SCIENTIFIC AND TECHNOLOGICAL LITERACY

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An Annotated Bibliography

UNESCO

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An Annotated Bibliography
compiled by

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ISBN 0 904421 70 8

Phototypeset from text received on disk and printed by the Print Services A division of University of Leeds Media Services

INTRODUCTION

The need to promote a 'world community of scientifically and technologically literate citizens' was recognized as urgent by the World Conference on Education for All held in Jomtien in 1990. Project 2000+, initiated to promote and guide the measures needed to give effect to this Jomtien declaration, seeks to:

- identify ways of promoting the development of scientific and technological literacy for all

- put forward educational programmes (formal and non-formal) which will empower all to satisfy their basic needs and be productive in an increasingly technological society
- provide guidelines for continuous development of science and technology educators and leaders
- encourage the formation of broadly-based national task forces to initiate programmes for greater scientific and technological literacy
- support the development of a wide range of projects designed to promote solidarity and co-operation in achieving scientific and technological literacy for all, and
- support the evaluation of existing and projected programmes in this vital area.

The Project is a major collaborative venture involving a group of major intergovernmental organisations and agencies together with non-governmental organisations with special concerns and responsibilities in the field of science and technology education and research. The work of the Project is being carried out in three phases.

The first phase, directed towards the collection, analysis and collation of information, and the completion of surveys and pilot projects concerned with scientific and technological literacy, was essentially preparatory to the second phase, an International Forum held in Paris in July 1993. This Forum, which brought together 400 participants from some eighty countries, sought to discuss issues and develop guidelines for designing, implementing and evaluating activities to be undertaken as the third phase of Project 2000+. This third phase, which is on-going, amounts to a long-term co-operative effort to move forward on a broad front by developing and strengthening interlocking links between the United Nations and other inter-governmental agencies, bilateral donors and non-governmental organisations. The basis for action is the Project 2000+

declaration that, by the year 2001, there should be in place appropriate structures and activities to foster scientific and technological literacy for all, in all the countries of the world.

This bibliography is an augmented and updated version of an earlier document prepared for Focus Area 1 of the Project 2000+ International Forum referred to above. The literature associated with the terms scientific literacy (SL) and technological literacy (TL) is voluminous and expanding. Among the various data bases concerned with education, a search of ERIC alone yields over two thousand items for the first of these key words. Inevitably, therefore, this compilation is selective and, as the title indicates, is limited to material which has a direct bearing on the meanings of, and rationales for, scientific and technological literacy (STL). It is also largely restricted to the literature published since 1980, an arbitrary starting date for which we can offer no justifications other than those of convenience and containment to match the resources available to us. There is, in fact, a substantial literature pre-1980, especially in relation to scientific literacy, an older term than technological literacy. Indeed, more than a decade ago, the Canadian science educator Douglas Roberts, in reviewing the development and changed meanings of scientific literacy, could categorize it as 'an aging slogan'!

As a rule, we have excluded literature which is primarily exhortatory, except where we have judged the source to be unusually significant and influential. Likewise, we have restricted references to computer literacy (CL), again the subject of extensive writings, to material focused on its relationship to scientific and/or technological literacy. On the other hand, we have included some items which do not refer explicitly to SL or to TL, but which nonetheless address issues identical to those in STLpublications. Thus, some writings concerned with 'Science for All' and the 'Public Understanding of Science' have been judged relevant. The extent to which source material is readily accessible was used as a criterion for inclusion and this has led to a predominance of published items. Theses and other unpublished reports and documents are not, therefore, listed, with one or two notable exceptions. A final point on the contents of the bibliography is that where we found an argument or analysis appearing in a number of sources, with only minor changes, we have tended to include only one or two examples of it, rather than multiply instances unprofitably. As for presentation, consideration of various formats has led us to conclude that the listing of entries alphabetically by author is likely to prove the most immediately helpful to the reader. The bibliography, therefore, is structured on this basis.

The items which constitute this bibliography prompt a number of important questions about scientific and technological literacy, the relationships between them and their engagement with basic education. It seems clear that there are close links between STL and basic education. It is difficult to conceive of a scientific or technological literacy which does not rest upon a sound basic education. However, it also seems likely that studies directed towards the promotion of scientific and technological literacy can contribute in significant ways to the development of basic education, not least by using appropriate and familiar scientific and technological phenomena or texts to promote the skills of reading, writing and comprehension.

There is now a significant body of evidence to sustain the view that seminal distinctions can be drawn between science and technology, although these two endeavours are often closely interconnected. The relationships between them are both complex and subtle, and show some dependence upon social and historical context, as well as upon the technology concerned. Perhaps not surprisingly, a variety of images has been invoked to describe them, e.g. 'mirror-image twins', 'two intersecting cognitive worlds'. It is inappropriate in the present context to explore the distinctions captured by these images, but it is important to acknowledge that technology cannot be regarded as merely the application of scientific knowledge and that it is necessary to consider scientific and technological literacy separately when exploring their meanings and rationales. It follows that scientific and technological literacy need to be seen as separate educational outcomes. How these outcomes can be achieved will inevitably differ from one set of circumstances to another, although it seems likely that, in many cases, separate but closely-related provision, is likely to offer the best way forward.

The items in the bibliography confirm, if such confirmation were needed, that the notion of 'literacy' is much in vogue among those concerned with scientific and technological education. In addition to SL and TL, the word 'literacy' is now often coupled with individual scientific disciplines (e.g. biological literacy), with particular contemporary concerns (e.g. AIDS literacy, environmental literacy), or with individual technologies (e.g. laser literacy, computer literacy). The possibilities for confusion and ambiguity are, therefore, considerable, and it would be helpful if the relationships between SL, TL and these other varieties of literacy could be explored and mapped in some detail.

Nonetheless, as far as scientific and technological literacy are concerned, it seems likely that the following would command a significant measure of agreement as their contributing elements:

(i) a core of facts, concepts and skills, the selection of which might show some dependence upon culture

(ii) some experience and understanding of what it means to work as a scientist or technologist, e.g. how scientific knowledge is generated, replicated and validated, and the confidence that can properly be placed in it, how a technological artefact or system comes to be designed, manufactured and used

(iii) an understanding of science and technology as cultural enterprises, including the values and assumptions which they accommodate and the mechanisms by which they are controlled and managed.

The relative weighting of these three elements in programmes designed to foster scientific or technological literacy is a matter of considerable importance. As far as science is concerned, it seems likely that (iii) requires much more attention than it has hitherto received within science education. It is this third element that lays the foundation of an informed trust in science, without which (i), the staple of much traditional science education, is likely to have little significance. Likewise, as far as technology education is concerned, making clear the characteristics of technology as a community of practice seems a prerequisite for a technological literacy which allows the citizen not only to recognize the central role of values in technology but also to question experts about the alternatives that were, or might have been, available and to explore their relative advantages and benefits.

The items in the bibliography also confirm that the current drive for enhanced scientific and technological literacy is strongly related to concerns about national economic competitiveness in rapidly changing world markets. However, this association of STL with economic advantage is not one to be taken at its face value. The relationships between scientific and technological literacy within a population and the generation of national wealth are complex and imperfectly understood, and their over-simple association is likely to burden scientific and technological education with responsibilities that cannot be met. This, of course, in no way denies that both science and technology have a crucial role to play in the development of human resources which are fundamental to economic prosperity.

It would be a mistake to see the case for STL solely in instrumental/economic terms. The items cited in this bibliography indicate that importance is also attached to STL as a means of ensuring (i) an adequate and respected scientific and technological workforce; (ii) a sustainable economic growth that secures an acceptable quality of life for all future generations; (iii) the empowerment/enabling of women or other groups within society; (iv) that citizens can contribute in informed ways that allow them to participate in democratic decision making about issues that have a scientific or technological dimension. To these should be added a claim for STL that is perhaps all too readily overlooked, namely that such literacy is an essential component of a liberal education, i.e. an education which makes people free by enabling them to conceptualize, express and recover meanings, in a world in which science and technology have become two of the most powerful symbolic systems.

It is by no means clear that programmes concerned with scientific and/or technological literacy can accommodate satisfactorily and simultaneously these different rationales for SL and TL. Narrowly conceived economic functionalism/instrumentalism may not sit easily alongside a commitment to sustainable growth/environmentalism, and the interrogative dimensions of STL may bring conflict with government or multinational corporations reluctant to expose their decision making processes or the data upon which they rely. By what mechanisms are the competing claims for STL to be resolved and with what outcome(s)?

The literature relating to the meanings of, and rationales for, scientific and technological literacy suggests an agenda to be addressed. As concepts, SL and TL need to be explained, promoted and translated into operational education programmes which, collectively, reflect different cultures and the values and advocacy of different interest groups. There is a corresponding need to share understanding and experience of these programmes and to explore the extent to which it is possible to establish common ground. It is hoped that this bibliography will encourage work towards these ends.

David Layton, Edgar Jenkins, Jim Donnelly
Leeds, November 1994

ACKNOWLEDGEMENTS

In an attempt to achieve an international coverage of our topic, we have been helped by many colleagues and friends around the world. Professor John Penick (University of Ohio) kindly provided a listing of SL articles compiled as part of Phase I of Project 2000+. Dr Rodger Bybee, Associate Director of Biological Sciences Curriculum Study (BSCS), generously made available to us two extensively referenced chapters from his forthcoming book on *Scientific Literacy*. Professor Michael Dyrenfurth (University of Missouri, Columbia) provided a wealth of material on the subject of TL, both books and journal papers. Professors David Waddington (York University) and Peter Kelly (Southampton University) pointed us to science and technology educators in countries around the world who were able to assist us in the search for relevant source material. We also benefited from access to networks associated with UNESCO, ICASE, ICSU/CTS and OECD, among other organizations. Those who provided source material and information include:

Professor V. Basnayake (Sri Lanka)

Dr Malcolm Carr (University of Waikato, New Zealand)

Dr Marian Divine (Scottish Council for Research in Education)

Dr P. James Gaskell (University of British Columbia)

Dr June George (University of the West Indies)

Dr Ved Goel (British Council Division, British High Commission, New Delhi)

Dr Lucille C. Gregorio (UNESCO Principal Regional Office for Asia and the Pacific)

Dr Tapani Kananoja (Finland)

Dr Robert McCormick (Director, Centre for Technology Education, Open University, UK)

Dr Yuri Orlik (Byelorussian University)

Dr Glenda M. Prime (University of the West Indies)

Mrs Bongile Putsoa (University of Swaziland)

Dr Geisha Rebolledo (CENAMAC, Venezuela)

Professor Svein Sjoberg (University of Oslo, Norway)

Dr Pisarn Soydhurum (Siam University, Bangkok)

Professor Peter E. Spargo (University of Cape Town)

Dr Joseph Stoltman (University of Michigan)

Mrs Eileen Turner (University of Stirling)

Mrs Sylvia Ware (Education Division, American Chemical Society)

Dr Patrick Whittle (University of Malawi)

Dr W. F. Williams (Co-editor, *Bulletin of Science, Technology and Society*, Pennsylvania State University)

We are indebted to UNESCO for a grant in aid of the production of this bibliography and to Mr Emmanuel Apea, Chief, Science and Technology Section, Division for the Renovation of Educational Curricula and Structures, UNESCO, for his constant advice, encouragement and support. We thank the University of Leeds for material support of various kinds, not least our colleagues in the University Library and those who undertook computer searches on our behalf. Finally, to Helen Barker who transformed annotations in three different styles of handwriting into immaculate text with outstanding speed, efficiency and good judgement, we owe a particular debt of gratitude.

ABBREVIATIONS

SL	scientific literacy
TL	technological literacy
STL	scientific and technological literacy
CL	computer literacy
STS	science, technology and society

ADAMS, D.L. 1990 1

Science education for non-majors: the goal is literacy, the method is separate courses. *Bulletin of Science, Technology and Society,* 10(3), 125-29.

SL is defined as an understanding of (I) the nature and limitations of science; (2) the basic concepts and principles (laws and theories) of science; (3) the technological applications of science; (4) the value of science as a contributor to a decision-making process on the major societal issues of our time; and (5) the uses of scientific knowledge in public policy decisions. SL is contrasted with 'science mastery' for specialists.

AGIN, M.L. 1974 2

Education for scientific literacy: a conceptual frame of reference and some applications. *Science Education,* 58(3), 403-15.

Attempts to provide a frame of reference to help consolidate and summarize the many definitions of SL. Identifies and discusses six broad categories of themes for education for SL: science and society; ethics of science; nature of science; concepts of science; science and technology; and science and humanities. Draws heavily on an earlier analysis of SLby PELLA, M.O., O'HEARN, G.T. and GALE, C.W. 1966. Referents to scientific literacy, *Journal of Research in Science Teaching,* 4, 199-208.

AIKENHEAD, G.S. 1980 3

Science in Social Issues. Implications for Teaching. Ottawa, Science Council of Canada.

This long (81 pages) and tightly argued essay approaches the notion of SL from the standpoint of the consumer of science education. It deals with the different kinds of scientific knowledge 'learned' in science classrooms, different social roles which students would assume as adults, and different ways in which they would use their scientific knowledge. Emphasis is placed on decision making for science related issues. Illuminating 'real-life' examples enhance the exposition. The author concludes that the personal interpretation of nature and of one's society is the highest priority for the scientifically literate citizen. An extensively referenced and scholarly contribution.

AIKENHEAD, G.S. 1985 4

Decision making on social issues related to science and technology. In HARRlSON, G.B. (ed.) *World Trends in Science and Technology Education,* Nottingham, Trent Polytechnic, 139-44.

Asks to what extent can society tolerate scientifically illiterate judges, politicians, managers and industrialists making decisions on social issues related to science and technology. Identifies prerequisite knowledge required for science education which prepares future key decision makers: the characteristics of science; the characteristics of technology; the limitations of science and technology; and the interactions among science, technology and society.

See also: AIKENHEAD, G.S. 1990 Scientific and technological literacy, critical reasoning and classroom practice. In NORRIS, S.P. and PHILLIPS, L.M. (eds.) *Foundations of Literacy Policy in Canada,* Calgary, Detselig Enterprises Ltd., 1 27-44.

AJEYALEMI, D. (ed.) 1990 5

Science and Technology Education in Africa. Focus on seven sub-Saharan countries. Lagos, University of Lagos Press.

Argues that a major aim of education in science and technology should be to infuse in students those modes of thought and action associated with the inquiry nature of science as well as the design and decision-making processes characteristic of technology. The book examines the extent to which these aims are achieved in Ghana, Lesotho, Nigeria, Swaziland, Uganda, Zambia and Zimbabwe (separate chapters by different authors). In a concluding chapter the editor provides a comparative analysis: a shift from an academic curriculum to a more relevant one based on the local environment is one general trend; technology education is still associated with technical education and suffers from low status; only in Ghana and Nigeria is an integrated course on technology education compulsory in junior secondary schools. Even there, curricula remain too narrow and tied to training in manual and vocational skills. Africa remains a consumer of technology rather than a contributor to contemporary technological culture.

AMARA, J.M. 1987 6

Indigenous technology of Sierra Leone and the science education of girls. *International Journal of Science Education,* 9(3), 317-24.

Argues that stressing the relevance of indigenous technology as a 'basis for science education' will encourage girls' involvement. This in turn is needed to encourage technological development. The need for such development appears to be justified on largely economic grounds, though the case is largely taken to be self-evident.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS) 1989 7

Science for All Americans. A Project 2061 Report on Literacy Goals in Science, Mathematics and Technology. Washington, DC 20005, AAAS.

What is the substance of SL, who can be expected to acquire the requisite knowledge and skills, and how can SL be achieved nation-wide in the US are the questions to which Project 2061 is developing answers. Its stance is that SL embraces science, mathematics and technology as interdependent human enterprises, each with strengths and limitations. SL also encompasses social sciences. Phase 1 of the Project, of which this volume is a report, established a conceptual base for reform and provides a major statement on the justifications and meaning of SL.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE 1993 8

Benchmarks for Science Literacy. New York and Oxford, Oxford University Press.

A further report from Project 2061, the benchmarks - occupying some three hundred pages of the volume - are statements of what *all* students should know or be able to do in science, mathematics and technology by the end of grades 2 5, 8 and 12. They define the common core of learning that contributes to the SLof all students, though many students will extend their learning beyond this core.

APEA, E. and KHAN, N.G.A 1988 9

The role and training of the science communicator. *CASTME Journal,* 8(2) 25-32.

Argues that scientific literacy involves increased communication skills among all with scientific knowledge, including practising scientists. 'Popularizing' science should cease to be seen as 'secondary to research'. Pupils' mother tongues should be used, and more imaginative ways of communicating (e.g. drama) should be developed by teachers. Specific forms of training are needed for each potential science communicator.

ARSECULARATNE, S.N. 1992 10

Scientific literacy: its meanings and significance. Keynote address: *Proceedings of the Eighth Asian Symposium of ICASE, Colombo, 2-6 August 1992*, Colombo, Sri Lanka Association for Science and Mathematics Education, c/o ICT, University of Colombo, PO Box 1490, Colombo 3.

The continued existence of problems associated with poor quality of life, low per capita food consumption and inadequate health care is in some measure due to indigenous scientific activity remaining satellitic to centres of Western science. Definitions of SL are reviewed from the perspective of the developing world. Four components of 'the matrix of SL' are identified: the social history of science; the factual content of science; scientific habits of mind; and the interaction between science, the public and the government. SL is essential for self-reliance and ability to cope with environmental problems: without it there is the possibility of manipulation by commercial or political interests. All four components of SL should be developed in schools where the present lack of practical instruction in science and a possible emphasis on applications ('black box' science), rather than understanding, will do nothing to lessen the technological dependence of Third World countries.

ASIAN PROGRAMME OF EDUCATIONAL INNOVATION FOR DEVELOPMENT (APEID) 1983 11

Science for All: Report of a Regional Meeting, Bangkok, 1983. Bangkok, UNESCO.

This report of a regional meeting attended by participants from 19 countries asserts that to achieve endogenous development, gain true self-determination and sustain healthy advancement, it is not sufficient to have just an elite cadre of experts. Science for all is needed, 'all' including not only children in primary and secondary schools, but also out-of-school children and youth, the work force including vast numbers of illiterates and the educated adult section of the populace. Science for all is not to be a lower status programme and fundamental criteria for the selection of content are specified. Useful knowledge, applicable skills, appreciation of science and technology in context and in relation to national development feature strongly. Such a course would be very different from one whose principle of organization was derived from the nature of the subject itself.

ASIA AND THE PACIFIC PROGRAMME OF EDUCATIONNAL INNOVATION FOR DEVELOPMENT (APEID) 1991 12

Popularization of Science and Technology: Delivery Systems for Out-of-School Science Activities including Regional Science Olympiads. Bangkok, UNESCO.

The assumption underlying this publication is that as 'people are helped to develop better living skills through the practical application of scientific principles, they will also develop scientific and technological awareness'. The booklet reviews the delivery systems for out-of-school science education directed at the formal school population, the out-of-school population, the work force and educated adults within a number of countries of Asia and the Pacific.

ASIAAND THE PACIFIC PROGRAMME OF EDUCATIONAL INNOVATION FOR DEVELOPMENT (APEID) 1991 13

Values and Ethics and the Science and Technology Curriculum. Bangkok, UNESCO Principal Regional Of fice for Asia and the Pacific.

'Science for All', embracing STS approaches, was affirmed by participants and resource persons at a meeting representing 12 countries of the region. Economic and cultural development entails both creative scientists of high calibre and 'a scientifically literate population' (p. 3). In their education, values and ethics should be addressed as part of the science and technology curriculum at both primary and secondary levels (examples are given in contributed papers). A broad view of science is adopted - 'conceptualized as something more than what has been traditionally taken as the domain of science'. In particular, 'Technology is a product of science, and a concern with technology should be a part of science' (p. 5).

ASIA AND THE PACIFIC PROGRAMME OF EDUCATIONAL INNOVATION FOR DEVELOPMENT (APEID) 1991 14

Science Curriculum for Meeting Real-Life Needs of Young Learners. Bangkok, UNESCO Principal Regional Office for Asia and the Pacific.

The publication aims to contribute, through innovations, to the strengthening of national capacities of the Member States to achieve relevant science and technology education for all. There are four chapters. Chapter 1 presents country experiences and discusses the current trends and issues in primary and lower secondary science learning. Chapter 2 provides a framework for real-life needs scientific competencies, creativity and relevance. Chapter 3 discusses the guidelines for developing science curricula derived from real-life experiences of the learners. Some basic assumptions in developing exemplars are also put forward. Chapter 4 includes the exemplars which are intended to provide modules to help teachers bring about effective changes in their teaching.

(Annotation supplied by Lucille Gregorio.)

ASIA AND THE PACIFIC PROGRAMME OF EDUCATIONAL INNOVATION FOR DEVELOPMENT (APEID) 1993 15

Future Contents in Secondary School Science. Bangkok, UNESCO Principal Regional Office for Asia and the Pacific.

The publication presents new trends in science and technology education at secondary level, future content and curricular designs. It is concerned with education for beyond the year 2000 and with the curriculum models, structures and strategies for the purpose.

