaging issues as well as the conservation and disease prevention requirements of importing and exporting plant material were omitted. *Programmes 19 and 20, 23 and 25* where food products were developed and marketed ostensibly covered all aspects of technological literacy with students carrying out market research, interviewing members of the biotechnological community that produced similar products and adapting products according to the consumer's evaluations. They were all given a (F) classification. When revisiting these flow charts it was apparent that the societal influences investigated were limited to the consumer's immediate requirements rather than an examination of technological outcomes within a social and historical context.

Programme 12 Hydroponics is another example of a programme that did achieve the (F) grade, but the wider implications of the introduction of this product or process were ignored. Here the students asked consumers about their preferences but the implications of hydroponics on the local horticulture industry, the issues of water table in the local area, the problems of glass house proliferation and the merits of organic versus chemical hydroponic systems were not explored.

Is it an unreasonable expectation that a teaching programme will attend to all of the components of technological literacy? This research demonstrates that there was less attention paid to the development of the societal component. Certainly a full development of a technological literacy was not achieved in any of the teaching programmes. In this research the poor relation in the technological literacy trio was revealed as the 'technology and society' component.

Perhaps the goal of technological literacy where the expectation that students not only have the opportunity to work on 'real life' problems and examine all aspects of this concept is unrealistic. Even though a holistic approach to technological literacy is a laudable goal is it beyond the expertise and resources of most New Zealand teachers and schools?

It would be a pity if such a worthwhile goal became a chimera for New Zealand teachers. If the lion's head represents technological knowledge, the goat's body represents technological capability what is the effect of cutting off the serpent's tail? If societal understanding and knowledge are not given due attention technology education will be a stunted expression of technological literacy.

Proposals to enhance the development of technological literacy

This research was carried out in the early stages of the development of the New Zealand technology education curriculum (Ministry of Education, 1995) and the development and implementation of these teaching programmes should be a matter of congratulations to the teachers rather than recrimination. However if our curriculum is to develop and mature we must be mindful of criticism and modify our interpretations of education for technological literacy. The following proposals may contribute to the on-going professional development.

During professional development there needs to be an emphasis on:

- facilitating a support network that allows groups of teachers with varying expertise to work together on programme planning
- providing an opportunity to develop integrated teaching programmes where the timetable can be collapsed to allow educational contributions from a wide range of educational expertise
- developing the links between non-specialists and experts so that both groups are able to communicate
- reducing the number of learning experiences that are covered in classroom year programmes so there is more time to develop all aspects of technological literacy

- creating opportunities to explore and critique contextual histories that demonstrate the close relationship between technological development and societal context as well as critique technological practice from a range of Discourses (Burns, 1997)
- using the resources from various movements such as STS [Science Technology and Society] (Solomon, 1993); HPA [History and Philosophy of Science]

(Monk & Osborne, 1997); HPSST [History and Philosophy of Science in Science Teaching] (Roth, 1998)

Even more important is the need to continue to research the implementation of a wide range of technology education teaching programmes so that we can contribute to this on-going dialogue about technological literacy. We must take part in the discussions about both scientific and technological literacy. The New Zealand technology curriculum has provided us with an inspiring goal of technological literacy but its implementation in the fullest sense is still being worked through. Let us hope that technological literacy will not become a chimera for teachers. It is our responsibility as tertiary educators and researchers to continue the dialogue and support teachers in their exploration of this concept.

References

Barnett, M. (1995) Literacy, Technology and 'Technological Literacy' *International Journal of Technology and Design Education* 5 pp.119-137.

Burns, J. (1997) *Implementing the Technology Curriculum: Promise and Prospect.* Paper presented to the Technology Education New Zealand Conference, 'From Curriculum to Classroom Practice, Christchurch, New Zealand, 8-10 October, 1997.

Cross, R. & Yager, R. (1998) Parents, social responsibility and Science, Technology and Society (STS): a rationale for reform. *Research in Science and Technological Education* 16 (1) pp.5-18.

Driver, R. & Osborne, J. (1998) *Reappraising Science Education for Scientific Literacy*. Paper presented at the NARST (National Association for Research in Science Teaching) Conference, San Diego, April 1998.

France, B. (1997) *Realising the technology curriculum: professional development in biotechnology education*. Unpublished D. Phil. Thesis. Hamilton, New Zealand; Centre for Science, Mathematics and Technology Education Research, University of Waikato.

Hurd, P. (1998) Scientific literacy, new minds for a changing world. *Science Education* 82 (3) pp.407-416.

Jenkins, E.W. (1997) Scientific and technological literacy: meanings and rationales. In E.W. Jenkins (ed.) *Innovations in Science and Technology Education Vol. VI.* Paris: UNESCO pp.11-39.

Jones, A. & Carr, M. (1993) A framework for technology education. In A. Jones and M. Carr *Towards Technology Education. Volume I Working Papers from the first Phase of the Learning in Technology Education Project*. Hamilton: Centre for Science and Mathematics Education Research, University of Waikato pp.1-47.

Jones, A., Mather, V. & Carr, M. (1994) *Issues in the practice of technology education. Volume 3: Working papers from the third phase of the Learning in Technology Education Project*. Hamilton: Centre for Science and Mathematics Education Research, University of Waikato.

Layton, D. (1993) *Technology's Challenge to Science Education. Cathedral, Quarry or Company Store?* Milton Keynes: Open University Press.

Lave, J. & Wenger, E. (1991) *Situated Learning. Legitimate Peripheral Participation*. Cambridge MA: Cambridge University Press.

Lewis, T. & Gagel, C. (1992) Technological literacy: a critical analysis. *Journal of Curriculum Studies* 24 (2) pp. 117-138.

Merriam, S. (1988) *Case Study Research in Education. A Qualitative Approach*. London: Jossey-Bass.

Ministry of Education (1995) *Technology in the New Zealand Curriculum.* Wellington: Learning Media.

Monk, M. & Osborne, J. (1997) Placing the history and philosophy of science on the curriculum: a model for the development of pedagogy. *Science Education* 81 (4) pp. 405-424.

O'Neill, A-M. & Jolley, S. (1996/97) Privatising curriculum. Constructing consumer society. The technology curriculum: the politics of food-women's work? To high tech or oblivion. *Delta 48* (2) 49 (1) pp.221-248.

Pacey, A. (1983) *The Culture of Technology*. Oxford: Basil Blackwell.

Roth, W-M. (1998) Science and technology studies and science education: a natural match? *Research in Science Education* 28 (1) pp.1-7.

Scott, W. & Oulton, C. (1998) Environmental values education: an exploration of its role in the school curriculum. *Journal of Moral Education* 27 (2) pp.209-224.

Solomon, J. (1993) *Teaching Science, Technology and Society*. Buckingham: Open University Press.

Staudenmaier, J. (1989) *Technology's Storytellers. Reweaving the Human Fabric.* Cambridge MA: Society for the History of Technology and The Massachusetts Institute of Technology Press.

Watkins, P. (1991) High technology, work and education. In D. Dawkins (ed.) *Power and Politics in Education. Deakin Studies in Education Series: 8*. London: The Falmer Press.

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