(Annotation supplied by Lucille Gregorio.)

ASIA AND THE PACIFIC PROGRAMME OF EDUCATIONAL INNOVATION FOR DEVELOPMENT (APEID) 1993 16

Strategies and Methods for Teaching Values in the Context of Science and Technology. Bangkok, UNESCO Principal Regional Office for Asia and the Pacific.

Presents the framework on the objectives and content of values education: the strategies that should be emphasized in the teaching-learning process, and the different ways of evaluating the learning outcomes. Guidelines were prepared on preparation of materials for teacher training.

(Annotation supplied by Lucille Gregorio.)

ASSOCIATION FOR SCIENCE EDUCATION, UK (ASE) 1981 17

Education through science - the policy statement of the Association for Science Education 1981. *School Science Review,* 63(222), 5-52.

This seminal statement presents the case for 'Science for All' and explores some of the implications for pedagogy, assessment, resources and teacher education. It distinguishes science as an intellectual discipline, as a cultural activity and as an endeavour which can be applied in the 'worlds of *work, citizenship, leisure* and *survival'.*

ASSOCIATION FOR SCIENCE EDUCATION, UK (ASE) 1988 18

Technological Education and Science in Schools. An ASE Occasional Paper. Hatfield, ASE.

Develops a conception of technological education consisting of four distinct but interrelated strands and explores the relationship of these to science education. The four strands are: (1) *technological literacy* - a familiarity with the content and methodologies of a range of different technologies; (2) *technological awareness* - an awareness of the personal, moral, social, ethical, economic and environmental implications of technological developments; (3;) *technological capability* - ability to tackle successfully a technological problem, both independently and in co-operation with others, (4) *information technology*-competence and confidence in the technological handling of information. Permeating and overarching these four strands should be a school's technological ethos.

ASSOCIATION FOR SCIENCE EDUCATION, UK (ASE) 1992 19

ASE Policy. Present and Future. Hatfield, ASE.

The ASE Policy Statement on *Balanced Science* states: 'In preparing our pupils for the 21 st century, we must work towards both universal scientific literacy and the maximum access to courses in science beyond the age of 16.'

The ASE Policy Statement on *Technology* states: 'The development of technological literacy and capability will also provide many young people with relevant and appropriate preparation for adult life and employment.'

ATANASSOVA, M. 1989 20

Computer literacy of teachers and students: a key component of their technological training. In DE KLERK WOLTERS, F., MOTTIER, I., RAAT, J.H. and DE VRIES, M.J. (eds.) *Teacher Education for School Technology. Report PATT-4 Conference,* Eindhoven, Pedagogical Technological College, PO Box 826, 5600 AV Eindhoven, The Netherlands, 402-09.

Although there is no consensus about the 'contents' of computer literacy in Bulgaria, some describe it as a 'second literacy', a key component of the technological culture of today. CL of secondary school students in Bulgaria includes familiarization with the principles of operation of electronic computer equipment; main characteristics of computer hardware and software; essentials of programming; the acquiring of skills for independent and competent work with computers. Various levels of CL of teachers are described.

BARNES, J.L. and EREKSON, T.L. 1991 21

Labor, private sector, and governmental perspectives on technological literacy. In DYRENFURTH, M.J. and KOZAK, M.R. (eds.) *Technological Literacy,* Council on Technology Teacher Education 40th Yearbook, Peoria, IL 61615-2190, Glencoe Division, Macmillan/McGraw-Hill, 94-118.

Reviews workforce trends and changes, the nature of work and workforce skills/competencies for the future, concluding that a technologically literate workforce is necessary to enable US industry to compete in a global market. To develop TL successfully, the corporate world must be involved in educational partnerships. Citizens need to be educated about technology, its history, promises, possibilities and impacts.

BARROW, L.H. AND MORRISEY, J.T. 1989 22

Energy literacy of ninth-grade students: A comparison between Maine and New Brunswick. *Journal of Environmental Education,* 20(2), 22-25.

The study explores and identifies differences in the levels of understanding of energy and relates these to gender and geographical location.

BAUER, H.H. 1992 23

Scientific Literacy and the Myth of Scientific Method. Urbana and Chicago, University of Illinois Press.

Whilst acknowledging that profound ignorance and misconceptions about science and technology can have regrettable consequences, Bauer focuses largely on the high order of prevailing misconceptions, as opposed to rank ignorance, about science and technology. He finds these misconceptions even among those who loudly bemoan the lack of SL. What science is, what it means to be scientific, and what is the relationship between science and technology are the source of dramatic misunderstandings which he illustrates. SL is 'being able to see science as a strand in the intellectual and religious history of humanity'.

BENSON, M.J. 1991 24

Educational Perspectives on Technological Literacy. In DYRENFURTH, M.J. and KOZAK, M.R. (eds.) *Technological Literacy. Council on Technology Teacher Education 40th Yearbook,* Peoria, IL 61615-2190, Glencoe Division, Macmillan/McGraw-Hill, 119-37.

Identifies and describes key educational organizations, mostly in the USA, which are concerned with technology education. Provides definitions of TL from industrial training organizations. Outlines the roles of citizen with respect to technology as user, purchaser, consumer, decision-maker, employee/worker and planner for the future.

BHATTACHARYYA, P.K. 1993 25

Should technology be a separate subject in the school? In CHOWDIAH, M.P. (ed.) *Structure and Limitations of Technology Policy: Proceedings of the Seventh Indian Engineering Congress, February 1993, Bangalore,* New Delhi, Tata McGraw-Hill Publishing Co. Ltd.

Technology, as a component in the general education of all school students, is needed in order to bring science closer to everyday challenges and to achieve manipulative skills and understandings of the interactions of science, technology and society which are essential to the development of full SL. Reviews the relationship of technology education to vocational and technical education. Urges a review of school curricula in order to see how technology may best be introduced at all levels; for a modest beginning, sees a link with the teaching of science as a realistic possibility. Technology could be an integrating factor which will bring many subjects together.

BIGALA, J. and KING, K. 1986 26

Interrelated teaching of science, mathematics and technical/vocational subjects as a preparation for the world of work. *CASTME Journal,* 6(2), 23-27.

Argues that 'lack of co-operation between education and the world of work is a matter of deep concern'. Suggests Fat, despite the threat of a narrow prescribed curriculum, such co-operation is essential, and that it should be based on interrelating subjects across the curriculum, greater emphasis on 'practical problem-solving methods' and greater active involvement by industry and commerce in the practice of education.

BINGLE, W.H. and GASKELL, P.J. 1994 27

Scientific literacy for decision-making and the social construction of scientific knowledge. *Science Education,* 78(2), 1 85-201 .

Two approaches to the nature of scientific knowledge are outlined. They are termed positivist and social constructivist. Their relevance to decision-making in the context of modern societies is examined. The first of the two approaches is thought to require knowledge of the 'constitutive values' of scientific practice to enable useful participation in decision-making, while the second 'provides citizens with accessible standards for evaluating scientific knowledge claims'. The authors argue that this latter approach is an appropriate framework for SL.

BIOLOGICAL SCIENCES CURRICULUM STUDY(BSCS) 1993 28

Developing Biological Literacy. A Guide to Developing Secondary and Post-secondary Biology Curricula. Colorado, BSCS.

The development of BL is a lifelong, continuous endeavour. Four distinct levels of BL are proposed: nominal - able to identify terms and concepts; functional able to use vocabulary, define terms correctly; structural - understand the conceptual schemes, procedural knowledge and skills; and multidimensional understand the place of biology among other disciplines, know the history and nature of biology, and understand the interactions between biology and society.

BLACK, P. and HARRISON, G. 1985 29

In Place of Confusion. Technology and Science in the School Curriculum. London and Nottingham, The Nuffield-Chelsea Curriculum Trust and the National Centre for School Technology, Trent Polytechnic.

Uses the term 'capability' rather than 'literacy', but many of the arguments have relevance to the meaning of STL. Presents a rationale for the purpose and nature of technological work in schools and sees science as an essential resource for technology. Outlines a view of the science curriculum which is consistent with the model needed for technology and develops an overall school curriculum plan to achieve 'full scientific capability', 'full technological capability' and a 'critically aware citizenry' amongst other types of capability.

BLANDOW, D. 1992 30

Tools for overcoming thought barriers: the missing element for effective technology education. In BLANDOW, D. and DYRENFURTH, M. (eds.) *Technological Literacy, Competence and Innovation in Human Resource Development,* Columbia, MO, Applied Expertise Associates,338 Crown Point, Columbia, MO 65203, USA, 524-36.

Outlines a competencies based concept of technology education and emphasizes the need to view any technology in relation to the supra- and sub-systems of which it is a part. In relation to the technological problem solving/innovation process, develops the concept of a 'modular tool box' to assist in the overcoming of thought barriers at each of seven stages of the process. To be successful problem solvers, young people must not only know the steps in the problem solving process but also must be adept at identifying and confronting the barriers to their own application of the process. In that way, they will become technologically literate, i.e. able to properly overcome barriers by the application of an understanding of, and capability with, ideas, materials, tools, processes, energy.

BLANDOW, D. and DYRENFURTH, M. (eds.) 1992 31

Technological Literacy, Competence and Innovation in Human Resource Development. Proceedings of the First International Conference on Technology Education. Columbia, MO, Applied Expertise Associates, 338 Crown Point Columbia, MO 65203, USA.

This volume of some 600 pages includes the 15 Keynote Presentations and the many papers delivered at the ICOTE, Weimar, Germany in April 1992. Major themes were: strategy transfer; the interchange of technology education between Eastern and Western countries; and technology, creativity and innovation. A number of the presentations and papers are annotated separately under the name of the author(s).

BODMER, SIR WALTER 1989 32

Scientific literacy for health and prosperity. *School Science Review,* 70(253), 9-22.

The author, arguing for 'sciency' (compare literacy, numeracy), asserts that an adequate science education at school is the 'cornerstone for a general public understanding of science'. The relevance of knowledge and of an understanding of probability/risk are highlighted in a discussion of science and health education.

BOWYER, J. 1990 33

Scientific and Technological Literacy: Education for Change. Paris, UNESCO.

The author argues strongly that worldwide scientific and technological literacy is essential if existing and future challenges are to be met. The key element in the analysis is 'development', to which science and technology are seen as the major contributors. The pamphlet reviews 'the facts' and issues required for policy development in several domains, focusing on formal education. There is a review also of the role of women, and a particular stress on the need to give priority to the education of 'third world rural women', in part because of their key role in agriculture.

BRICKHOUSE, N.W., EBERT-MAY, D. and WIER, B.A. 1989 34

Scientific literacy: perspectives of school administrators, teachers, students, and scientists from an urban mid-Atlantic community. In CHAMPAGNE, A.B., LOVITTS, B.E. and CALINCER, B.J. (eds.) *This Year in School Science 1989. Scientific Literacy,* Washington, DC, American Association for the Advancement of Science, 157-76.

Explores the extent of consensus on the meaning of SL among four groups from one local community, as in the title (the students were university ones). A multidimensional concept of SL was used, based on Roberts' (see ROBERTS, 1983) seven curriculum emphases, plus a further category, 'Appreciation of Science'. Discussants achieved limited consensus on the outlines of what ought to be taught to create a citizenry with SL, but major disagreements emerged on matters of detail and also on the reasons for the competencies identified as necessary. Because they lived in the same community, members of the four groups shared many interests and concerns. The authors speculate on the extent of differences when attempting to reach a national consensus on the meaning and justifications for SL.

BROOKS, H. 1991 35

Scientific literacy and the future labour force. In HUSEN, T. and KEEVES, J.P. (eds.) *Issues in Science Education. Science Competence in a Social and Ecological Context,* Oxford and New York, Pergamon Press, 19-29.

Describes attempts to construct elements of SL by AAAS Project 2061 and by the US National Research Council's Mathematical Sciences Education Board. Mathematical literacy is probably the most important single element of SL. A strong foundation in basic literacy and symbol-manipulation skills is required to use technologies intelligently. A danger with the current enthusiasm for TL is that too much emphasis will be placed on training in the use of technologies that will rapidly become obsolete.

BUGLIARELLO, G. 1990 36

Empowering citizens through technological literacy. *Bulletin of Science, Technology and Society, 10(4),* 187-90.

TL is meaningless without basic literacy. Key concepts in science and technology must be identified (as in Project 2061; see AAAS 1989). TL as a practical tool is meaningless without also focusing on personal habits/attitudes: accuracy, reliability etc. are essential for functioning successfully in a complex socio-technological environment. Above all, TL entails the development and empowerment of a new set of ethical concerns and responsibilities.

BULLETIN OF THE UNESCO REGIONAL OFFICE FOR EDUCATION IN ASIAAND THE PACIFIC 1982 37

Special Issue. Out-of-School Science in Asia and the Pacific. Bangkok, UNESCO.

The whole of this special issue is devoted to accounts of out-of-school science in countries of the region. There is an extensive Bibliographical Supplement.

BYBEE, R.W. (ed.) 1985 38

Science-Technology-Society. 1985 Yearbook of the National Science Teachers Association. Washington, DC 20009, NSTA.

Includes Bybee's own important chapter, 'The Sisyphean question in science education: what should the scientifically and technologically literate person know, value, and do - as a citizen?' (79-93). Bybee's subsequent work has yielded a framework for STL, developed at BSCS. This distinguishes between: *nominal* STL, basically word association; *functional* STL, ability to read, write and talk about science and technology; *conceptual and procedural* STL, understanding parts and whole of science and technology as disciplines; and *integral and contextual* STL, understanding the conceptual structures, history and philosophy of science and the interactions of science, technology and society. The 1985 Yearbook also includes E. J. Piel on TL (155-57). 'The technologically literate person understands some of the basic concepts of engineering (what a system is, how feedback affects systems, what probability is, how models are used); has some understanding of how certain technologies work and what their capabilities and limitations are; recognizes that technologies are matched to the users; and has confidence to learn about technology even without a technical background.'

BYBEE, R.W. (ed.) 1993 39

Reforming Science Education. Social Perspectives and Personal Reflections. New York and London, Teachers College Press.

This collection of previously published papers, adapted for this volume and accompanied by the author's reflections, contains many references to SL, including a conceptual framework for STL. It is argued that the STS theme should be expanded to include some understanding of the nature and history of science and technology - their strategies and processes, the differences between science and technology and their cultural heritage.

CAMBROS, J., HELLER-HENDRICK, J. and SABONIS-CHAFFEE, B. 1992 40

Educating global citizens. *Tough Questions*, Summer 1992, 11 and 15 (published by Student Pugwash USA,1638 R Street NW, Suite 32, Washington, DC 20009-6446, USA).

This report of an Education working group at the Student Pugwash 7th International Conference addresses the issue: Educating for the Socially

Responsible Use of Technology. 21 Criteria were developed in moving to a working definition of 'socially responsible technology' as: 'must be environmentally and economically sound, politically and socially acceptable over time, and it must meet the needs of today's population without compromising the needs of future generations'. Formal education should prepare globally educated citizens with skills in critical thinking, creativity, empathy, and the ability to communicate effectively. They must also be ethically concerned and able to develop, select, and use culturally sustainable technologies.

CANNON, J. AND JINKS, J. 1992 41

A cultural literacy approach to assessing general scientific literacy. *School Science and Mathematics,* 92(4), 196-200.

claims there is a gap between the existing school curricula in science and the demands of living in a scientifically and technologically driven economy. Draws on Hirsch*'s Cultural Literacy. What Every American Needs to Know* and the accompanying *Dictionary of Cultural Literacy* to extract science-related terms. A Panel is used to Q-sort items, which fall into five discipline areas: physical science and mathematics; earth science; life Science; medicine; and technology. Finds the terms drawn from Hirsch are not influenced by Subgroup characteristics, but a value ;judgment remains as to whether a 50 per Cent score by an individual is 'good' Or 'bad'.

CHAMBERLAIN, P.J. 1981 42

Superstitious beliefs and the learning of science in a developing country. *CASME Journal,* 2(1), 1-9.

Surveys research in this area and presents empirical data .The data show a moderate degree of belief in superstitious explanations of simple phenomena, and no simple relationship with age. The author questions whether any simple distinction can be drawn between superstition and religious belief, argues that efforts should be made to indicate the boundaries of the authority of science but suggests that certain beliefs in areas of agriculture and medicine need to be challenged through science.

CHAMPAGNE, A.B. and KLOPFER, L.E. 1982 43

Action in a time of crisis. In HEAD, J. (ed.) *Science Education for the Citizen. The Proceedings of a UK/USA Science Education Seminar*, London, The British Council, 159-66.

A major theme in this paper is to show how SL is pertinent to society's needs. Knowledge of the concepts, principles and theories of science are prerequisites to TL, needed by industry and the military. Other justificatory arguments are built around society's desire for the well-being of its people, the need for effective citizens, and national pride especially in the face of educational comparisons with the Soviet Union.

CHAMPAGNE, A.B., LOVITTS, B.E. AND CALINGER, B.J. (EDS.) 1989 44

This Year in School Science 1989. Scientific Literacy. Papers from the 1989 AAAS Forum for School Science. Washington, DC, American Association for the Advancement of Science.

The editors describe SL as a concept in search of a definition and the six chapters which follow their introduction to this volume bring perspectives from economics, philosophy, science and education to bear on the meaning of SL. Attempts to achieve some empirical warrant for SL are described, as are levels of SL and its relationship not only to knowledge-sharing but also to power-sharing. Individual chapters are annotated separately under the names of their authors. In their introductory chapter, Champagne and Lovitts (1 - 14) describe a conceptual framework for SL in terms of which they discuss barriers to consensus.

For a critical review of this volume see PAGE, REBA N. 1992 *Journal of Curriculum Studies,* 24(5), 474-80.

CHAMPGNE, A.B. and NEWELL, S.T. 1992 45

Directions for research and development: alternative methods of assessing scientific literacy. *Journal of Research in Science Teaching,* 29(8), 841-860.

Acknowledging the severe limitations of conventional testing in the USA, the authors outline a 'Research and Development Agenda', directed towards the design of exercises intended to measure accurately the diverse outcomes that comprise scientific literacy.

CHAPMAN, B. 1991 46

The overselling of science education in the eighties. *School Science Review,* 72(260), 47-64.

The author offers an important critique of most of the major claims made for science education in the 1980S, including that for 'science education for citizenship'. He concludes that science for *all is* an unattainable and unrealistic goal for school science education.

CHHOTAN SINGH 1985 47

Relevance of the science we teach in schools. In HARRlSON, G.B. (ed.) *World Trends in Science and Technology Education,* Nottingham, Trent Polytechnic, 61 -66.

Asserts that little is being done to improve SL among the masses and to help improve sanitation in homes and prevent disease. The main elements of science education which responds to the actual needs of people in developing countries - the author writes from an Indian perspective - are: development of capability for adapting to change; improvement of the lot of the poor in the shortest possible time; engagement in problem-solving and decision-making activities; and the integration of technology in the teaching of science.

CHISMAN D. 1984 48

Science education and national development. *Science Education,* 68(5),563-69.

Reviews UN and UNESCO pronouncements on science and technology for national development and argues for a more practical outcome from science education. Compelling reasons for SL in a country are: (1) to function successfully and responsibly in a scientific and technologically based society, to be safe, healthy and comfortable; (2) to maintain a vigorous democratic state in which citizens participate knowledgeably in deciding public issues; and (3) to maintain and expand the world-wide position of the country. Considers the role of science teacher associations and international organizations such as ICASE and ICSU: leads up to the 1985 Bangalore Conference.

CHISMAN, D. and HOLBROOK, J. 1990 49

Summary Report. The Future Direction of Sustainable Development in the Curriculum. International Council of Associations for Science Education.

This report discusses the outcomes of a meeting to interpret the idea of sustainable development (s.d.) in an educational context and to see how s.d.

concepts can be integrated into the curriculum. An understanding of s.d. in the context of environmental, economic and energy strategies, thus promoting the sharing of a better quality of life, is in harmony with the declared aims of UNESCO for STL for all, worldwide. It is argued that s.d. education, through environmental education, energy education, health education and an understanding of economic development, is essential. Strategies for change are reviewed and criteria for change identified: relevance, practicality and values driven. Curriculum models for s.d. education are considered and the relationship between environmental literacy and s.d. literacy examined.

COLLINS, H. 1993 50

Untidy minds in action. *The Times Higher Education Supplement, 9* April 1993, 15, 17.

Collins argues that there are several types of understanding of science. That required by the general public is such as to enable judgements to be made in cases of scientific controversy and to prevent political issues being decided by experts claiming 'science' as their authority. In other words, 'it is education for democracy that is at issue'.

COLLINS, H. AND PINCH, T. 1993 51

The Golem: What Everyone Should Know about Science. Cambridge, Cambridge University Press.

Written by two sociologists of science, the book is intended 'for the general reader who wants to know how science really works'. (The golem is a creature of Jewish folk-lore, well-meaning, but prone to mistakes.) Seven case studies of science being 'done', ranging over biology and physics especially, are used to reveal science as a much messier and more problematic enterprise than it is commonly portrayed. The authors claim that for citizens 'who want to take part in the democratic processes of a technological society, all the science they need to know about is controversial'.

COLLINS, H.M. 1987 52

Certainty in the public understanding of science: science on television. *Social Studies of Science,* 17(4), 689-713.

Collins criticizes the Royal Society report on the public understanding of science because of its emphasis on scientific facts rather than the process by which scientific knowledge is created. He illustrates, by analyses of two television programmes, how an image of certainty and inevitability is created for scientific knowledge, and argues that a more reflective understanding of scientific activity among the public is an important goal.

COLLINS, P.M.D. and BODMER, W.F. 1986 53

The public understanding of science. *Studies in Science Education, 13,* 96- 104.

The authors were joint secretary and chairman respectively of the *ad hoc* group of the Royal Society which produced a report on *The Public Understanding of Science* in 1986. The article summarizes the report which discusses in some detail the roles of the formal education system, the media, museums, libraries, industry and the scientific community in enhancing the public understanding of science. The exhortation to scientists to 'communicate with the public, be willing to do so, and consider it your duty to do so' reflects the concern of the Royal Society and exposes the assumption that public understanding of science is a matter of understanding science 'on the scientists' terms', coupled with appropriate supportive attitudes.

COMMONWEALTH SECRETARIAT 1985 54

Popularization of Science. Report of a Commonwealth Regional Workshop, April 1985, Lusaka, Zambia. London, Commonwealth Secretariat.

After reviewing earlier inter-governmental initiatives in the field of STL in Africa, the keynote address at this conference asks which aspects of scientific and technological understanding governments should seek to promote. Subsequent papers explore the role and training of those with particular responsibility for promoting STL through television, science journalism and formal education systems. The report concludes with summary workshop and country reports.

COURT, D. 1989 55

Forum on children's scientific and technological literacy. *Studies in Science Education,* 17, 123-25.

The Forum, supported by the Rockefeller Foundation, aims to foster popular understanding of the practical applications of science and technology, especially among children, and to promote a scientifically literate public in African countries. A fundamental assumption is that the potential benefits of science and technology will be realized only if they are based upon some popular understanding which is rooted in local African cultures and integrated with the indigenous knowledge and values of the communities. The programme aims to identify and develop ways of increasing people's ability to assess, control and benefit from the array of technological interventions that are currently being directed towards them.

CROSS, R.T. and PRICE, R.F. 1992 56
Teaching Science for Social Responsibility. Sydney, Australia, St Louis Press.

Without specific reference to SL, the authors nevertheless attribute a meaning to it by adopting 'social responsibility' as the main goal of science education. Their interpretation of 'social responsibility' involves 'understanding the nature of science as it is practised in the world of R and D; understanding the nature of theory, the relation of theory to the observations and experiments which are supposed to ground it and the role of theory in both science and technology; and the possession of minimum skills in logic and statistics/mathematics necessary to understand and evaluate the arguments which citizens of tomorrow will have to face'. The seven chapters in the book develop this theme and provide examples of teaching and curricula which are designed to enable future citizens to participate in decisions about controversial ST-related issues.

DAY, R.B., BEINER, R. and MASCIULLI, J. 1988 57
Democratic Theory and Technological Society. New York, M.E. Sharpe Inc.

A collection of articles which discuss the theories of a wide variety of philosophers and sociologists (including Marx, Lukacs, Dewey, Habermas and Benjamin) in relation to contemporary technological developments. The book is not indexed, and only the piece on Dewey (by Frank J. Kurtz) explicitly addresses educational issues, arguing that 'only the school and the teacher enjoy the political power sufficient to liberate the enormous democratic potential of technology'.

DE BOER, G.E. 1991 58

Scientific literacy and the new progressivism. In DE BOER, G.E. *A History of Ideas in Science Education. Implications for Practice,* New York and London, Teachers College Press, 173-89.

Describes how SLbecame the watchword for many science educators in the 1970S. Its relationship to the STS movement in the 1980S is analysed and the debate about social issues as organizing themes for the science curriculum is reviewed.

DELORIA, V. (Jnr.) 1992 59

Ethnoscience and Indian realities. *Winds of Change,* 7(3), 12-18.

Compares the epistemology of Western science and traditional tribal knowledge, discusses the possible expansion of some fields of scientific enquiry to embrace 'ethnoscience' and explores the role of American Indians studying science in furthering this wider perspective of scientific literacy.

DEVON, R.F. 1987 60

In praise of computer illiteracy. *Bulletin of Science, Technology and Society,* 7(1 & 2), 338-43.

Asks why is there so much concern over CL when there is little pressure for e.g. laser literacy or airplane literacy. Is the computer a meta-technology? Distinguishes between technological expertise and technological sense and asserts that there is more than one way in which to be TL. Society will benefit by having a large reservoir of people who are computer illiterate enough to ask 'awkward' questions, e.g. 'Who owns the data?', 'Will people lose their jobs?' From questions like these another form of TL - technological sense - is built up.

DE FORE, P.W. 1986 61

Measuring technological literacy: problems and issues. *Bulletin of Science, Technology and Society,* 6(2 & 3), 202-09.

Technology is defined as 'the study of the *creation and use of technical means* - tools, machines, techniques, technical systems - and the *behaviour of technological systems* in relation to people, their societies, the environment and the civilization process'. Develops a 'model' showing what to measure if one wants to assess TL in individuals. This lists the intellectual skills and abilities, the systems and components of technical means, and the contexts in which technological activity takes place.

DE PORE, P.W. 1987 62

Cultural paradigms and technological literacy. *Bulletin of Science, Technology and Society,* 7 (5 & 6), 711-19.

Basic questions about TL cannot be answered without reference to the cultural paradigm (e.g. capitalism, socialism, Buddhism etc.) in which the discussion is embedded. Characteristics of a new, evolving cultural paradigm, consisting of concerns which are grounded in ecology and the quality of human life, are identified and implications for TL are reviewed.

DOORMAN, S.J. (ed.) 1989 63

Images of Science. Scientific Practice and the Public. Aldershot, Gower.

This collection of articles discusses both scientists' self image and the image of science which is available in literature and television. The introduction presents several perspectives on the legitimate relationship between scientists and 'laymen', including the views that, on the one hand, it is the duty of scientists to promote public discussion of their work and that, on the other, scientific knowledge should be available only to those specialized in its use, or, at least, only this group should contribute to relevant political decisions. The 'Concluding Remarks' include the suggestion that theories of art education are more appropriate guides to educating the public in the 'complex world of science we would like to communicate' (228).

DURANT, J. 1993 64

What is scientific literacy? In DURANT, J. and GREGORY, J. (eds.) *Science and Culture in Europe* (a special issue of the French journal of science and culture *Alliage),* London, Science Museum.

Discusses three approaches to SL: knowing a lot of science, knowing *how* science works; knowing how science really works - concentrating upon the social structures or institutions of science - scientific culture. Argues that the public needs more than factual knowledge of science: it needs a feel for the way the social system of science works to deliver what is usually reliable knowledge about the natural world.

DURANT,J.,EVANS,G.,THOMAS,G.1992 65

Public understanding of science in Britain: the role of medicine in the popular representation of science. *Public Understanding of Science,* 1(2), 161-82.

The authors offer a reliable and valid multi-item scalar measure of scientific understanding and argue its usefulness in analysing the relationship between science and the public. The use of this measure with a random sample of 2009 adults confirms significant differences between professional and popular representations of science and suggests that medical science may be paradigmatic for the popular representation of science in Britain.

DUSHENKOV,V.M.1992 66

A new approach to teaching science in Russian secondary schools. *Science Education International,* 3(2), 14- 17.

Asserts that the survival of our civilization and the whole planet depends on whether or not our children will be educated to become *ecologically literate* (EL) (e.g. aware of the inter-connectedness of all levels of life, of living beings and non-living matter, of humankind as an integral part of the environment). Describes an Environment Course and a General Science Course which have been developed with EL as a goal, and which integrate 'nature, culture, technology, people, ideas and feelings'.

DYRENFURTH, M.J. 1990 67

Technological Literacy in Industry. Columbia, Applied Expertise Associates, 338 Crown Point, Columbia, Missouri, USA.

Reports on the evaluation of a robotics and automation literacy training program at four factory sites in middle America and describes the development and validation of an instrument to measure TL, involving cognitive, affective and psycho-motor assessments. The cognitive aspects were assessed by three instruments: a 10 item 'Today's World' scale derived from the work of J. D. Miller (see MILLER, 1983); an 18 item Content Information Inventory; and a 35 item Technological Literacy Scale derived from Dyrenfurth's model of TL (see DYRENFURTH, 1991). Affective aspects were assessed by an adaptation of Remmers' scale to yield information about: liking technology; importance of technology; learning about technology; and nature of technology.

DYRENFURTH, M.J. 1991 68

Technological literacy synthesized. In DYRENFURTH, M.J. and KOZAK, M.R. (eds.) *Technological Literacy. Council on Technology Teacher Education 40th Yearbook,* Peoria, IL 61615-2190, Glencoe Division, Macmillan/McGraw-Hill, 138-183.

A detailed and comprehensive synthesis of writings on TL, including the other chapters in this Yearbook. After a review of expanding meanings of the concept of literacy and of the nature of technology, a number of approaches to the definition of TL are described: descriptive characteristics; competency list; and graphic. Each is well illustrated. The diverse interpretations of it by the authors in the Yearbook are noted and a synthesized definition constructed with a supporting model. 'TL is a concept used to characterize the extent to which an individual understands, and is capable of using, technology. TL is a characteristic that can be manifested along a continuum ranging from *non-discernible* to *exceptionally proficient.* As such, it necessarily involves an array of competencies, each best thought of as a vector, that include: basic functional skills and critical thinking, constructive work habits, a set of generalized procedures for working with technology, actual technological capability, key interpersonal and teamwork skills, and the ability to learn independently.'

DYRENFURTH, M.J. 1991 69

European perspectives on technology and education about technology. Paper to the Technology Education Symposium XIII: Technological Impacts: Social, Environmental, Economical, Ethical. Terre Haute, Indiana, USA.

Provides insightful comparisons between European perspectives on technology education and American ones, including the meanings of TL and arguments for it. Finds agreement on TL necessarily involving 'an ability to do' and on the generic technology clusters of materials, energy and power, and communication. Beyond this, there is no single coherent concept of TL evidenced by practice in European countries and the term TL is not widely used. An important set of arguments for TL is associated with the private sector's pursuit of competitiveness. Interpretations of TL are influenced by culture and politics, an example being 'the rampant devaluation of technology education in Eastern Europe', following the political and economic reforms there, probably because of technology education's association with polytechnic education and Leninist/Marxist principles.

DYRENFURTH, M.J. 1992 70

The structure of technological competence. In BLANDOW, D. and DYRENFURTH, M. (eds.) *Technological Literacy, Competence and Innovation in Human Resource Development,* Columbia, MO, Applied Expertise Associates, 338 Crown Point, Columbia, MO 65203, USA, 397-402.

Describes a model of TL as a construct consisting of 7 vectors infused throughout a set of 5 components. Reports on an empirical study of industrialists' ratings of generalizable workforce skills needed for the future. Seven major factors were found to comprise the skills deemed most important by industry supervisors and these are said to represent the basic structure of TL as perceived by industry. The similarity between these empirically derived workforce competencies and the vectors in the model of TL is noted, as is a convergence between what the private sector is calling for from education and what the technology education profession seeks to deliver. In the face of this commonality of interest, the author asks why there is not more co-operation and urges 'our profession' to concentrate on defining the generalizable core of technological skills that lies at the heart of TL, technological competence, workforce flexibility, citizenship and personal comfort.

DYRENFURTH, M.J. and KOZAK, M.R. (eds.) 1991 71

Technological Literacy. Council on Technology Teacher Education 40th Yearbook. Peoria, IL 61615-2190, Glencoe Division, Macmillan/McGraw-Hill.

The eleven chapters of this volume are devoted to the theme of TL. Six categories of reasons for the significance of the concept of TL are given: (I) democratic needs; (2) nature of life in society; (3) dehumanization/ humanization; (4) new liberal arts directions; (5) nature of jobs/ competitiveness/workforce literacy; (6) technology as a discipline. TL is defined as a multi-dimensional term that includes the ability to use technology (practical dimension); the ability to understand the issues raised by or use of technology (civic dimension); and the appreciation of the significance of technology (cultural dimension).

EADE, E. 1992 72

Preliminary Bibliography on Traditional Science and Technology in the Pacific Islands. Pacific Information Centre, Suva, Fiji.

This annotated bibliography presents and reviews literature concerned with the traditional and technical knowledge of Pacific peoples before the arrival of the

European. There are 444 entries, drawn entirely from sources in English, and the geographical area is confined to Melanesia, Micronesia and Polynesia, excluding New Zealand. Papua New Guinea and Hawaii are also excluded. The subjects covered by the bibliography are agriculture/ethnobotany; astronomy/navigation; canoes/canoe building; conservation/resource management/ecology; fishing/fishing poisons; foodstuffs/food preservation, storage, preparation; fire/fire walking; games; houses/house building; measurement/time/weather; medicine/medicinal plants.

EDUCATION IN ASIAAND OCEANIA 1992 73

AIDS education and the school curriculum challenge. *Reviews, Reports and Notes,* No. 26 (1989-90), 1-27, Thailand UNESCO Principal Regional Office for Asia and the Pacific.

Set down goals of AIDS education (= AIDS Literacy?): to create a better understanding and awareness of the nature of the virus, the modes of transmission, preventive methods, as well as the medical and social implications of HIV/AIDS; to assist the target audience to understand the importance of the preventive methods for themselves and others; to instil in the target audience a commitment to developing such attitudes, values and behaviours as will help minimize the possibilities of being infected and infecting others. Seeks to define an educational discipline or subject area. Describes case studies of AIDS education but acknowledges that evaluation is incomplete.

EIJKELHOF, H.M.C. and KORTLAND, K. 1988 74

Broadening the aims of physics education. In FENSHAM, P.J. *Development and Dilemmas in Science Education,* London, Falmer Press, 282-305.

This is an account of the Dutch PLON project which began in 1972 and is committed to preparing students to cope with their future roles as consumers and citizens in a technologically developing, democratic society, as well as to providing the basis for future study/employment. Examples are given of 'citizen physics' and of evaluation studies of PLON initiatives.

EVERED, D. AND O'CONNOR, M. (eds.) 1987 75

Communicating Science to the Public. Ciba Foundation Conference, Chichester and New York, John Wiley and Sons.

Proceedings of an international conference: mainly USAand UK, but representatives of Australia, France, Italy, N. Zealand and Singapore also. The chapter by W. M. Laetsch (I -18) critiques instrumental reasons for promoting SL: better political decisions; economic returns; elimination of superstition; behavioural changes (e.g. cigarette smoking); a more ethical world view. Rather, according to Laetsch, SL is primarily a humanistic endeavour and should be promoted because understanding of science leads to an enriched existence, a view challenged by conference participants. The chapter by J. D. Miller (19-40) reports on attempts to measure SL of adults in the USA, using a three-dimensional measure of SL: an understanding of the process of science; the existence of an adequate vocabulary for understanding scientific communications; and the relationship of science and technology to society. A stratified model of 'the public', according to attentiveness to science, is used.

FAYARD, P. 1991 76

But where are the Cossacks? An alternative strategy for popularization. *International Journal of Science Education*, 13(5), 597-601.

Rejecting the notion that popularization of science is essentially a matter of communication, Fayard argues that the issue is one of how best such popularization can be used to further a particular policy goal and what strategic decisions need to be made to bring that goal about.

FENSHAM, PJ. 1984 77

A second chance for school systems and new vision for population outside of school. *Bulletin of the UNESCO Regional Office for Education in Asia and the Pacific. No. 25. Science Education in Asia and the Pacific*, Bangkok, UNESCO Regional Office for Education in Asia and the Pacific, 437-68.

The two very distinct societal demands on science education - specialist manpower and a more scientifically literate citizenry - are now recognized as conflicting, not complementary. Reviews the difficulties and problems associated with a concentration on the first of these demands, e.g. the majority learn they are unable to learn science; the very specialized education of the elite. To achieve 'science for all' (equated with SL), the education for the elite must be 'contained' in upper secondary education or identified as one limited (academic) form of science education or retained in the total curriculum, but as an option only. Discusses the content of 'science for all' and criteria for selection of a minimum content. Emphasizes the important role of science education for the out-of-school population.

FENSHAM, P.J. 1985 78

Science for All: a reflective essay. *Journal of Curriculum Studies,* 17(4), 41535.

Science for All (= SL) is a splendid and recurring vision in the history of science education, but if those attempting to achieve it in the 80S and 90s are not to repeat the mistakes of the 60S and 70S (e.g. assuming that a cleverly designed pedagogical approach would enable the masses to learn, and find the same satisfactions in, science as the course designers had) they will need to avoid imposing on the majority something that is, and was, important to a small minority. Unquestionably science education for an elite has been successful, although there are prices to be paid e.g. overspecialization; the problem now is how to maintain this success and also provide an effective science for all. The essay reviews changes in school systems, organization of the curriculum and, particularly, content that are necessary for the success of science for all.

FENSHAM, P.J. 1990 79

Practical work and the laboratory in Science for All. In HEGARTY-HAZEL, E. (ed.) *The Student Laboratory and the Science Curriculum,* London and New York, Routledge, 291-311.

Fensham contrasts science education for future scientists (elitist science) with Science for All (which equates with SL) and develops a case for laboratory work as part of the latter. He argues that laboratory work consistent with the aims of Science for All would have quite different roles from laboratory work in elitist science courses. Criteria for the content of SL courses are discussed and two approaches to laboratory work explored. The first involves technology as an integral part of Science for All; the second, which he calls 'product worth', involves consumer association types of investigations. The role of practical work in Science for All is likely to be quite critical if the movement from elitist science is to have any success.

FENSHAM, P.J. 1993 80

Academic influences on school science curricula. *Journal of Curriculum Studies,* 25(1), 53-64.

Building on the specific experiences of academic control over the school science curriculum encountered by a group developing a new single-science subject for the final year of secondary education in the state of Victoria, Australia, Fensham explores more generally the politics of SL, especially the actors who manage the tension between school science as preparatory to further academic study and school science as related to societal concerns.

FIFE-SCHAW, C. et al. 1987 81

Attitudes towards new technology in relation to scientific orientation at school. A preliminary study of undergraduates. *British Journal of Educational Psychology, 57(1),* 114-21.

The attitudes of 534 British undergraduates towards technology are surveyed and related to gender differences and previous scientific education at school.

FLEMING, R. 1989 82

Literacy for a technological age. *Science Education,* 73(4), 291-404.

Argues that the key result of literacy is empowerment in one's own culture and uses this idea in his subsequent interpretation of TL. Draws on research in the history and philosophy of technology to identify characteristics of technological knowledge. A person who is technologically literate must understand the relationship between technology and social change, and also the nature of decision-making in a decisionistic democracy if a depoliticized electorate is not to result. Ability to uncover the hidden value positions implicit in conflicting technological actions and claims is at least as important as technical knowledge. The implications of this view of TL for instruction at pre-service and in-service level are explored. Central points are that technology is *not* applied science and that technological knowledge is a unique form of cognition.

FLORMAN, S.C. 1983 83

Science for public consumption: more than we can chew? *Technology Review,* 86, 12-13.

Argues that reliance on experts is inescapable. A knowledgeable public, technologically literate, will not expect to resolve each technical issue by analysing evidence, but will seek to establish a fruitful relationship with its experts - and its politicians - a combination of trust and suspicion, respect and obstinacy, calculated to best translate social objectives into technical decisions.

FOUREZ, G. 1989 84

Scientific literacy, societal choices and ideologies. In CHAMPAGNE, A.B., LOVITTS, B.E. and CALINGER, B.J. (eds.) *This Year in School Science 1989. Scientific Literacy,* Washington, DC, American Association for the Advancement of Science, 89- 108.

Reviews aspects of the ideology - concepts, attitudes, and values - related to SLin four recent reports on school science (three USA, one UK). Each document presents a different view of what SL is; the influences from which differences arise are analysed. Contrasting ideologies of science and technology are explored and the author probes the social reasons that seem to forbid 'the mingling of science and technology as a unified process'. From the standpoint that SL is reflective of an image of society, Fourez criticizes the AAAS report, *Science for All Americans* (see AAAS, 1989) for portraying 'an aseptic utopia' in which poverty, hunger, racism, sexism, the Third World, military intervention, and the arms race appear not to exist. In the literature he reviews, Fourez finds the concept of SL to be an individualistic, rather than a collectivist, one: he speculates that SL is not only concerned with knowledge-sharing, but also, and perhaps mainly, with power-sharing.

FRANKEL, C.S. 1990 85

Teaching science to the unimpressed. *Bulletin of Science, Technology and Society,* 10(3), 120-22.

States that a central tenet of the STS enterprise is that a technologically literate and informed populace will make better decisions about matters related to e.g. health, environmental quality. Proposes four goals for 'minimum technological literacy': understand how science works (the 'scientific method'), and its limitations; understand that science is the only reliable means we have for answering questions and solving problems involving measurable phenomena; learn to differentiate scientific from non-scientific evidence and be sceptical about claims unsupported by science; and expect the same standards of evaluation in policy making by those entrusted with leadership. Ways of stirring children's emotions to persuade them of the importance of TL are discussed.

FULLINWIDER, R.K. 1987 86

Technological literacy and citizenship. In SHORTLAND, M. (ed.) *Scientific Literacy Papers*, Oxford, Scientific Literacy Group, Department of External Studies, University of Oxford, 31-35. (Also: *Bulletin of Science, Technology and Society* 1987, 7(1 & 2),320-24).

Attacks the belief that TL is crucial to democratic citizenship. The more informed about science that citizens become, the more they realize how inadequately prepared they are to challenge the experts. ST illiteracy is no more a matter of concern than economic and political illiteracy. Some advocates of STL claim the important features are better habits of inquiry, respect for evidence, care in drawing conclusions, a healthy scepticism and ability to manipulate formal models. But these are not unique to science and can be taught by the study of other subjects. If STL is to be supported, it needs better arguments than that 'from democracy'.

FURNHAM, A. 1992 87

Lay understanding of science: young people and adults' ideas of scientific concepts. *Studies in Science Education*, 20, 29-64.

Different research paradigms for investigating lay people's understanding of science are described and their relative strengths and weaknesses discussed. The author is critical of some research methodologies and stresses the need for some theoretical advance in, for example, studies of children's understanding of scientific ideas.

GARRARD, J. 1986 88

Health education and science education: changing roles, common goals? *Studies in Science Education,* 13,1-26.

The health education of adolescents is placed within the context of reformed science curricula which reject the pre-professional instrumentalism of traditional courses. Health education is a component of 'science for all' and the article explores the practical and theoretical implications of this claim.

GARRISON, J.W. and LAWWILL, K.S. 1992 89

Scientific literacy: for whose benefit? In HILLS, S. (ed.) 1992 *The History and Philosophy of Science and Science Education. Proceedings of the Second*

International Conference on the History and Philosophy of Science and Science Education, Vol. I, Kingston, Ontario, 337-46.

The authors attack the wholesale linking of the concept of SL to the promotion of economic efficiency and profit in business. They argue both for a wider interpretation in general and, specifically, the promotion of critical thinking in relation to science.

GASKELL, P.J. 1992 90

Science, technology and society: issues for science teachers. *Studies in Science Education, 9,* 33-46.

The author identifies three influences acting to promote an 'STS' focus within school curricula, namely a greater emphasis on technology, on the philosophical and cultural nature of science, and on science and social issues. Each of these is discussed and the author concludes that the emergence of STS courses presents science teachers with questions they have traditionally been able to ignore, questions about the social context of science, the political nature of the curriculum and what it means to educate a person about a social issue.

GEORGE, JUNE M. 1988 91

The role of native technology in science education in developing countries: a Caribbean perspective. *School Science Review,* 69(249), 815-20.

The author reviews general aspects of the claims that are made for introducing aspects of pupils' everyday lives into science education, and suggests that there is a need to stress the importance of indigenous artifacts in this process. This is supported by an example drawn from the manufacture of the steelpans used by Caribbean steelbands.

GEORGE, JUNE M. 1992 92

Technological literacy in an essentially oral context. In KUBONI, O. (ed.) *Literacy in the modern world. Proceedings of a Symposium,* Faculty of Education, University of the West Indies, St Augustine, Trinidad, 50-53.

Reviews meanings of TL and applies Fleming's (1989: see above) conception to a rural setting, concluding that a technologically literate person is one who understands how resources have been harnessed and knowledge applied to deal with practical tasks within the village. Additionally, such a person would be empowered to assess existing technologies and to imagine, and perhaps produce, alternatives. TL in the rural context is not only an individual concept, but applies to the whole community i.e. a collective TL. Although young men and women in a village studied by the author were in possession of technological knowledge and skills, these were used largely to replicate existing technologies (e.g. fishing, trapping, wine-making) and their technological activities lacked dynamism, a condition possibly attributable to oral teaching with an emphasis on 'know that' and 'know how', rather than the 'reason that'. Science curricula in rural schools need re-examination and indigenous technologies used as a springboard for developing in students an appreciation for the 'reason that' and an ability to tackle and solve technological problems.

GEORGE, JUNE M. 1993 93

Quality provision in science in an environment with limited commercial resources. *International Journal of Science Education*, 15(1), 17-25.

Although this paper does not employ the concepts of SLor TL explicitly, it has implications for their interpretation. A review of the role of material resources in science education leads to the conclusion that their availability is no guarantee that quality education will result. Educators in developing countries, where such resources are limited, may still achieve high quality science education by drawing on the strengths of indigenous resources. The possibilities of this are explored, though more investigation of the approach is needed and it is not suggested that it would necessarily be appropriate to the later years of secondary education. The author argues that science education problems in developing countries are in some ways unique and require unique approaches.

GEORGE, JUNE and GLASGOW, JOYCE 1988 94

Street science and conventional science in the West Indies. *Studies in Science Education, 15,* 109-118.

The article documents some of the cultural beliefs of children in the West Indies that are likely to influence learning in science. The authors point out that a scientific literacy, based upon an understanding of the interaction of variables and a commitment to tentativeness and a questioning attitude, reflects an entirely different set of values from those prevailing in a community which valorizes direct effects and ready generalization.

GIDDINGS, G.J. 1992 95

Science, technology and society: initiatives in Australian schooling. In YAGER, R.E. (ed.) *The Status of Science-Technology-Society Reform Efforts around the World. ICASE Yearbook 1992,* International Council of Associations for Science Education.

Reviews national and state concerns over the condition of Australian science education. The case for incorporating technology education is examined, with particular reference to its relationship to science education in different states. Examples are provided of curriculum developments in technology education in schools in Western Australia: in these, distinctions are drawn between 'technology awareness', 'technological literacy', and 'technological capability'. TL is associated with objectives such as developing a technical vocabulary, a wide range of communication skills and ability to model.

GLOVER, P.H. 1990 96

Goals for science education in a modern South Africa and their implications for science teaching. In OLIVIER, A.I. (ed.) *Proceedings of Rational Subject Didactics Symposium,* University of Stellenbosch.

Argues that the concept of SL provides the basis for a reconceptualized goal of science education. The science curriculum should be organized around problem-solving skills, real-life issues and personal and community decision-making. By having as its aim a scientifically literate population, science education becomes proactive, value-laden and self-consciously cultural. School science experience should take place within the context of STS.

GOLDSMITH, M. 1986 97

The Science Critic. A Critical Analysis of the Popular Presentation of Science. London, Routledge and Kegan Paul.

The author argues that the lack of an understanding or 'feel' for science is fatal to popular participation. The purposes of this participation are not systematically discussed but seem to be related to 'improving our condition' (p. 12) and enlightening the public about the risk consequent on certain types of scientific work. Science and technology appear to be treated as identical. The author calls for the creation of a body of popular science different from, but 'equally valid' with research science. Its creation is the work of the 'science critic' of the title, a person comparable with the drama or art critic. There are brief discussions of formal education and the situation in 'third world' countries.

GOLDSMITH, M. 1994 98

An approach to scientific literacy. *CASTME Journal*, 14(2), 23-31.

The author argues against popularization as a model for the achievement of scientific literacy and finds the notion of the 'two cultures' unduly conducive to a pessimistic and polarized view on the possibilities of achieving scientific literacy. He argues that it is necessary to identify the common needs of education in science and the humanities. He sketches the role of the 'Science Critic', who would help the non-scientist to penetrate more deeply, so that the latter might be able to enjoy the poetry of scientific experience.

GRAHAM, L. 1987 99

Lay participation in decision-making involving science and technology. In BROOKS, H. and COOPER, C.L. (eds.) *Science for Public Policy*, Oxford, Pergamon Press, 127-43.

The author describes and analyses differences in the approach to policy-making in the USA and the then Soviet Union. There were some formal similarities between the two, but the degree of lay involvement was in practice less in the USSR. This stemmed from ideological differences and consequent differences in institutional organization. It is claimed that, in general, in the USSR decisions were taken by groups of technical specialists. The issue of 'lay participation' is not directly related to that of public scientific and technological literacy because lay participation is generally seen as involving either an intellectual elite or pressure groups.

GRAUBARD, S.R. (ed.) 1983 100

Daedalus. Scientific Literacy. Issued as Vol. 112, Number 2, of the *Proceedings of the American Academy of Arts and Sciences*, Cambridge, Massachusetts, American Academy of Arts and Sciences.

The whole of the Spring 1983 issue of *Daedalus* was given over to the topic of SL. The twelve authors of chapters include representatives of history, mathematics, paediatrics, philosophy of science, physics, political science and science education. A landmark volume, still with much of value in its analyses although parts have been overtaken by subsequent developments.

GRAUBARD, S.R. 1983 101

Nothing to fear, much to do. *Daedalus*, 112(2), 231 -48.

The author argues that the special issue of *Daedalus* on scientific literacy of which this is part shows the uncertainties over the nature of scientific literacy. The article critically reviews narrowly economic and related perspectives, and argues that scientific literacy needs to be set in a much wider frame of 'providing good education'. The focus is on formal education.

GRODZKA-BOROWSKA, A. 1989 102

Technological literacy in the curriculum of Polish elementary schools and technology teacher training. In DE KLERK WOLTERS, F., MOTTIER, I., RAAT, J.H. and DE VRIES, M.J. (eds.) *Teacher Education for School Technology. Report PATT.-4 Conference,* Eindhoven, Pedagogical Technological College, PO Box 826, 5600 AV Eindhoven, The Netherlands, 416-32.

Describes a model of technological activity and the branches of technology in the school curriculum, including the culture of work. Technological literacy is defined in terms of abilities: to gain information, to make designs; to plan the process of production; to organize one's work; to apply different technologies of work; to operate different devices and apparatus; to carry out measurements and control operations.

GROSS, A.G. 1994 103

The role of rhetoric in the public understanding of science. *Public Understanding of Science,* 3(1),3-24.

The author sees 'rhetoric' as 'both a theory capable of analysing public understanding and an activity capable of creating it'. He identifies two models of public understanding: the deficit model and the contextual model. He argues a that the former, which seeks to accommodate science to perceived limitations in public understanding, seeks to eliminate ethical dimensions of science. The latter seeks to create understanding on more equal terms by the interaction of scientific knowledge and human interests in specific contexts. By this process public understanding is created.

HABERER, J. 1987 104

Technological literacy and the ethos of democratic governrnent. *Bulletin of Science, Technology and Society,* 7(5 & 6), 683-86.

From the standpoint of a political scientist, the relationship between TL and democracy is explored. Argues that there is little evidence to support the belief that the greater the level of TL in a given society, the more likely it will tend towards democratic norms. There is no necessary connection between literacy, technology and democracy. TL has the potential to act as an enabling element for change in the direction of increased democratic participation, but must be accompanied by significant redistributions of political and economic power.

HAGGIS, S. 1991 105

Education for All: Purpose and Context. World Conference on Education for All. Monograph 1. Paris, UNESCO.

A review in one chapter of the impact of technological change on needs for basic knowledge and skills leads to the conclusion that a world community of citizens literate in science and technology is needed. Numeracy is seen as an essential complement to STL and its interpretation is considered. Slow progress has been made with the involvement of women in STL programmes and more effort is required here. Examples are given of ways in which the scope of basic education can be extended to real life situations. Further chapters deal with Environmental Literacy for All; Population Education; and Health Education for All. To achieve a scientifically literate society, it may be necessary to re-shape many of the major components of school systems, including school organization, curriculum and pupil-teacher relationships.

HARDING, J., HILDEBRAND, G. and KLAININ, S. 1988 106

Recent international concerns in gender and science-technology. *Educational Review,* 40(2), 185-193.

The authors review some of the initiatives and research which have occurred in the previous decade, and the concerns of (then) current research. They then offer a three-component model of the influences determining girls' and women's situation with regard to science. They finally provide two case studies (based on Thailand and Australia respectively) showing how local circumstances are significant, and stressing the importance of influences other than formal schooling.

HARDING, S. 1993 107

Eurocentric scientific literacy - a challenge for the world community. In HARDING, S. (ed.) *The 'Racial' Economy of Science. Toward a Democratic Future,* Bloomington and Indianopolis, Indiana University Press,1-22.

This is an introductory chapter to Sandra Harding's edited collection of writings (from various authors) which seeks to expose the Eurocentric, imperialist and androcentric assumptions of many of those engaged in promoting the public understanding of science. These assumptions, it is suggested, amount to a particular form of scientific illiteracy, encompassed by the term 'racial' economy of science. The chapter reviews the resources available for understanding this economy.

HARLEN, W. 1989 108

Education for equal opportunities in a scientifically literate society. *International Journal of Science Education,* 11 (2), 125-134.

The author hypothesizes that a process approach to science education, desirable in its own right, is likely to have a particular appeal to girls and women.

HART, E.P. and ROBOTTOM, I.M. 1990 109

The science-technology-society movement in science education: a critique of the reform process. *Journal of Research in Science Teaching,* 27(6), 575-88.

While welcoming 'STS' initiatives as a means of promoting scientific and technological literacy, the authors register concern at the processes of change. In particular, they stress the importance of exploring strategies for reform that are participatory and critical and take due account of the need to transform, rather than reproduce, curricula.

HAYDEN, M.A. 1992 110

Building a general education core around technological literacy. *Bulletin of Science, Technology and Society,* 12(3), 163-66.

Describes the development and content of a university general education programme which incorporated a central TL component. Includes, as an appendix, a TL Bibliography.

HAZEN, R. AND TREFIL, J. 1993 111

Science Matters. London, Cassell.

The authors argue that there are three important justifications for SL: a civic argument; an aesthetic argument; and an argument based on the interconnectedness of all intellectual matters. The greater part of the book is given over to accounts of the various branches of science. There is no development of an economic justification for the SL of everyone. SL is the ability to respond/contribute to public policy issues. Trefil is the author of a related volume: *One Thousand and One Things Everyone Should Know about Science,* London, Cassell, 1993. (See also: POOL, R. 1991.)

HERNANDEZ, D.F. 1980 112

Biology in community education: a Philippine scenario for lifelong education, *European Journal of Science Education,* 2(3), 217-30.

The author describes an attempt to deploy science (especially biology) education to improve the quality of life and learning in a rural community. Important issues in lifelong education and school-community relationships are identified.

HILGARTNER, S. 1990 113

The dominant view of popularization: conceptual problems, political uses. *Social Studies of Science,* 20(3), 519-39.

The paper analyses how popularization of science is commonly represented, in a two-stage model. It is shown that the process is in fact more complex and diverse. The ways in which scientists, as the legitimate source of authority, can deploy a range of strategies to undermine perspectives with which they disagree as 'distortions' is discussed. The language of popularization can thus be used to maintain a 'social hierarchy of expertise'.

HLEBOWITSH, P.S. and HUDSON, S.E. 1991 114

Science education and the reawakening of the general education ideal. *Science Education,* 75(5), 563-76.

Argues that 'general education' has undergone a renaissance of popularity in recent years and analyses what implications this orientation to common learning has for science education. Reviews arguments both against and in support of SL as a worthwhile and practicable goal and compares STS initiatives with Project 2061 in terms of their respective general education tenets. Concludes that 'a science education program that aims to develop enlightened social behaviour in the resolution of social-scientific problems is a science program that must cultivate scientific habits of mind (dealing with evidence and argumentation); general levels of appreciation for nature and the physical environment; and a knowledge base that converges upon technological, cultural, and scientific domains'.

HOLTON, G. 1992 115

How to think about the 'anti-science' phenomenon. *Public Understanding of Science,* 1(1),103-128.

Holton draws upon historical examples to suggest that, when allied to political power, anti-science phenomena threaten the fundamental values of a civilized, democratic culture. Greater scientific literacy is seen as one essential component of social and political stability and of the continued successful prosecution of science.

HORVAT, R.E. 1993 116

The Science Education for Public Understanding Program: What's new with SEPUP. *Bulletin of Science, Technology and Society,* 13(4),208-10.

The Science Education for Public Understanding Program (SEPUP) at the Lawrence Hall of Science, Berkeley, USA, promotes SL by teaching students about: evidence-based decision-making; the nature of science - experiments and evidence; the limitations of science - uncertainty and controversy; thresholds, toxicity and risk; living with chemicals; science and social systems. The aim is to provide the necessary knowledge and understanding so that students can more effectively make their own decisions as members of a free and democratic society.

HURD, P. DE H. 1989 117

Science education and the nation's economy. In CHAMPAGNE, A.B., LOVITTS, B.E. and CALINGER, B.J. (eds.) *This Year in School Science 1989. Scientific Literacy,* Washington, DC, American Association for the Advancement of Science, 15-40.

Contends that the definition of SL currently guiding educational practice is out of step with the realities of living, learning and working in modern America. Existing science curricula are socially, culturally and cognitively outdated. A new definition of SL should be premised on the economic needs of the nation, especially the needs of business and industry and on new conceptions of the workplace and the worker. To be scientifically literate, students must be equipped with the cognitive and noncognitive skills relevant to their occupational futures. Achieving consensus on the components of SL requires a major co-operative effort from people informed about the natural, cognitive and social sciences, technology, education and business.

HURD, P. DE H. 1990 118

Historical and philosophical insights on scientific literacy. *Bulletin of Science, Technology and Society,* 10(3), 133-36.

Draws on views on science education since Francis Bacon and analyses the characteristics of the reform movement today. SL needs to be viewed as the major part of civic and social intelligence essential for effective participation in a culture distinguished by achievements in science and technology. Teaching SL is a process of socializing and enculturating young people for active membership in a science/technology-based democracy.

HYNES, H. PATRICIA 1993 119

Gender and the teaching and learning of technology. In LAYTON, D. (ed.) *Renovations in Science and Technology Education, Vol. 5,* Paris, UNESCO.

Traces the roots of the present situation in which technology appears as 'a world without women' and argues that many girls and women, preferring connected knowing and socially useful activities, are alienated from the rationalistic and reductionist methods and the anti-humanist and anti-environment impacts of much technology. Measures to encourage girls to study technology and take up technological careers are reviewed. Prominent among these is the need to change the science and the technology, and their associated pedagogies, not the girls, if TL is to be anything other than a male attribute. What counts as TL needs to be rethought.

ILLICH, I. 1987 120

Computer literacy and the cybernetic dream. *Bulletin of Science, Technology and Society, 7(1 &* 2), 306-09.

Warns of the danger that the machine and its cybernetic logic can induce a dream-like mental state, a mind set in which a purely formal, abstract, disembodied system of reference becomes identified with what is going on in the mind. CL, for Illich, is a means to 'keep awake' in the computer age, to exorcise the paralysing spell the computer can cast whereby science dreams up and 'constructs man and history on the basis of a few abstract indices'. For those who engage in this dreaming, 'man in reality becomes that manipulation which he takes himself to be'. The case of a school teacher and her student, writing about drought and hunger in Africa, is used to illustrate the argument.

IMSEN, G. 1987 121

Gender, values and technology: a cultural perspective. In DANIELS, JANE Z. AND KAHLE, JANE B. (eds.) *Contributions to the Fourth GASAT Conference,* Volume 3, 103-111. Michigan, University of Michigan, Ann Arbor, USA.

Whilst emphasizing the complexity of the mechanisms that keep girls away from science and technology, focuses on their construction of self-concept/gender identities, and sub-cultures. Argues that female culture is permeated by relationships, helpfulness and empathy. As a result we should show the social aspects of science (e.g. cooperation, travel, meeting people) and present technology as a way of solving human problems, not as an end in itself. Effort should be directed towards interesting a group of girls who already know one another, so that the knowledge of science/technology can be built into their 'inner circle'.

INDUSTRIAL RESEARCH AND DEVELOPMENT ADVISORY COMMITTEE (IRDAC) OF THE COMMISSION OF THE EUROPEAN COMMUNITIES 1991 122

Schools and Industry. IRDAC Opinion. Brussels, COMETT Technical Assistance Office.

This report has a background of concerns about a probable shortage of qualified persons in Europe to develop and exploit advanced and innovative products and processes. Its main thrust is that 'No young European should leave school scientifically and technologically illiterate'. Action is called for regarding three objectives: raising the overall level of TL; preparing for and understanding the world of work; and encouraging the pursuit of scientific and technical careers. *IRDAC Opinion* tends to equate TL with technical education.

JALALUDDIN, A.K. and MALLIK, U. (eds.) 1983 123

Science and Man: an Anthology. New Delhi, NCERT, New Delhi, India.

Includes writings about science by Jawaharlal Nehru, Zakir Husain and Sarvepalli Radhakrishnan. All emphasize the need to recognize the social consequences of scientific activity, the importance of working with ethical norms in the interest of social solidarity and social justice, and the power of 'the great ideas enshrined in our culture'.

JENKINS, E.W. 1990 124

Scientific literacy and school science education. *School Science Review,* 71(256), 43-52.

The author explores various meanings of 'scientific literacy' and examines their implications for school science education. He suggests that universal scientific literacy is an unrealistic objective for school science education.

JENKINS, E.W. 1991 125

Alfabetizafacao em ciencia: uma ideia subversiva? In TRIVELATO, S.F. and BIZZO, N.M.V. (eds.) *Perspectivas de Ensino de Biologia,* Sao Paulo, Faculdade de Educaçao da Universidade de Sao Paulo, 45-48.

The author associates scientific literacy with the empowerment of lay citizens and argues that such literacy is essentially political since it challenges many features of science which collectively constitute the nature and locus of scientific authority.

JENKINS, E.W. 1992 126

School science education: towards a reconstruction. *Journal of Curriculum Studies*, 24(3), 229-46.

The industrialization of science and its 'merger with power' requires a different portrayal of science in school curricula if perceptive pupils and parents are not to react to what is offered as anachronistic and irrelevant to their personal concerns. The goal of SL is examined and different meanings and rationales reviewed in the light of recent research on public understanding of science. The idea of a general SL is less useful than that of a multiplicity of functional SLs empowering people to operate effectively in occupation, domestic, recreational etc. contexts. Those aspects of SL that schools can legitimately hope to develop in pupils need identification. The reconstruction of school science is also examined from the perspectives of 'the nature of science' and of 'values'. Implications for a reconstructed science curriculum are drawn.

JENKINS, F. 1990 127

STS Science Education. Unifying the Goals of Science Education, Curriculum Support Branch, Alberta Education.

Argues that citizens and leaders will have to be more scientifically and technologically literate, and more aware of the limitations of science and technology in solving society's problems. Seven dimensions of TL should be systematically integrated into the science curriculum, as technology curriculum emphases: (1) technological knowledge; (2) technological skills; (3) technological problem solving and design; (4) technological attitudes; (5) technology in science; (6) technology in society; (7) nature of technology.

Although most of the TL movement is intertwined with the STS movement, TL has become a political and economic issue in most of the developed and developing countries of the world. Argues that TL, should be and can be integrated into the science curriculum by using the conceptual organizers - STS and curriculum emphases.

JOHNSON, J.R. 1989 128

Technology. Report of the Project 2061 Phase I Technology Panel. Washington, DC, 20005, AAAS.
This is the report of one of five scientific panels associated with Project 2061 (see AAAS, 1989) and charged with developing ideas on basic subject-matter areas. The Technology Panel was asked: 'What is the technology component of SL?' Its response takes a broad view of technology: eleven fields of technology are reviewed for significant concepts and ideas; in general education it is argued that education should be described in a holistic way, as part of history, everyday existence and the future. Sixteen questions are listed as ones which a technologically literate citizen should understand, and have some familiarity with the ways in which answers are developed.

JONES, A.T. 1993 129

Technology Education Policy Papers. Six papers prepared for the New Zealand government by Dr A.T. Jones in association with colleagues at the Centre for Science and Mathematics Education Research, University of Waikato, Hamilton, as part of the Technology Education Policy Project. (The papers are being prepared for publication, but details were not available at the time of compiling this entry.)

Six grounds for developing technology in general education are given: economic; pedagogic; motivational; cultural; environmental; and personal. General aims of technology education include: to develop technological knowledge and understanding; to develop an understanding and awareness of the interrelationship between technology and society; to develop technological capability. These are elaborated into achievement aims, involving the description of technological areas and contextual themes. Implementation and pedagogical issues are also considered, as well as questions of access involving gender, culture and people with differing abilities. Although the concept of TL is not used, much of the first three papers provides an explication of its meaning and relates to justifications.

JONES, ISABEL 1987 130

Increasing biological literacy through interest in public health. In SHORTLAND, M. (ed.) *Scientific Literacy Papers*, Oxford, Scientific Literacy Group, University of Oxford Department of External Studies, 107-08.

Biological literacy (BL) is said to imply a lack of alienation from the biological sciences and biologists and to involve an understanding of the thought processes leading to new theories and new science and technology practices; also, a willingness to use the same processes in approaching individual situations in private and public life, and to draw on information from the biological field as a basis for these processes. The author describes a course on Popular Medical Science which she has used to increase BL.

JONES, R.C. 1992 131

Technological literacy for liberal arts majors. Report of a workshop. *Bulletin of Science, Technology and Society,* 12(3), 138-48.

Implicit agreement that TL equals engineering literacy, although some argue that TL is broader. There is danger in diluting the thrust of TL if too much is included. Consensus in the workshop that students' understanding of the technological process was more important than specific content. Even though TL is often considered to be part of the STS field, it is often difficult to identify the components in many STS programs.

JONG-HA HAN 1992 132

Science education reform in Korea. In YAGER, R.E. (ed.) *The Status of Science-Technology-Society Reform Efforts around the World. ICASE Yearbook 1992*, International Council of Associations for Science Education.

Reviews social and economic changes in Korea over recent decades and argues that SL and TL are essential to the education of prospective leaders who will be the decision takers. Distinguishes between science programs for future scientists and for non-science college-bound students and outlines STS type characteristics for the latter. Difficulties that arise in attempts to introduce such courses, and incorporate technology into basic science education are enumerated.

KHAN, M.J. 1990 133

Access to science education in a developing country: the challenge of scientific literacy. *Compare*, 20(2), 155-62.

The author draws upon a detailed study of the status of science and technology in Botswana to explore SL within the context of the Botswana economy. He concludes that the development of SL has been impaired by the lack of a scientific and technological infrastructure and a dynamic industrial base.

KHAN, M. and ROLLNICK, M. 1983 134

Science education in the new South Africa: reflections and visions. *International Journal of Science Education*, 15(3), 261-72.

Irrespective of political viewpoints, the long-term skilled person power needs are assessed to be far in excess of the output of the present system. Political changes have raised expectations among the disenfranchised. Whether it is argued that the key to developing an equitable society is through redistribution, or through economic growth alone, there is agreement that the technological future of the country depends on developing all South African citizens into a scientifically literate community. The article includes consideration of how the content, methodology and contextual presentation of school science could be changed so as to ensure greater SL and the entry of many more people into science-based employment. Draws on evidence from the BOLESWA countries.

KAPIYO, R.J.A. 1990 135

Curriculum and Socio-Cultural Issues in Appropriate Technology Education. African Regional Workshop, Nairobi, Appropriate Technology Centre, Kenyatta University, PO Box 43844, Nairobi, Kenya.

Papers from this UNESCO supported workshop, collected in this volume, came predominantly from participants representing several African countries, with others from European and North American speakers. The theme of TL, including its justifications and interpretations in African contexts, is recurrent throughout the papers. Distinctions between Appropriate Technology, Intermediate Technology and Technology are drawn, curriculum models of various kinds explored and specific curriculum developments in school technology education and the preparation of technology teachers are described.

KELLY, G.J., CARLSEN, W.S. and CUNNINGHAM, C.M. 1993 136

Science education in sociocultural context: perspectives from the sociology of science. *Science Education*, 77(2), 207-20.

Reviews how sociology of science has brought a new understanding of science and explores the educational possibilities which result. Identifies five consequences for science educators of social studies of science. These include the abandonment of the idea that by learning science, citizens will be equipped automatically to make good public policy decisions. Also, rather than viewing SL as the mastery of officially certified knowledge, teachers need to work to create conditions in which students are involved in creating and recreating science, e.g. through local projects.

KIDWELL, C.S. 1985 137

Nature knowledge in the Americas. *Osiris, 1, 209-28.*

The article is principally concerned with native American science and reviews some of the problems involved in studying it. Nonetheless, it has considerable relevance to the notion of what it means to be scientifically literate.

KING, K. 1986 138

Mapping the environment of science in India. *Studies in Science Education*, 13, 53-69.

The article describes innovations in formal and non-formal (e.g. the People's Science Movement, the Patriotic and People-oriented Science and Technology Group) science education in India. Stressing that experience of these innovations has much to offer other countries, a substantial agenda for research/dissemination is identified, including the need to generate accounts of culture-dependent, fully formed sciences and technologies.

KING, K. 1986 139

Science and technology images and policies in the ambits of education, training and production in Chile. *Compare*, 16(1),37-63.

Portrays how scientific and technical knowledge is distributed and valued in several formal and informal sectors of education in Chile and explores how science and technology are shaped by their location in education, training and production. The author concludes that in some parts of Latin America, as in India, popular education implies a somewhat different image of science and technology than is suggested in the conventional science of schools.

KING, W.K. 1984 . 140

Out-of-school science activities - retrospect and prospect in the Caribbean. In MEYER, G.R. and RAO, A.N. (eds.) *Teaching Science Out-of-School with Special Reference to Biology,* Singapore and Sydney, International Union of Biological Sciences, Commission for Biological Education and Asian Network for Biological Sciences, 101-08.

Argues that out-of-school activities have a powerful role to play in developing scientifically literate citizens. They can be used to alleviate some of 'the disorders of underdevelopment' such as lack of technological expertise, and the great reluctance to change. Involvement in such activities can help to eradicate the idea that science is magical and can help to develop the community educationally, economically, socially and aesthetically.

KINTGEN, E.R. 1988 141

Literacy, literacy. *Visible Language,* 22(2-3), 149-68.

The article traces the different historical senses of the term literacy and examines the semantics of its usage in the contexts of scientific, visual and cultural literacy.

KLOPFER, L.E. and CHAMPAGNE, A.B. 1990 142

Ghosts of crisis past. *Science Education,* 74(2), 133-54.

In the course of a detailed review of projects for the reform of science education since the end of World War II, the authors distinguish between 'professionalist' perspectives (i.e. science education for the economy, military etc.) and 'visionary' perspectives (i.e. a kind of literacy in science for everyone). The development of the latter is the most important function of school science education. Amongst projects described is the Engineering Concepts Curriculum Project of the late 1960S whose primary object was 'the development of technological literacy. This includes not only the learning of certain concepts, such as modeling, decision-making, optimization, feedback, stability etc., but also involves developing realistic attitudes about the strength and limitations of technology and the problems involved in the interaction of technology and society.' The ownership of the school science curriculum is considered and a range of stakeholders other than teachers and scientists is identified.

KRASILCHIK, MYRIAM 1987 143

Science and technology education and the concept of quality of life. In RIQUARTS, K. (ed.) *Science and Technology Education and the Quality of Life. Vol. 2. Technology Education: Science-Technology-Society,* Kiel, IPN, D-2300 Kiel 1, Olshausenstrasse 62, Germany, 668-73.

Quality of life is not restricted to the fulfilment of biological necessities, but implies also the fulfilment of individual and group aspirations including health, education, working conditions, availability of leisure etc. This obliges science teachers to face new situations and examples are given of STS relationships, ST and development relationships, ST and environment relationships, and relating scientific problems to human aspects. The objective is to assist students to synthesize their opinions, to build up their own concept of their individual aspirations and of the community's aspirations.

KRUGLY -SMOLSKA, E.T. 1990 144

Scientific literacy in developed and developing countries. *International Journal of Science Education,* 12(5), 473-80.

Recognizing that the cultural and economic contexts of science education are different in developed and developing countries, the author argues that scientific literacy must be defined in terms of science as process if these different contexts are to be accommodated.

KUILMAN, M. 1989 145

The importance of school technology for industry. In DE KLERK WOLTERS, F., MOTTIER, I., RAAT, J.H. and DE VRIES, M.J. (eds.) *Teacher Education for School Technology. Report PATT-4 Conference,* Eindhoven, Pedagogical Technological College, PO Box 826, 5600 AV Eindhoven, The Netherlands, 11-17.

From the perspective of the modern electronics industry, a case is made for a good relationship between industry and school technology. Although the term TL is not used, Professor Kuilman argues that employees in his industry need to have a basic knowledge and skills in technology, apart from their special vocational education; citizens need basic technology education to function effectively in society; and a broadly founded understanding of technology is desirable for an appreciation of the social usefulness of modern industry.

KYLE, W.C. Jnr. 1991 146

The reform agenda and science education: hegemonic control vs. counterhegemony. *Science Education,* 75(4), 403-11.

Asserts that SL - embracing science, mathematics and technology for future human needs - is a national priority. A vision needs to be articulated which challenges schools to provide *all* students with the skills and knowledge associated with STL for self and social empowerment. Provides a sociological analysis of the purposes of schooling, the roles of teachers and of research. Concludes that SL for all should start to mean just that - literacy for *all* - not just SL for the subset of youth who attend 'schools of choice' or happen to be born into the 'dominant culture and social group'.

LA FOLLETTE, M.C. 1982 147

Science on television: influences and strategies. *Daedalus 111 (4), 183-97.*

The author reviews the forms which science as presented on television takes, but uses this as a basis on which to discuss wider issues connected with SL. The need to direct attention at the 'attentive' audience for science (see MILLER, *1983) is* contrasted with claims that a much wider public can and should be informed. The piece concludes with a discussion of how scientists and their supporters have failed to reflect on their own reaction to the 'creationists' position in the USA, and calls for more 'open meeting places where both "the cultivated" and "plain people" can learn about science'.

LAUGKSCH, R.C. and SPARGO, P.E. 1993 148

Development of a scientific literacy test based on AAAS literacy goals: methods and procedures. Paper presented at the International conference on the Public Understanding of Science and Technology, Chicago, October *1993.*

Describes the construction of an SL test consisting of three subtests: the nature of science subtest; the cognitive science knowledge subtest; and the impact of science and technology on society subtest. *475* test items were generated, closely related to the specification for SL in AAAS's *Science Moray Americans* (q-v-)

LAYTON, D. 1987 149

Some curriculum implications of technological literacy. In HARRISON, M., LAYTON, D. and BOLTON, *N. Technology Education Project. Paper 1. Papers submitted to the Consultation held on 15 and 16 November 1985,* York, St William's Foundation, 5 College Street, York YO1 2JF, UK, *4-8.*

For curriculum planning, it is helpful to think of TL in terms of a series of functional competencies: (1) technological awareness or 'receiver competence' - the ability to recognize technology in use and acknowledge its possibilities; (2) technological application or 'user competence' - the ability to use technology for specific purposes; *(3)* technological capability or 'maker competence' - the ability to design and make, maintain and repair; *(4)* technological impact assessment or 'monitoring competence' - the ability to assess the personal and social implications of technological developments; (5) technological consciousness or 'holistic competence' - an acceptance of, and ability to operate within, a 'mental set' which defines what is a problem, and what counts as a solution; and (6) technological evaluation or 'critic competence' - the ability to judge the worth of a technological development in the light of personal values and to step outside the 'mental set' to evaluate what it is doing to us.

LAYTON, D. 1991 150

Science education and praxis: the relationship of school science to practical action. *Studies in Science Education, 19,* 43-79.

Drawing upon research in the history, philosophy and sociology of science and technology, it is argued that technological knowledge, 'structured by a tension between the demands of functional design and the constraints of the ambience', is cognitively unique. Its relationship to scientific knowledge is not a simple derivative one, but frequently entails the reworking of science before it can articulate with practice. Evidence from recent research on public understanding of science is used to support this view: so-called 'scientific illiteracy' is not explicable in terms of a cognitive-deficit model; the relationship between 'publics' and science is an interactive one. Psychological studies of situated cognition add a further layer of meaning to the processes involved when lay persons encounter and use science. Implications for, and research questions relating to, content, pedagogy and institutional provision of science education are considered.

LAYTON, D. 1992 151

Reconceptualizing science and technology education for tomorrow. *Science, Technology and Development,* 10(2), 141-61.

One of several articles in this Special Issue of the journal devoted to 'Education in Science and Technology: Innovations and Implications for the Developing World'. Analyses contextual changes which are driving reforms in science and technology education, notably a convergence of the academic and the vocational (the former becoming more 'practical' and the latter more general). The emergence of technology as a component of general education is related to this and features of technological knowledge are described, drawing upon the work of historians and philosophers of technology. Various conceptualizations of technology education are examined and specific influences in developing countries are noted. The contribution of science education to the development of pupils' technological capability is discussed.

LAYTON, D. 1992 152

Values and Design & Technology. Design Curriculum Matters 2. Loughborough, Department of Design and Technology, Loughborough University of Technology, Loughborough, Leicestershire LEI I 3TU.

Argues that the politics of TL - who creates and controls the meanings of the phrase, how the imposition of meaning is achieved -- is a central concern of technology education today and is inescapably rooted in value considerations. Identifies, and characterizes by value orientation, a number of stakeholders in the socio-political shaping of school technology: economic functionalists; professional technologists; women; sustainable developers; liberal educators. TL should equip people with the knowledge and skills to make technologies 'transparent', i.e. to reveal the value assumptions within them. The particular problem of using theoretical knowledge from science to produce technological knowledge for practical action is explored from the standpoint of values.

LAYTON, D., DAVEY, A. and JENKINS, E. 1986 153

Science for Specific Social Purposes (SSSP): perspectives on adult scientific literacy. *Studies in Science Education,* 13, 27-52.

Following a brief historical review of the public understanding of science, the article reviews the different conceptual and methodological approaches to scientific literacy evident in the literature. Emphasizing that the learning of science by adults is strongly context-related and drawing upon what is known about how adults learn science, the authors conclude that if science is to assist people in dealing with problems having a scientific dimension, then such science will need to be structured in ways that relate to the interests of specific groups (SSSP). In addition, the consequent variety of functional scientific literacies will entail novel kinds of institutional provisions and a renegotiation of the contract between science, society and its citizens.

LAYTON, D., JENKINS, E., MACGILL, S. and DAVEY, A. 1993 154

Inarticulate Science? Perspectives on the Public Understanding of Science and Some Implications for Science Education. Driffield, Studies in Education Ltd., Nafferton, Driffield, East Yorkshire YO25 OJL, UK.

Adults' understanding of science, and ability to use it in specific situations, are investigated in a series of case studies involving parents with a child suffering from Down's syndrome, elderly women and men undertaking their domestic energy practices in the context of straitened financial circumstances, local government elected representatives faced with a problem of methane seepage from a landfill site, and people living in the vicinity of a nuclear fuel reprocessing plant around which there was an alleged higher incidence of childhood leukaemia. It is argued that the findings of the research have important implications for the ways in which science is represented to the public; for the means of using science, generated in laboratory contexts, in particular 'real world' contexts and articulating it with practical action; for the kinds of institutional provisions through which people have access to science; and for the practices of teachers of science. The cognitive-deficit model of scientific illiteracy is incompatible with the evidence and an interactive model of the lay person's understanding of science is developed.

LEVRAT, R. (ed.) 1992 155

Technologie. Textes de Référence. Sèvres, Centre International d'Etudes Pédagogiques.

Whilst not referring to TL by name, this volume (in French) is concerned with the contribution of technology to general education. It includes two reports from COPRET (Commission permanente de reflexion sur l'enseignement de la technologie) and also a translation into French of the discussion paper by Paul Black and Geoffrey Harrison, *In Place of Confusion* (1985). The contributions of technology to education at various levels in the French educational system are discussed.

LEWENSTEIN, B.V. 1992 156

Industrial life assurance, public health campaigns, and public communication of science, 908-1951. *Public Understanding of Science,* 1(3), 347-65.

Lewenstein explores the role of private life assurance companies in the USAin promoting public health through greater understanding of the scientific issues involved. In essence, public understanding of science was an aspect of corporate planning, designed to meld the institutional and economic goals of the insurance companies with the broader social mores of the community at large.

LEWENSTEIN, B.V. 1992 157

The meaning of 'public understanding of science' in the United States after World War II. *Public Understanding of Science, I (1),* 45-68.

The author explores a shift in the meaning of the public understanding of science in the USA. Until the 1960s, such understanding was equated with a public appreciation of the social benefits derived from scientific knowledge. The rise of a politically-oriented, environmental journalism in the 1960s transformed the relationship between scientific journalism and the major scientific institutions and led to a more critical era of 'popular science'.

LEWIN, K.M. 1992 158

Science Education in Developing Countries: Issues and Perspectives for Planners. Paris, International Institute for Educational Planning.

In reviewing national science policy and science education aims, the author notes the repeatedly voiced concerns for more widespread scientific literacy defined in terms of a basic understanding of science in order to make informed decisions in daily life and to function effectively as a citizen. This is subdivided into: (I) survival needs in a physical environment pervaded by science derived products, machines and devices; and (2) the need to participate responsibly in formulating policy and making decisions concerning public issues having technological components which involve a basic understanding of science.

LEWIN, K.M. 1993 159

Planning policy on science education in developing countries. *International Journal of Science Education,* 15(1), 1 - 15.

Identifies major areas where research in science education is needed. In some contexts, though science may be taught to all students, the science experienced by the non-specialists is generally taught by the least qualified teachers, under the worst conditions with the least enthusiasm. Extending SL may be of comparable importance to ensuring that adequate numbers of specialists are produced, depending on what type of development policy is pursued. Achieving this is at least as difficult a problem as improving the provision for specialists and the appropriate approaches need as much research and curriculum development.

LEWIS, J.L. and KELLY, P.J. (eds.) 1987 160

Science and Technology Education and Future Human Needs. Oxford and New York, Pergamon Press for the ICSU Press.

The first of nine volumes resulting from the Bangalore Conference whose title is the title of this book. The message of the Conference is that the development of health; food and agriculture; energy resources; land, water and mineral resources; industry and technology; the environment; and information transfer and technology, is essential for any country's future. An understanding of science and technology is fundamental to such developments and an appreciation of ethics and social responsibility in relation to them is a crucial cultural requirement. It is imperative that science and technology education should be oriented to such topics. Terms such as SL and TL are not prominent in this or other Bangalore volumes and there is little advocacy of technology as a distinct component of general education. There is strong emphasis on making science and technology education relate to practical problems in the world outside school.

LEWIS, T. 1991 161

Introducing technology into school curricula. *Journal of Curriculum Studies,* 23(2),141-54.

Identifies and comments on problems of implementing technology education, especially the variety of meanings and the lack of discipline structure. Reviews the ways in which technology has been taught in industrial arts contexts and STS courses. Explores meanings of TL and endorses the Deweyan view that technology is a valid and unique sphere of knowledge. This is the strongest justification for technology in school curricula as there is no other component of the curriculum in which this knowledge and its associated form of enquiry can be systematically considered.

LEWIS, T. and GAGEL, C. 1992 162

Technological literacy: a critical analysis. *Journal of Curriculum Studies*, 24, 117-38.

Reviews the nature of literacy and of technology as a prelude to an analysis of conceptions of TL derived from (1) US higher education- (2) the STS movement; (3) Technology Education (formerly Industrial Arts education); and (4) the US public and private (industrial) sectors. Concludes that TL has emerged as a new purpose of general education, but its meaning remains unclear because technology is an ambiguous concept and advocacy of TL comes from very diverse quarters. TL appears to require a whole-school approach: the study of technology is fundamental to the teaching of TL, but contributions are needed from many other subjects.

LIAO, T.T. 1990 163

Cybernetics: a new liberal arts course. *Bulletin of Science, Technology and Society,* 10(3), 151-55.

TL spans the range from how specific devices and machines work to the understanding of more complex systems for satisfying human wants and needs. TL includes not only the application of scientific and mathematical principles underlying the devices and systems, but also consideration of the human, environmental and societal impacts. The knowledge base for a TL curriculum is categorized into five content areas: technological systems and engineering concepts; application of scientific concepts; applied mathematics and quantitative methods; how individuals interface with technology; how technological systems interact with other systems.

LOEPP, F. 1986 164

Technological literacy: an educational challenge. In SANDERS, M. (ed.) *Technological Literacy: an Educational Mandate. Proceedings of the Technology Education Symposium Volt,* Blacksburg, VA, Virginia Polytechnic Institute and State University.

Defines TL as 'the competency to locate, sort, analyse and synthesize information that relates to achieving practical purposes through efficient action'.

LUCAS, A.M. 1983 165

Scientific literacy and informal learning. *Studies in Science Education, l 0,* 1 -36.

This article considers the purposes that might be served by adult scientific literacy, discusses a framework for thinking about questions of informal learning and its interaction with school science learning, and considers the literature relevant to various types/sources of informal learning (e.g. museums, science centres, zoos, botanic gardens, fictional and non-fictional media sources, clubs).

LUCAS, A.M. 1988 166

Public knowledge of elementary physics. *Physics Education,* 23(1),10-16.
The author reports the results of a survey of British people over the age of 15, designed to establish the level of understanding of elementary physics. The data are analysed with respect to the gender and level of formal education of respondents and the author shows how little of formal school science education is retained into adult life.

LUTTERODT, S.A. 1980 167

The adaptation of science curricula- an exploratory analysis of some relevant decisions. *European Journal of Science Education,* 2(2),121-38.
The author explores the issues involved in adapting science curricula for use in different geo-political/cultural contexts and directs attention to the critical role of socio-economic issues in determining the likelihood of successful adaptation.

MAARSCHALK, J. 1988 168

Scientific literacy and informal science teaching. *Journal of Research in Science Teaching,* 25(2),135-46.
The Rand Afrikaans University Scientific Literacy Project distinguishes formal, non-formal and informal science teaching. The last of these is explored in the context of the home and the garden using a three day diary completed by 200 pupils in grades 10/11 in a multiracial Johannesburg school. Structured interviews were also used with a sample of 20 pupils in the same grades. Preliminary results suggest that formal science teaching does little to encourage scientific literacy beyond the school context.

MAARSCHALK, J. and STRAUSS, J. 1992 169

Scientific literacy standards for a new education dispensation. S. *Afr. Tydskr. Opvoedk, 12(1),* 38-41.
Distinguishes between formal, non-formal and informal science teaching and argues that SLis both the outcome of and condition for informal science teaching. 'A scientifically literate person's hierarchy of values as manifested in his cognitive preferences will be such that he will frequently partake in informal science teaching. He will not only spontaneously engage in scientific dialogue, thinking and wonder, but also spontaneously be on the lookout for scientific endeavours.'

MACKAY, H., YOUNG, M. and BEYNON, J. (eds.) 1991 170

Understanding Technology in Education. London and New York, The Falmer Press.

This collection of eleven contributions on aspects of technology and technology education, addresses TL at a number of points. In his chapter on 'Technology as an educational issue: social and political perspectives' (I-12), Mackay argues for TL as something much broader than CLas conventionally defined: it entails the capacity to decode the ways in which technology has been encoded and to understand the nature and scope of social relations which it embodies, represents and supports. This includes how and by whom technology is invented, designed, marketed, what people have to know to use it, how it affects the nature of work and leisure, its symbolic value, its cultural nature, who consumes it, and its effects. Michael Young, in a concluding chapter, 'Technology as an educational issue: why it is so difficult and why it is so important' (234-43) enlarges on these themes; the extension of technology in education from the preparation of specialists to TLfor all has major implications for the curriculum and for culture generally.

MALEY, D. 1987 171

Knowledge and skill base entering and working in the world of technology. *Bulletin of Science, Technology and Society,* 7(5 & 6), 741-47.

Reviews a wide range of evidence and opinion, including that from industrial sources, on the knowledge (mathematics, science, economics, safety, health), skills (survival, operational) and human qualities needed for effective performance in the contemporary industrial/technological workplace. Although these are not related explicitly to the concept of TL, there are clear messages.

MARX, G. 1991 172

Comment. In HUSEN, T. and KEEVES, J.P. (eds.) *Issues in Science Education. Science Competence in a Social and Ecological Context* Oxford and New York, Pergamon Press, 162-64.

Challenges the idea that SL can be defined in terms of elements of scientific knowledge. Lists some 'deeper' ideas e.g. handling energy and information; positive/negative feedback: stabilization/amplification; loss/efficiency etc. which are more important. Science is the best strategy ever invented for exploration of the unknown future which will confront young people. Respect for reality, selecting relevant data, inventing alternative models for anticipation of future events, testing and improving them - these are of primary importance for exploration of the unknown.

McCONNELL, M.C. 1982 173

Teaching about science, technology and society at the secondary school level in the United States. An educational dilemma for the 1980S. *Studies in Science Education, 9,* 1-32.

The author presents substantive questions about the feasibility of 'STS' education, e.g. relating to its cognitive complexity and inter-disciplinarity and asks how much understanding of science and technology is necessary before a person can understand anything about the role of science and technology in the contemporary world.

MILLAR, R., DRIVER, R., LEACH, J. and SCOTT, P. 1993 174

Students' awareness of science as a social enterprise. Working Paper 9 from the ESRC project on the development of children's understanding of the nature of science. Leeds, Children's Learning in Science Research Group, School of Education, University of Leeds and Science Education Group, University of York.

Following Wynne's analysis of public understanding of science into three aspects (see WYNNE, B. 1991 below), the authors describe an attempt to elucidate the third aspect (science's forms of institutional embedding and control). Specifically, they ask what ideas should a learner be introduced to and what would an understanding of this aspect of science entail? Two case studies involving scientific controversy were undertaken with 16 year old students: the safety of food irradiation and Wegener's hypothesis of continental drift. The authors conclude that there is need for explicit curricular interventions if we wish to help students move towards a more subtle understanding of the nature of theory-making and theory choice in science.

MILLER, J.D. 1983 175

Scientific literacy: a conceptual and empirical review. *Daedalus,* 112(2),29-48.

The author examines the topic using both commentaries and empirical sources. The discussion relates to economic and political aspects of SL, but the focus is on the latter. Overall the piece places its main emphasis on the need for a greater understanding by the various publics (distinguished as 'general' and 'attentive') of the knowledge and value systems of professional 'scientists and engineers', so that they will understand the 'problems and aspirations' of the latter. By this method 'the science policy process can function effectively'. This effective functioning appears to consist of professional scientists obtaining the resources they seek.

MILLER, J.D. 1983 176

The American People and Science Policy. New York, Pergamon.

This book is based around 'four major surveys' of public attitudes to science. It focuses particularly on what it calls 'the attentive public' for science policy: those who are sufficiently interested to 'become and remain informed' about particular issues. This is estimated at about 20 per cent of the adult population. The attitudes and distribution, as well as the changes over time, associated with this group are discussed statistically at some length. The book is oriented toward discussing how 'science policy leaders' can 'mobilize' this portion of the population to support their aims, particularly in relation to obtaining resources, but also in relation to resisting the claims of such groups as creationists.

MILLER, J.D. 1986 177

Technological literacy: some concepts and measures. *Bulletin of Science, Technology and Society,* 6(2 & 3), 195-201.

SL is conceptually different from TL. Restates his three-dimensional definition of SL from his chapter in *Daedalus* (see GRAUBARD, 1983) and described here under EVERED and O'CONNOR, 1987. Develops a three-dimensional measure of TL: an understanding of some of the basic terms needed to communicate about technological issues; an understanding that technology is a national effort to apply scientific knowledge to the solution of definable problems; an ability to distinguish between likely scientific or technical results and fictional or hearsay accounts. Provides exemplary test items and discusses implications for science and mathematics education. Views TL as a continuous variable and defines it as an understanding of the application of science and engineering to the solution of concrete problems. In practice, categories such as T illiterate, minimum TL, and higher level of TL might be useful.

MILLER, J.D. 1992 178

Toward a scientific understanding of science and technology. *Public Understanding of Science, (1)1,* 27-30.

Miller reviews the development of the *Science Indicators* studies of scientific literacy, defined in terms of scientific ideas and processes and their social impact. Attention is drawn to comparable measures in Britain, Canada, New Zealand and the European Community and the author identifies two 'challenges' for the 1990s, namely an improvement in/expansion of crossnational studies and research into the dynamics of the search for scientific knowledge, the formation and stability of attitudes and individual participation in scientific and technical controversies.

MITMAN, A.J., MERGENDOLLER, J.R., MARCHMAN, VIRGINIA A., and PACKER, M.J. 1987 179

Instruction addressing the components of scientific literacy and its relation to student outcomes. *American Educational Research Journal,* 24(4), 611-33.

The instruction of 11 seventh grade science teachers was observed in order to determine the extent to which they made linkages between science content and its societal, reasoning, historical and attitudinal implications. Such linkages were hypothesized to facilitate students' SL. (Five components of SL are elaborated in an appendix.) Data were gathered on students' perceptions of teacher instruction and SL. Found that teachers rarely or never addressed the non-content components of science in their presentations and academic work assignments. Students perceived content as the prominent focus of teachers' instruction. Concluded that there is a large gap between SL as a normative goal of science instruction and current teaching practices.

MOORE, J.L. 1987 180

A technique for discovering young pupils' ideas about technology. *CASTME Journal,* 7(1), 1-9.

Presents a method based on the idea of asking pupils to 'draw a technologist at work'. The author found associations with science, gender and material objects in pupils' drawings, but pupils' responses varied according to their age and gender. An association between scientists and technologists was found to disappear among older pupils.

MULEMWA, JANE N. 1987 181

The environment and appropriate science and technology in curriculum development in Uganda. In RIQUARTS, K. (ed.) *Science and Technology Education and the Quality of Life, Vol. I . Science Education*, Kiel, IPN, D-2300 Kiel 1, Olshausenstrasse 62, Germany, 107-14.

Describes the Namutamba Project involving initially a teacher training college and six primary schools. Critical of existing SL/TL provisions (too academic a curriculum; no use of local environment; imported resources; students learn to despise manual work), the aim was to improve living conditions in a selected area and assist children to integrate effectively and rapidly into the social, cultural and economic development of Uganda. New content was introduced into the primary school curriculum including the study of the environment; constructional work; food and nutrition; and agricultural activities. Community involvement through non-formal education was encouraged. The programme was extended to ten other training colleges and its name was changed to Basic Education integrated into Rural Development (BEIRD): a technological component was added.

Related developments in other countries including Malawi, Zambia and Bhutan are described in KNAMILLER, G. 1992: Narrowing the school/home science gap through teacher training. In LAYTON, D. (ed.) *Innovations in Science and Technology Education,* Vol. 4, Paris, UNESCO, 39-51 .

NATIONAL INSTITUTE FOR EDUCATIONAL RESEARCH (NIER) 1992 182

Science and Technology Education: Directions for Curriculum Change. Tokyo, NIER.

This report presents an analysis of trends in the science education curriculum in participating countries from Asia and the Pacific, identifies problems and issues and implications for curriculum change, and makes recommendations for the direction of change.

(Annotation supplied by Lucille Gregorio.)

NATIONAL SCIENCE BOARD COMMISION ON PRE-COLLEGE EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY 1983 183

Educating Americans for the 21st Century: A Report to the American People and the National Science Board, Washington, DC 20550, National Science Foundation.

Presents a detailed strategy for making US mathematics, science and technology education the world's best by 1995. Argues for a return to 'basics' but re-defines the 'basics' of the 21st century as including communication and higher problem-solving skills and STL. Contributory to TL is an understanding of (I) the historical role of technology in human development; (2) the relationship between technological decisions and human values; (3) the benefits and risks of choosing technologies; 14) the changes occurring in current technologies; and (5) an understanding of technology assessment as a method for influencing the choice of future technologies (Source Materials, p. 74).

NATIONAL SCIENCE FOUNDATION 184

NSF to support statewide reforms in science, math, and engineering education. *NSF Directions,* 3(3) 1.

New guidelines for the improvement of science education are announced. These are for *all* students with the aim of boosting SL and citizen understanding of science related issues... the influence of technology on the physical world and the human condition - at every educational level. Science instruction 'must deal with improving critical thinking and habits of mind developing better understanding of the contribution of science to the lives of individuals and societies, and generating stronger student commitment to positive value systems and ethical conduct'.

NATIONAL SCIENCE TEACHERS' ASSOCIATION, USA (NSTA) 1990 185

Position Paper on STS. In *Bulletin of Science, Technology and Society,* 1 0(5 & 6), 249-50.

This Position Paper, unanimously approved by the NSTA Board of Directors in July 1990, asserts that: 'Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions about current problems and issues... STS provides direction for achieving scientific and technological literacy for all.' A section of the paper is headed: 'STS: A Way of Producing Scientific and Technological Literacy.' A list of the characteristics of an STL person follows. Concludes that: 'The experience of science education through STS strategies will create a scientifically literate citizenry for the 21 st century. '

(The NSTA Position Paper on *School Science Education for the 70s* similarly listed the traits of 'a scientifically literate person'! *The Science Teacher,* 38(8), Nov. 1971.)

NELKIN, D. 1987 186

Selling Science. How the Press Covers Science and Technology. New York, W. H. Freeman & Co.

The author attacks the ways in which scientists and scientific knowledge are represented in the media (mainly the popular press). She argues that 'by idealizing technical professions, they oversimplify... the meaning of science literacy'. The book devotes almost no attention to formal education, mainly examining it as a dimension of how newspapers represent specific issues. The tensions and accommodations between science and journalism are explored, and the need for a responsible, independent role for the press is argued.

NGANUNU, M. 1988 187

An attempt to write a science curriculum with social relevance for Botswana. *International Journal of Science Education,* 10(4), 441-48.

Describes an attempt to devise a science curriculum to serve students of a wide ability range, most of whom will leave school after year 9, and which it is possible to teach under simple conditions, if necessary in an ordinary classroom. Examples are given of the real-life orientation of the syllabus and how it is related to local and contemporary needs and experience.

NOBLE, D. 1984 188

Computer literacy and ideology. *Teachers College Record,* 83(4), 602-13. Also in: WATKINS, P. 1986 *High Tech, Low Tech and Education,* Deakin University, Victoria 3217, Australia, 82-93.

Distinguishes consumer literacy, student literacy, worker literacy and argues that CL is no more necessary for citizenship than motorcar literacy is. The CL phenomenon is best viewed, not as education, but as an ideological campaign that coincides with and reinforces a hegemonic vision of a computerized future.

OGAWA, M. 1986 189

Toward a new rationale of science education in a non-Western society. *European Journal of Science Education,* 8(2), I 13-19.

Using Japan as his example, the author argues that one of the main aims of science education in a non-Western society should be to compare traditional and scientific views of nature and to clarify similarities and differences between them.

OGUNNIYI, M.B. 1988 l90

Adapting Western science to traditional African culture. *International Journal of Science Education, I0(1), 1-9.*

The author reviews African scientific systems of thought and argues that they are not incompatible.

OGUNIYI, M.B, 1991 191

Scientific and Technological Literacy in Africa: The Nigerian Experience. Ibadan, Federal Ministry of Education/University of Ibadan.

Using a six-page questionnaire of 92 items, together with a small number of interviews, Ogunniyi investigated several dimensions of scientific and technological literacy among an educated group in 13 states of Nigeria. Some 4,353 usable questionnaires generated a wealth of data and prompted a range of important policy recommendations.

OKEKE, E.A.C. 1986 192

Attracting women into science-based occupations (SBOs): problems and prospects. *CASTME Journal,* 6(3), 44-58.

The author stresses the occupational importance of science education, and the economic and social reasons for increased representation of women. She considers several possible reasons for women's underrepresentation, including intellectual level, childhood experiences, school experiences and societal influences. She accepts all but the first of these and suggests methods to reduce their impact.

OLORUNDARE, S.A. 1988 193

Scientific literacy in Nigeria: the role of science education programmes. *International Journal of Science Education,* 10(2), 151-58.

The relevance of science education programmes in Nigeria to the development of scientific literacy is explored. Such literacy is defined in terms of scientific knowledge.

O'REILLY, F.D. 1991 194

Education of farmers for technology transfer in the Third World. *Science, Technology and Development. Journal of the Third World Science, Technology and Development Forum, 9(1 &* 2), 129-139.

Reviews methods by which central agencies have attempted to communicate with peasant farmers about technological interactions, and discusses the role of education in agricultural development. In so doing, challenges beliefs about the value of literacy and identifies value conflicts between 'the managed' and 'the managers' as contributory to the failure of agricultural innovations.

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) 1989 195

Education and the Economy in a Changing Society. Paris, OECD.

Adopts a human capital/economic functionalist view of education and argues for technologically literate consumers and technologically literate young people equipped to understand and use new technology in their chosen occupations.

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD) 1992 196

Technology and the Economy. The Key Relationships. Paris, OECD.

This volume provides a very detailed analysis of technological innovation and its relation to the economy. In a chapter on human resources in the production system emphasis is placed on CL as a component of a broader conception of TL which, in turn, should be incorporated in a concept of liberal education expanded to reflect scientific and technological issues in a critical perspective.

ORPWOOD, G.W.F. 1984 197

Technology and Education: Preparing for the Information Society. Ottawa, Science Council of Canada.

Identifies three components of TL: (I) understanding what technology is/is not; (2) understanding how technology functions, including how it affects society, its impact on work, lifestyles etc.; (3) understanding how technology is controlled and that no technology is inevitable. Argues that TL must become a vital goal of the school curriculum.

OST, D.H. 1985 198

The nature of technological literacy. *School Science and Mathematics,* 85(8), 689-96.

TL, a new element of basic education, though not a new component of education, implies having the frame of mind and the ability to enter into complex thinking and to feel comfortable in a problem-solving situation. Comments on the relationship of TL to science education, mathematics education and computer education. Mathematics is 'the language' of the TL person. Argues that all students are capable of being technologically literate.

PAPA, B.R. 1990 199

Promoting technology as an income-generating activity for girl dropouts from rural areas - a case study. In *Proceedings of the Third World GASAT Conference,* Jonkoping, Sweden, GASAT (Gender and Science and Technology).

Girls in rural areas in India who were school dropouts were enrolled in a course on electricity provided by a university and taught to repair defective appliances. The reaction of the girls to school science was that it was 'dry and lacking first hand practical experience'. They did so well on the 'electrical repairs' course that the university was tempted to offer courses in wiring and electronics.

(Annotation based on Sylvia Ware, 1992.)

PENA, MARGARITA M. 1992 200

Technology in the general curriculum: a Latin American perspective. In BLANDOW, D. and DYRENFURTH, M. (eds.) *Technological Literacy, Competence and Innovation in Human Resource Development,* Columbia, MO, Applied Expertise Associates, 338 Crown Point, Columbia, MO 65203, USA.

Technology as part of general education bridges the gap between academic and technical education. Its purpose is not vocational. It is interdisciplinary and aims for mastery of the practical, theoretical and ethical knowledge inherent to technological devices and systems. Five dimensions constitute the disciplinary framework for technology education: a cultural, social and historical one; a communicational dimension; a scientific-technical one; a methodological one; and a functional one. A list of ten contents blocks is provided.

PERRY, LORD 1990 201

Science and education. *Science and Public Affairs,* 4(2), 65-82.

In this Bernal lecture, Lord Perry identifies a number of ways in which scientific discoveries and technological developments are communicated to the general public. He identifies science education, including adult continuing education, as a key element in developing understanding of the global problems all societies face at the end of the twentieth century.

POMEROY, D. 1992 202

Exploring science across cultures. *Harvard Graduate School of Education Alumni Bulletin,* Fall 1992, 8-9.

Asserting that non-Western cultures have sciences of their own, a case is outlined for a scientific literacy which rests upon the notion of cultural epistemology. Reference is made to a project in Alaska in which students draw upon the knowledge of Inupiaq elders and explore its epistemological foundations.

POOL, R. 1991 203

Science literacy: the enemy is us. *Science*, 251, 266-67.

Reports on the attempt of geophysicist Robert Hazen and physicist James Trefil to identify the 20 'Greatest Science Hits', i.e. the most fundamental and important ideas underlying all science. The list is published with an invitation to readers to respond with comments on what students should know to be scientifically literate. Hazen and Trefil cite examples of scientific illiteracy amongst professional scientists, e.g. a Nobel Prize-winning chemist who had never heard of plate tectonics.

The responses to Hazen and Trefil's list are reported by CULOTTA, E. 1991: 'Science's 20 greatest hits take their lumps', *Science*, 251, 1308-09. Hazen and Trefil published a book, *Science Matters: Achieving Science Literacy* and James Trefil is the author of *One Thousand and One Things Everyone Should Know About Science*, Doubleday, 1992.

POSTLETHWAITE, T.N. 1991 204

Achievement in science education in 1984 in 23 countries. In HUSEN, T. and KEEVES, J.P. (eds.) *Issues in Science Education. Science Competence in a Social and Ecological Context*, Oxford and New York, Pergamon Press, 35-59.

Describes results from the second international study of science achievement conducted by the International Association for the Evaluation of Educational Achievement in 1983-4. With respect to Population 2 (14-year-olds) argues that their science achievement is an indicator of the SL of the majority of the future labour force. The bottom 20 per cent of such students in developing countries, as well as in England, Hong Kong, Singapore and the USA have very low scores and their SL might be questioned. The extent to which IEA test questions 'measured' SL is questioned by GRIMVALL (60-61) because an important element of SL (ability to recognize a scientific way of reasoning) was not captured by them.

POSTMAN, N. 1993 205

Technopoly. The surrender of culture to technology. New York, Vintage Books.

Argues that those in the USA now live in a Technopoly - a self-justifying, self-perpetuating system wherein technology of every kind is cheerfully granted sovereignty over social institutions and national life. Although he does not use the term TL, Postman offers some guidelines, with clear educational implications, for those who wish to defend themselves against the effects of Technopoly. They must understand that technology must never be accepted as part of the natural order of things; all technologies are products of particular economic and social contexts; they require scrutiny, criticism and control. For Postman, as for Paul Goodman, 'Whether or not it draws on new scientific research, technology is a branch of moral philosophy, not of science.' Much of the final chapter, entitled 'The Loving Resistance Fighter', is given over to a discussion of the kind of school curriculum needed to enable us to distance ourselves from the thought-world of Technopoly and then criticize and modify it. (See also the critique of Postman' s argument by David Nartonis in *Bulletin of Science, Technology and Society,* Vol. 13, No. 2, 67-70.)

POWER, C. 1987 206

Science and technology: towards informed citizenship. *CASTME Journal,* 7(3), 5-18.

The author stresses the importance of science and technology education if the power of science and technology is to be harnessed for the general good. He suggests that science must not be allowed to be the preserve of professionals only, that there is a need to introduce into the curriculum such issues as ethics and social responsibility, and decision making within value conflicts, as well as for a study of areas such as the environment, food and health, and energy. Science and technology must not be left as a matter for 'big business and government'.

POWER, C.N.1990 207

Policy issues in science education: an international perspective. In JENKINS, E.W. (ed.) *Policy Issues and School Science Education,* Leeds, Centre for Studies in Science and Mathematics Education, The University of Leeds, 1-17.

Reviews economic, environmental and scientific-technological challenges to science education. Explores the implications of Science for All, especially for the supply and training of science teachers and for international co-operation. Concludes that SL - personal, societal and cultural - is essential in the developing as well as the developed world if the exploitation of the weak and the abuse of science are to be averted, and if students are to be equipped to make their way in the modern world at work, in the home and as enlightened citizens.

PREWITT, K. 1983 208

Scientific illiteracy and democratic theory. *Daedalus,* 112(2), 49-64.

The paper is part of a full issue of *Daedalus* dealing with SL. It identifies three dimensions to the issue, relating to the role of science in the economy, the nature of public policy for science and the role of scientific knowledge in democracy. Attention is devoted mainly to the second and third of these. The author argues that there is a need for attention to the consequences of scientific knowledge and that less emphasis should be placed on 'knowledge... for its own sake'. The discussion appears to identify science and technology very closely (p. 61) and the author calls for a dispersal of what he calls 'scientific savvy' linking the citizen with (scientific?) public life.

PRIME, GLENDA M. 1992 209

The role of technology education in the Caribbean. In BLANDOW, D. and DYRENFURTH, M. (eds.) *Technological Literacy, Competence and Innovation in Human Resource Development,* Columbia, MO, Applied Expertise Associates, 338 Crown Point, Columbia, MO 65203, USA, 65-73.

The Caribbean region is described in terms of its technological characteristics, its existing technological activity, its technological needs and the role that technology must play in regional development. Existing human resource development activities are reviewed, and curriculum plans are evaluated in the light of technological needs previously identified. The incorporation of technology education as a component of general education is advocated and guidelines for content and curriculum emphases suggested. Distinguishes between technological awareness (so that citizens are made sensitive to the social and cultural implications of technology), TL, and technological capability. Whilst some dependence on foreign technology is inescapable, there is a need to reduce this as far as possible by developing local expertise in the maintaining, repairing, dismantling and re-assembling of foreign technology, and in 'unpacking' it so that components can be manufactured locally.

PRIME, GLENDA M. 1992 210

Gender issues in technology education in Trinidad and Tobago. Paper presented at the ITEA/PATT International Conference, Reston, Virginia, USA.

Documents the results of participation and attitude studies which show that girls seldom choose the technological streams in secondary education in Trinidad yet do not have significantly different attitudes to technology from boys. Reports on an investigation which compares girls and boys on all subscales of an attitude and concept scale (PATT). Concludes that if girls do not have less positive attitudes to technology than boys, and are not less capable in technological and practical science skills, the focus of technology education ought to be on providing the right conditions that would enable and empower them to develop their interests and capabilities, rather than trying to find so-called 'girl-friendly' technological content. Also, so long as society differentially rewards men in technology, girls will continue to shy away from technological subjects and careers.

PROUT, A. 1985 211

Science, health and everyday knowledge: a case study about the common cold. *European Journal of Science Education,* 7(4),399-406.

The author reports an empirical study of the knowledge of British 15-year-olds about the common cold, illustrating the problems in suggesting either that everyday issues can easily be integrated into education or that taught science can influence what he calls 'the grain of everyday life'. He suggests that the power of science in this regard is commonly exaggerated, and suggests that the relation between these two areas needs more subtle and realistic attention in the context of the curriculum.

QUIN, M. 1991 212

The interactive science and technology project: the Nuffield Foundation's launchpad for a European collaborative. *International Journal of Science Education,* 13(5), 569-73.

The author surveys the initiatives in interactive, 'hands-on' science and technology centres in the USA and Europe. She sets these initiatives in the context of general concern about the need to promote 'public understanding of science', and sees them as orientated mainly in this direction. There is no further analysis of the concept.

RAAT, J.H. and DE VRIES, M. 1987 213

Technology and education: research and development in the project 'Physics and Technology'. *International Journal of Science Education*, 9(2), 159-68.

Gives an account of a research project focusing on identifying the need for, and developing, curricula in technology. The discussion focuses mainly on technology, and some empirical data on pupils' attitudes is reported. The emphasis on physics occurs intermittently and, although the authors' fundamental position is not explicitly stated, the piece appears to embody a perspective in which technological literacy is seen as an adjunct to knowledge of science.

REAVAN, S.J. 1987 214

Science literacy needs of public involvement programs. *Bulletin of Science, Technology and Society,* 7(1 & 2), 347-56.

From experience of the public's involvement in controversies over STS issues (examples are given), the difficulty in diagnosing expert disagreement emerges as an important problem. This has two components: (1) difficulty in comparing the positions of each side as a whole; and (2) difficulty in evaluating the validity of individual technical claims. To solve these difficulties, SL programs should: train citizens to be aware of argument style differences, as an aid in spotting when and how the different sides of an issue talk past one another; teach citizens to be aware of the wide range of views on the nature of science, and how they affect the evaluation of technical claims; focus on the 'idea' assumptions behind the main technical claims, as an aid to sharpening the evaluatory skills of participants.

REID, D.J. and HODSON, D. 1987 215

Science for All: Teaching Science in the Secondary School. London, Cassell.

Argues that a basic education aimed at SL should contain at least: science knowledge - certain facts, concepts and theories; applications of scientific knowledge in real and simulated situations; skills and tactics of science; problem solving and investigations; interactions with technology; socioeconomic-political and ethical-moral issues in science and technology; history and development of science and technology; and study of science and scientific practice.

ROBERTS, D.A. 1983 216

Scientific Literacy. Towards Balance in Setting Goals for School Science Programs. Ottawa, Science Council of Canada.

Building on his analysis of seven science curriculum emphases, Roberts reviews the emergence of SL as a slogan and the multiple interpretations of it in the 1960s and 70s. He distinguishes a *composite* sense of SL (embodying every conceivable category of science education objectives, all of which are appropriate in some measure for all students) and a *distinctive* sense, more narrowly and precisely defined. The former can mask legitimate differences in value preferences concerning the goals of science education. The latter is the better guide for curriculum planning. A case is made for use of a crisper set of terms than SL ('an aging slogan') in order to achieve an appropriate balance in the goals of science education.

ROSENBERG, G. 1987 217

Computer literacy education. *Bulletin of Science, Technology and Society,* 7(5 & 6), 984-994.

Critically reviews CL education in US schools in the late 80s. In so doing identifies topics included in CL classes, whilst acknowledging that the goals of such classes are often unclear. Justifications (e.g. jobs, mental discipline, informed citizens) for teaching CL are examined. Concludes that there is no justification for mandatory CL education as then taught. Also, emphasis on computers in schools should not be allowed to become a smoke-screen diverting attention from fundamental problems that may not have technological solutions.

ROTHSCHILD, JOAN 1989 218

Teaching Technology from a Feminist Perspective. A Practical Guide. New York and Oxford, Pergamon Press.

Touches on the meaning of TL at a number of points, especially in connection with liberal arts courses for non-science students. The rationale for these courses is that students in non-scientific fields will be disempowered if they do not overcome their alienation and antipathies and gain the requisite knowledge and skills of things mathematical, scientific and technological to function in a technologically-oriented world. Examples of courses integrating 'hands on', and theoretical and conceptual materials are suggested as models for TL courses. If the feminist dimension of this model is not transferred as well, the course may end up empowering only men. When gender perspectives are integrated into TL courses, the gender stereotypes about technical vs. non-technical thinking can be challenged and re-thought.

The science/technology/society connection. *Curriculum Review,* 24(3), 12-14.

TL is defined as 'the ability of a citizen to communicate effectively, in all the normal activities and transactions of daily life, about all the major forces affecting us in a highly technological world'. TLis highly situational and CL is not a synonym for it. The target audience in schools is the 99 per cent who do not go on to become scientists. STS provides the kind of general education needed.

ROY, R. 1986 220

Technological literacy - clarifying the concept and its relation to STS. *Bulletin of Science, Technology and Society, 6(2 &* 3), 131-37.

Identifies different aspects of TL, a slogan which is not analogous to SL. Uses an analogy with language to distinguish between *comfort with* technology, *competence in* technology and *control of* technology, which comprise the TL continuum. It follows that TL is a situational term, i.e. how much competence and control one needs is a function of one's environment and responsibilities. There is no such thing as general TL. The contribution of STS education to TL is reviewed.

RUSSELL, T.L. 1983 221

Analyzing arguments in science classroom discourse: can teachers' questions distort scientific authority? *Journal of Research in Science Teaching,* 20(1), 2745.

Verbatim transcripts of parts of three science lessons are analysed for the nature of the arguments deployed by the teacher. The analysis highlights the importance attached to getting 'the right answer' and suggests that this may be at the expense of a more rounded and well-founded understanding of the nature of scientific authority.

SALISBURY,A.J. 1992 222

Scientific literacy as a resource for the educator: scientific and mathematical literacy. *CASTME Journal,* 12(1),23-31.

The author provides a general analysis of issues in scientific literacy with a focus on 'mathematical literacy as an important sub-set of scientific literacy'. He focuses on the issues of 'process' versus 'product' and the need to define a common core of minimum requirements. He lays particular stress on the fact that 'science for all' must imply differentiation according to interests, abilities and needs.

SAVAGE, M. 1992 223

Nourishing innovation in science education in Africa: the experience of the African Forum for Children's Literacy in Science and Technology. *Science, Technology and Development,* 10(2),246-64. (Special Issue on 'Education in Science and Technology: Innovations and Implications for the Developing World' edited by KING, K. and LAYTON, D.)

Describes the various factors (expanding school systems, deteriorating economies, political and donor pressures) that have adversely affected the quality of schooling in many contexts. The role of the Forum (see also COURT, D. 1989) in funding innovative projects in the field of science and technology education is described, with examples, many of which involve non-formal education and are concerned with empowerment in relation to practical problems.

SCARBOROUGH,J.D. 1991 224

International perspectives on technological literacy. In DYRENFURTH, M.J. and KOZAK, M.R. (eds.) *Technological Literacy. Council on Technology Teacher Education 40th Yearbook,* Peoria, IL 61615-2190, Glencoe Division, Macmillan/McGraw-Hill, 54-79.

Reports the results of a mail survey of 40 countries, incorporating data from other surveys also. TL is found to be 'a cause celebre' in the USA, Canada and parts of Europe only, although concern about the impact of technology on society is worldwide. The stage of development of a country determines how TL is interpreted.

SCIENCE COUNCIL OF CANADA 1984 225

Report 36. Science for Every Student. Educating Canadians for Tomorrow's World. Ottawa, Science Council of Canada.

In discussing the aims of science education, argues that programs should include a balanced coverage of four important aspects: (1) science for informed participation by citizens in a technological world; (2) science for further education; (3) science as preparation for the world of work; and (4) science as a means of students' personal development. The Science Council supports a concept of SL that has a composite nature (see ROBERTS, 1983). Eight major recommendations for the renewal of science education are outlined: these have been critically reviewed by LEITH, Sylvia,1985, *Journal of Curriculum Studies*, 17(4), 440-45.

SECONDARYSCIENCE CURRICULUM REVIEW 1983 226

Science Education 11-16: Proposals for Action and Consultation, London, SSCR.

This consultative paper, concerned with science education in England and Wales, assumes that STL set within a broad general education is central to economic growth and social well-being and may help young people better manage the complex demands of life in an advanced technological democracy. It offers proposals for science curriculum reform, claiming that these amount to a 'new direction for science studies'.

SEGAL, H.P. 1988 227

The several ironies of technological literacy. *Michigan Quarterly Review*, 27(3), 448-53.

According to the author, TL has been presented by some as the 'long-sought bridge' between the sciences and the humanities. However he suggests that it involves several 'ironies'. These include the common rejection by 'humanists' of the need for TL, while accepting the need for humane studies for technologists, the fact that greater familiarity with the 'principles, functions, and values' of technology often serves to reinforce suspicion of it, the common ignorance of scientists about technology, the tendency toward technological utopianism among advocates of technological literacy and 'Whiggish' tendencies. Segal also suggests that the concerns expressed by such advocates reflect an underlying pessimism about the general attitude to technology of 'other educated persons'.

SHAHN, E. 1988 228

On science literacy. *Educational Philosophy & Theory,* 20(2), 42-52.

The author argues that science literacy cannot involve merely 'factual knowledge' but requires linguistic and mathematical competencies and skills. He suggests that this view should be used to inform the development of science curricula.

SHAMOS, M.H. 1988 229

Science literacy is futile: try science appreciation. *The Scientist,* 3 October 1988, 9 and 12.

Whether SL is defined as a functional ability to read, comprehend and discuss science or the possession of scientific habits of mind, there is little incentive for the vast majority of the public to achieve it. The 'good life' can be led in the US without any knowledge of DNA, quarks or the Second Law of Thermodynamics. Participation by the public in debates about technically-based issues is an unreal prospect because the science background needed goes well beyond that of most professional scientists and engineers. Only by acquiring a sense of the process of science can one truly share in 'a common science culture'. 'Science appreciation', as advocated by Edward Teller, is a more realistic goal, i.e. courses that are interesting, stimulating and amusing and which lead the public to being pro- rather than anti-science.

SHAMOS, M.H. 1988 230

Views on scientific literacy in elementary school science programs: past, present and future. In CHAMPAGNE, A.B., LOVITTS, B.E. and CALINGER, B.J. (eds.) *This Year in School Science 1989. Scientific Literacy.* Washington, DC, American Association for the Advancement of Science, 109-27.

Reviews past efforts to reform the elementary school science curriculum and provides a 'specific, bounded and readily testable' definition of SL in terms of which to evaluate present efforts. He distinguishes 'cultural SL' (familiarity with a lexicon of terms) from 'functional SL' (ability to converse, read, write coherently, using scientific terms in a non-technical but meaningful context) and from 'true SL' (knowing something of the major theories, how they were arrived at, why accepted, the role of experimentation and 'scientific method'). He concludes that the new curricula will be no more effective in helping children to achieve SL than those of the past. Also, 'true SL' is an unreasonable expectation as a goal for elementary school science, as well as for most of the adult public.

SHAPIN, S. 1992 231

Why the public ought to understand science-in-the-making. *Public Understanding of Science,* 1(1),27-30.

The argument here is that public understanding of science must include a commitment to telling the public 'how, with what confidence, and on what bases, scientists come to know what they do'. This account of 'science in the making' can, it is suggested, be presented by drawing upon the findings of the sociologists of scientific knowledge such as Barnes, Latour, Pinch, Leigh Star etc.

SNOW, R.E. 1987 232

Core concepts for science and technology literacy. *Bulletin of Science, Technology and Society,* 7(5 & 6),720-29.

Science and technology are treated as systems of thought and action within which sociological factors and value laden decisions play central roles. Ten claims are articulated, and concept maps constructed, for each system. Emphasis is placed on recognizing the subjective element in science and on understanding that technological artefacts are political statements (i.e. technologies are always the products of individuals/groups seeking to serve particular interests).

SOLOMON, J. 1988 233

The dilemma of science, technology and society education. In FENSHAM, P.J., *Development and Dilemmas in Science Education,* London, Falmer Press, 266-81.

Following a brief review of the factors that have prompted the development of STS education in many parts of the world, the author discusses the different courses and rationales that have emerged in an attempt to provide a science education for all. She points out that too little is known about the response of students to STS education, but suggests that an appropriate philosophical perspective on science as a way of knowing might be a useful pedagogical starting point.

SOO-BOO TAN 1991 234

The development of secondary school science curriculum in Malaysia. *Science Education,* 75(2), 243-50.

The article, describing the Malaysian education system, its goals and the development of new science curricula, includes an interesting section on 'the language issue'. The translation of British curricula into Bahasa Malaysia posed many problems, which the author illustrates e.g. use of borrowed words; difficulty of expressing scientific concepts in a scientifically unenriched language; dearth of reference material written in Bahasa Malaysia. Although in this case, the language issue is described as a transient problem, Bahasa Malaysia having developed to meet its role as a language of instruction in schools, the account adds a particular dimension of meaning to SL in developing countries.

SOOD, J.K. 1987 235

Science and technology in the Third World countries: priorities and possibilities. In RIQUARTS, K. (ed.) *Science and Technology Education and the Quality of Life. Vol. 1. Science Education,* Kiel, IPN, D-23000 Kiel 1, Olshausenstrasse 62, Germany, 76-84.

There is a distinct line between urban, affluent, elitist groups and rural, traditional, illiterate masses; both groups have failed to imbibe the ethos of science and the latter is missing even basic scientific and technological knowledge. Other problems - overpopulation, limited resources - are identified. Much of the science teaching in schools is discipline centred, textbook oriented and fails to achieve SL for all. Lists changed priorities including the presentation of a holistic view of science, including reference to values and ethical, moral and social aspects of science. Non-formal methods and voluntary organizations such as the Kerala People's Science Movement and Hoshangabad Science Teaching program, using issue based science teaching, are doing much to popularize science: for them, the aim of science education is to impart ability to acquire problem solving skills.

SOYDHURUM, P. 1990 236

Secondary School Science Education in Thailand into the 1990s. Penang SEAMEO-RECSAM Penang, Malaysia.

A comprehensive and detailed account in twelve chapters of science education in Thailand. During the 1980s the issue of science for everyday life was emphasized (sometimes called 'Science for All' or 'Science for the average citizen'): the extent to which actual school curriculum experiences are congruent with this goal is investigated, drawing on evidence from the IEA Second International Science Study and ratings for specific content areas. Emphases for the future are STS, science for all, science for urban development, science for the rural poor, technology education in science, information technology for science education and science components in education 'for' the environment.

SPARGO, P.E. 1990 237

Looking to the future: the role of science education in the solution of South Africa's problems. Paper presented at the National Subject Didactics Symposium, Stellenbosch, September 1990.

Reviews the problems - demographic, social and economic as well as political - confronting South Africa and argues that the development of a scientifically literate population is crucial for South Africa's survival. Existing school science subjects are judged unsuited to this task and the case for an issues-based new course, which will encourage skills of debate and the weighing of evidence, is made.

STUNKEL, K.R. 1987 238

Seeking technological perspective in the undergraduate curriculum. *Bulletin of Science, Technology and Society,* 7(5 & 6), 854-60.

Reports an intra-college debate about the meanings of, and needs for, TL. Agreement focused on the following outcomes of TL courses: systems thinking and analysis; technological rationality; appreciation of values; historical perspective; artefacts in operation; interaction of society with technology; democratic decision making. Diverse faculty resources were used.

SZUCS,E. 1992 239

Technology, culture and education. In BLANDOW, D. and DYRENFURTH, M. (eds.) *Technological Literacy, Competence and Innovation in Human Resource Development,* Columbia, MO, Applied Expertise Associates, 338 Crown Point Columbia, MO 65203,502-509.

Argues that school systems in the 21st century cannot exist without a subject representing and developing TL. Outlines eight goals for school technology education of which 'making popular the concept of technical beauty' is judged the most important. (If we cannot motivate all pupils, the rest is useless.) Identifies a number of 'dangerous forces' working against the development of technology education: these include the belief that technology is not part of general culture; an extreme 'handicraftsman' orientation; misunderstanding the role of computers (CL is important, but is only a part of general TL).

TALISAYON, V.M. 1984 240

Enhancing the relevance of science teaching and learning for community needs and development concerns. *Bulletin of the UNESCO Regional Office for Education in Asia and the Pacific. No. 25. Science Education in Asia and the Pacific.* Bangkok, UNESCO Regional Office for Education in Asia and the Pacific, 469-81.

In science education, community development is implied in the widely accepted goals of national development and SL for the general population. Describes the community-based projects of the Science Education Centre of the University of the Philippines from 1977 to 1984. The focus has been on concerns such as health, sanitation, nutrition, agriculture, farming and fishing, and population growth.

THE SECRETARY'S COMMISSION ON ACHIEVING NECESSARY SKILLS (SCANS) 1991 241

What Work Requires of Schools. A SCANS Report for America 2000. Washington, DC 20402-9328, US Government Printing Office.

This initial report from SCANS (set up by the Secretary of the US Department of Labor) describes the results of discussion with employers of many kinds over a period of twelve months. The Commission identifies five competencies and a three-part foundation of skills and personal qualities that are needed for 'solid job performance'. Apart from the ability to productively use resources and interpersonal skills, the competencies include 'use of information', 'use of systems (understanding social, organizational and technological systems, monitoring and correcting performance, and designing and improving systems)' and 'use of technology (selecting equipment and tools, applying technology to specific tasks, and maintaining and troubleshooting technologies)'. Neither scientific nor technological skills receive specific mention under the foundation heading but 'Thinking Skills', identified there, include 'thinking creatively, making decisions, solving problems, seeing things in the mind's eye, knowing how to learn, and reasoning'.

THIER, H.D. and HILL, T. 1988 242

Chemical education in schools and the community: the CEPUP project. *International Journal of Science Education,* 10(4), 421-30.

The authors describe the aims and outcomes of a Chemical Education for Public Understanding Programme (CEPUP), linking chemical concepts and processes with social issues. The aim of CEPUP is to increase public awareness of the nature of chemicals and hence improve public understanding of chemical-related issues. Although the term 'chemical literacy' is not used, it is argued that understanding how chemicals interact with people and the environment is essential to informed citizenship in any society.

THOMAN, ELIZABETH 1993 243

Media, technology and culture: Re-imagining the American Dream. *Bulletin of Science, Technology and Society, 13(1),* 20-27.

Her thesis is that the *images* of culture create the *myths* in our heads which shape the *values* we use to make *choices* day in and day out. A new vision of education in a mass media world is needed - 'media literacy'. This is 'the ability to interpret the symbols and meanings of the hundreds, even thousands of messages we get every day through television, radio, newspapers and magazines, even advertising, It's the ability to choose and select, the ability to challenge and question, the ability to be conscious about what's going on around you and not just be couch potatoes.'

THOMAS, G. and DURANT, J. 1987 244

Why should we promote the public understanding of science? In SHORTLAND, M. (ed.) *Scientific Literary Papers*, Oxford, Scientific Literacy Group, Department of External Studies, University of Oxford, 1-14.

Reviews nine arguments for promoting the public understanding of science which they equate with SL, though not defined in too rigid or formal a way. To be scientifically literate 'is not to be expert in anything particular, but rather to be able to deal effectively with matters scientific when they arise in the course of life; to be able to cope with science in a way that is both respectful of scientists' legitimate expertise and wary of their fallibilities and weaknesses'. A later paper in the same volume describes a survey of the understanding of, and attitudes towards, science of adult students. The instrument used is included (37-66) .

THOMPSON, M. and DE ZENGOTILA, T. 1989 245

Science literacy and the language game of science. In HERGET, D.M. (ed.) *The History and Philosophy of Science in Science Teaching. Proceedings of the First International Conference,* Science Education and Department of Philosophy, Florida State University, Tallahassee, Florida, 344-52.

Draws an analogy with language learning to inform the meaning of SL. A child doesn't have to learn the grammar in order to become a native speaker. A student who gets lost trying to visualize calories, for example, is like a second language learner.

TODD, R.D. 1991 246

The natures and challenges of technological literacy. In DYRENFURTH, M.J. and KOZAK, M.R. (eds.) *Technological Literacy. Council on Technology Teacher Education 40th Yearbook.* Peoria, IL 6165-2190, Glencoe Division, Macmillan/McGraw-Hill, 10-27.

Explores the meaning of TL as slogan, concept, goal and program, as well as the development of TL. Argues that TL is a minimum, not an adequate, level of competence and proposes a taxonomy of capability for technological decision making, distinguishing between technological awareness, literacy, ability, creativity and criticism.

TUMAN, MYRON C. 1992 247

Word Perfect: Literacy in the Computer Age. University of Pittsburgh Press, Pittsburgh, PA.

Deals with the struggle between two competing models of literacy, one based in print and the other in new computer technology. Explores the impact which computers are having on how we read and write, and, generally, on how we define literacy and on our understanding of what it means to be literate.

UNESCO 1993 248

Final Report. Project 2000+. International Forum on Scientific and Technological Literacy for AIM. Paris, 5-10 July, 1993. Paris, UNESCO. ED-93/Conf. 016/LD-14.

The report covers the following topics: the nature of and the need for STL for all; STL for development; the teaching and learning environment; teacher education and leadership; assessment and evaluation; non-formal and informal development of STL. Also included are reports from Regional Groups - Africa, Arab States, Asia and Pacific, Europe and North America, Latin America and Small Island States - on interpretations of STL and proposals for development projects. A Project 2000+ Declaration from the Forum participants reaffirms a belief that STL are essential for achieving responsible and sustainable development and recommends that by the year 2001 there should be in place appropriate structures and activities to foster STL for all, in all countries.

UREVBU, A.O. 1987 249

Science and technology education and African values. In RIQUARTS, K. (ed.) *Science and Technology Education and the Quality of Life, Vol. 2, Technology Education: Science-Technology-Society,* Kiel, IPN, D-2300 Kiel 1, Olshausenstrasse 62, Germany, 701-713.

Examines the extent to which African thought systems and values appear to be inimical to the development of science and technology and raises questions about the relationship of the 'traditional' to the 'modern', and about the meaning of 'development'. Looks in some detail at the social values of Africans and how these influence reactions to technology transfer. Levels of technological choice - village-level, baseline or infrastructural level, and advanced production level - are distinguished - and their interactions with values (e.g. self-sufficiency) are explored. Implications for the kinds of TL required at each level are undeveloped.

In a second paper delivered at the 4th International IOSTE Symposium at Kiel on 'World trends in science and technology education' (Vol. 3,61-80) the same author identifies concerns of developing countries in relation to the impact of science and technology (e.g. excessive dependence on developed countries) and concludes that, at the domestic level, it is important to build 'a popular technological awareness' crossing the borderline between traditional and modern technology, i.e. TL. Science and technology education in schools must reflect a multi-cultural perspective.

VOHRA, F.C. 1987 250

Technology as part of general education. In RlQUARTS, K. (ed.) *Science and Technology Education and the Quality of Life. Vol. 2. Technology Education: Science-Technology-Society*, Kiel, IPN, D-23000 Kiel 1, Olshausenstrasse 62, Germany, 410-418.

Traces UNESCO's advocacy of technology as a component of general education and reviews rationales. Reports on different approaches to the incorporation of technology into school curricula in different countries and the outcome of a Consultation Meeting in 1984, which included a working definition of technology which moves it beyond technical and vocational education. Technology's special relationship with science is examined and the case for linking technology to the teaching of science is advanced.

WAETJEN, W.B. 1987 251

The autonomy of technology as a challenge to education. *Bulletin of Science, Technology and Society,* 7(1 & 2), 28-35.

Distinguishes science from technology. A student who possesses TL will understand basic scientific concepts; know societal needs and moral constraints; understand the application of scientific principles to tools and materials; and be able to use these tools and materials to a certain extent. An engineer requires far more sophisticated knowledge than this. For TL, it is necessary to think of technology in the broadest possible manner. CL is not synonymous with TL, but an aspect of it.

WAKS, L.J. 1987 252

A technological literacy credo. *Bulletin of Science, Technology and Society,* 7(1 & 2),357-66.

Argues that the TL and STS movements have come of age and advances 22 propositions for discussion in order to be clearer about values and programmatic emphases. Included among these propositions are: TL - possession of basic concepts and skills to participate in the technology-dominated economy and understand technology-dominated social issues and participate meaningfully in their resolution - is within the grasp of all undamaged youth of secondary school leaving age. SL is a 'stronger' concept than TL, with additional science knowledge and skill requirements: whilst TL is essential for the functioning of democratic institutions and a modern economy, SL for all may not be appropriate or even possible to achieve. STS is one of many vehicles for promoting TL.

WALBERG, HJ. 1991 253

Improving school science in advanced and developing countries. *Review of Educational Research,* 61(1), 25-69.

This long, detailed and richly referenced review is in five sections, two of which relate to SL. Section 2, Science for Adult Life, summarizes research on what adults know and what they need to know. Section 5, Science Curriculum Reforms, reviews and evaluates some of the major science curriculum ideas since the 1960s. Notes the extent of scientific illiteracy even among teachers.

WARE, SYLVIA A. 1992 254

Secondary School Science in Developing Countries. Status and Issues. Washington, The World Bank. Population and Human Resources Department, Education and Employment Division, Document No. PHREE/92/53.

Whereas the main emphasis in this report is on secondary school science in developing countries, with recognition that this is experienced by only a minority of students of secondary school age, there are interesting comments on 'Science for All' and SL. No country, developed or developing, has ever achieved widespread SL and the problem of knowing when this has been achieved is acknowledged. It is also questioned whether the expectation that a scientifically literate populace can reshape society is a realistic one. If science education is overloaded with responsibilities and the outcomes are less than anticipated, there could be a severe backlash against science education. The plea is for realistic expectations.

SL is viewed as an understanding of (1) the vocabulary and basic concepts of science; (2) the nature of science; and (3) the ways in which science and society interact.

WELSH, I. 1993 255

The NIMBY syndrome: its significance in the history of the nuclear debate in Britain. *British Journal of the History of Science,* 26(1), 15-32.

The 'Not In My Back Yard' (NIMBY) syndrome of the 1980s reflects several competing views of the public understanding of science which have a wider relevance than the nuclear debate. Part of this paper explores these competing views.

WIJKMAN, A. 1991 256

Issues in the scientific education of the citizen in the high technology area. In HUSEN, T. and KEEVES, J.P. (eds.) *Issues in Science Education. Science Competencies in a Social and Ecological Context,* Oxford, Pergamon Press, 19-29.

Notable for its global perspective, this chapter urges the case for a scientific education which is inter-disciplinary and problem-orientated, and addresses the challenges facing the world community e.g. environmental threats, overpopulation, gross inequalities of wealth, health and diet. Examples are given of multi-disciplinary approaches to the study and analysis of complex systems.

WOLPERT, L. 1992 257

The unnatural nature of science. London and Boston, Faber and Faber.

An uncompromising exposition of the nature of science as fundamentally different from common sense: with rare exceptions, scientific ideas are said to be counter-intuitive. Probably the only way to understand science is to do scientific research, but this is clearly not an option to improve public understanding. Science education, nevertheless, should acknowledge more explicitly how different scientific thinking is, compared to 'common sense' thinking.

WORKING GROUP ON SCIENCE AND MATHEMATICS 1985 258

Approach Paper on Science and Mathematics in General Education. New Delhi, Department of Education in Science and Mathematics, NCERT, New Delhi, India.

Reasserts a commitment to 'Science for All'. More complicated problems are emerging in the areas of agriculture, health, nutrition, population, energy, environment and technology; these, with the nation's socio-economic and cultural needs call for a strong component of science and mathematics in general education, linked with local specific and real life situations. Also, the method of science has applicability beyond science disciplines; it can help enlightened decision-making and overcome obscurantism and prejudices. Emphasis should be placed on improving indigenous scientific and technological capabilities. Detailed objectives for primary and secondary school science are provided.

WORLD CONFERENCE ON EDUCATION FOR ALL 1990 259

Meeting Basic Learning Needs: A Vision for the 1990s. Background Document New York, The Inter-Agency Commission (UNDP, UNESCO, UNICEF WORLD BANK).

In the preamble to the World Declaration on Education for All (155-57) it is stated that 'sound basic education is fundamental to the strengthening of higher levels of education and of scientific and technological literacy and capacity and thus to self-reliant development'.

WRIGHT, D.H.M. 1982 260

New science for a new era: the Zimbabwean experience. *European Journal of Science Education,* 4(4), 367-75.

The article outlines the response to a Zimbabwean government decision to expand secondary science education and explores the economic, philosophical, political and cultural issues which this expansion has raised.

WYNNE, B. 1988 261

Unruly technology: practical rules, impractical discourses and public understanding. *Social Studies of Science,* 18(1), 147-67.

The author argues that the practice of technology is not rule-governed, that rules emerge *post hoc,* but that this situation is not made clear in the public discourses of 'experts'. In consequence technological failures produce 'general disorientation'. It is necessary that a different kind of public discourse, which includes the exposure of the actual technological practices, be created, if the relation between 'experts' and 'public' is to be redrawn in sustainable form.

WYNNE, B. 1991 262

Knowledges in context. *Science, Technology and Human Values,* 16(1),111 -21.

Reviews the findings from a number of UK Economic and Social Research Council funded projects in the field of public understanding of science. Three levels of public understanding are identified relating to: (I) the intellectual contents of science; (2) its research methods; and (3) its organizational forms of ownership and control. All are necessary for SL, but neglect of any public discussion of the third factor can undermine attempts to improve the other two. The social basis of trust and credibility of sources of science is a crucial question affecting public uptake of science.

WYNNE, B. 1992 263

Misunderstood misunderstanding: social identities and public uptake of science. *Public Understanding of Science,* 1(3), 281-304.

Starting from the belief that the public uptake of science depends primarily upon the trust and credibility public groups are prepared to invest in scientific organizations and their representatives, the paper highlights the ways in which lay citizens reflect upon their social relationships towards scientific experts and upon the epistemological status of their own 'local' knowledge in relation to 'outside' knowledge. The author suggests that the public uptake of science might be improved if a similar public reflexivity were evidenced by scientific institutions.

YEARLEY, S. 1994 264

Understanding science from the perspective of the sociology of scientific knowledge: an overview. *Public Understanding of Science*, 3(3), 245-58.

The author argues that the sociology of scientific knowledge (SSK) has developed a coherent and relatively uncontroversial account of the nature of scientific practice, stressing its reliance on trust, discussion and judgement. He suggests that this perspective should contribute largely to the attempt to increase general understanding of science, understood not as a body of knowledge but as a practice.

YOUNG, C.S. 1986 265

Making science, technology and maths education relevant to youth, especially girls. *CASTME Journal*, 6(3), 25-43.

The author is critical of the orientation of (mainly) science education to producing disciplinary specialists rather than educating the wider population. This is said to be reflected in its orientation to specialist disciplines, high-level abstractions and concepts rather than skills. The paper argues for a greater orientation towards the impact of the subjects on human life and the development of 'rational faculties'. Science and technology education should be integrated, and both should place greater emphasis on 'basic skills orientated to work'.

ZA'ROUR, G.I. 1981 266

Adapting science and technology education to a changing society and to the diversity of needs of Arab states. *European Journal of Science Education*, 3(4), 373-82.

The 'needs' of the states concerned are seen largely in economic terms, though the role of scientific and technological education in other forms of social benefit are referred to. A series of recommendations is made, focusing on increasing the relevance to everyday life and technological development of curricula and institutions.

ZHANG, Z. and ZHANG, J. 1993 267

A survey of public scientific literacy in China. *Public Understanding of Science,* 2(1), 21-38.

The first survey of Chinese public scientific literacy was conducted in September, 1990, using a questionnaire derived from those deployed in other countries. Some of the results, reported in this article, suggest a very low level of scientific literacy (as determined by questionnaire). The authors conclude that raising the level of scientific literacy requires a significant improvement in the basic education of China's population.

ZILIOTTO, A. 1982 268

Appropriate training for rural artisans. *CASTME Journal,* 2(3), 31 -35.

Examines the trends which have occurred since decolonization in training artisans (mainly blacksmiths) in the techniques needed. He suggests a three-phase model, the overall thrust of which has been towards increasing decentralization. He offers guidelines for future development which stress localized initiative, direct training and close links with production, to avoid 'academism', that is, the institutional and cognitive dominance of formal education.

ZIMAN, J. 1991 269

Public understanding of science. *Science, Technology and Human Values,* 16(1), 99-105.

The author explores the principles that seem to govern the way people receive and use scientific knowledge. The results of three surveys, conducted in England and the USA, are compared along a number of dimensions, scientific literacy, gender differences, social context and attitudes towards scientific change.

ZOLLER, U. 1982 270

Decision-making in future science and technology curricula. *European Journal of Science Education, 4(1),* 11 - 17.
The author argues that the need of secondary school pupils is not for 'technical competence' but 'a fair degree of scientific and technological literacy'. He does not distinguish between these, but suggests that both can best be served by

employing curricula which involve a large element of active decision making involving real problems, value judgements, probabilistic approaches and situational contingency. There are no concrete examples of what such curricula might contain.

ZOLLER, U., DONN, S., WILD R. and BECKETT, P. 1991 195

Teachers' beliefs and views on selected science-technology-society topics: a probe into STS literacy versus indoctrination. *Science Education*, 75(5),541 -61.

In connection with an investigation into the beliefs and values of STS and non-STS teachers, three superordinate goals for an STS course are identified: (1) develop an appreciation of the interactive nature of science, technology and society; (2) gain knowledge of technologies as applications of science; and (3) develop the ability to respond critically to technological issues. The new goals of science education, associated with STS literacy, involve critical and high-level thinking, higher-order cognitive skills, rational power, as well as problem-solving and decision-making capacity for citizenry. Uses the idea of STES (science, technology, environment, society) problem-solving/decision-making act.

INNOVATIONS IN SCIENCE AND TECHNOLOGY EDUCATION

The series of publications, *Innovations in Science and Technology Education*, was initiated by UNESCO to provide information on an international basis about innovations in science and technology education at all levels of schooling, and in related teacher education (both pre-service and in-service) and out-of-school activities. It was launched in association with the International Network for Information in Science and Technology Education (INISTE) which UNESCO established in 1984. The volumes published so far, each edited by Professor David Layton, are as follows.

Volume I, 1986 *(Innovations in Science and Technology Education, Teacher Training and Out-of-School Activities)*

Volume II, 1988 *(Science and Technology Education at a Time of Rapid Scientific and Technological Change)*

Volume III, 1990 *(Assessment in Science and Technology Education)*

Volume IV, 1992 *(The Training and Professional Development of Primary and Secondary School Teachers of Science and Technology)*

Volume V,1994 *(Technology Education)*

The sixth volume, edited by Professor E W Jenkins and concerned with the meanings of, and rationales for, scientific and technological literacy, is in Preparation.

The INISTE/Project 2000+ bulletin, also published by UNESCO, carries information on Project 2000+ world-wide.

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The *Education for Capability Research Group* was established in 1989 within the School of Education at the University of Leeds. It aims to foster and disseminate research concerned with any aspect of education for capability and its membership reflects a wide range of academic and professional interests and expertise. Further information about the activities of the Group may be obtained from A Anning, School of Education, University of Leeds, Leeds LS2 9JT, UK.

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No.6 Angela Anning, *Technological Capability in the Primary School Classroom,* 1994, ((£1.50).
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