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ABSTRACT

The key to New Zealand's future prosperity lies in the promotion of science and technology. Two major issues are identified: (1) the need to close the scientific and technological manpower gap that is increasingly being experienced; and (2) the need for a re-organized system of vocational education. The implications for teaching and learning in New Zealand's secondary schools, Institutes of Technology and Universities in producing students who will be scientifically and technologically literate are far-reaching and call for a re-organization of the relationships between classrooms, industry and government. This document examines each of these aspects of education in New Zealand. (Author/TW)

SCIENCE, TECHNOLOGY AND THE

REORGANIZATION OF NEW ZEALAND

EDUCATION

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ABSTRACT

The key to New Zealand's future prosperity according to a recently published report of a ministerial Working Party, lies in the promotion of science and technology. Two major issues were identified: the need to close the scientific and technological manpower gap that is increasingly being experienced and the need for a re-organized system of vocational education. The implications for teaching and learning in New Zealand's secondary schools, Institutes of Technology and Universities in producing students who will be scientifically and technologically literate are far-reaching and call for a re-organization of the relationships between classrooms, industry and government.

SCIENCE, TECHNOLOGY AND THE RE-ORGANIZATION OF NEW ZEALAND EDUCATION

A recent report [1] of a Ministerial Working Party on New Zealand Science and Technology has been described as "bold", "profound", "convincingly argued", and a document from which"Australians' can learn from New Zealanders" in the development of policies for science and technology.[2] Unfortunately, however, more enthusiam has been generated so far for this document in Australia than in New Zealand, possibly because of the momentous implications for education that it portends. Two major issues underlying the report have to be addressed : the technological manpower gap and the need for a re-organized system of vocational education. The extent to which these are addressed will, according to the authors of the report, determine the country's future prosperity. This paper will examine some of the report's implications.

New Zealand technological education has evolved through three inter-related stages : from a "craft stage" to a "theory-to-technology stage" and finally, as highlighted by the ministerial working party report, to a stage of technological "enlightment". These will be outlined as a background to the present situation.

STAGES IN THE DEVELOPMENT OF TECHNOLOGICAL EDUCATION

One: The Craft Stage[3]

From this perspe tive technical education is developed by relating practice to practice as in the case of an apprentice studying the skills of a master. In this sense the craft stage is like a closed system: future skills are learnt largely through practising traditional, or at least existing, technologies under the direction of an experienced teacher.

The outstanding feature of the craft stage of technological development is its emphasis on practice. Theory, while not ignored, is learnt through the systematic practice of skills rather than as a guide to the utilization of technological knowledge. Problems are solved by learning already existing practices rather than developing new critical skills.

There are obvious limitations in the widespread application of the craft stage of technical education as technological problems are approached using traditional skills. In a closed perspective like this there are enormous difficulties in adapting to technological changes. When considered in a national or global sense, there is very little likelihood of teachers of technology influencing the direction of change from within such a framework. Technologies learnt in this way can at best only respond to change, and probably only respond gradually.

If technical education is seen largely in practical terms i.e. as practical people teaching practical people, it is difficult to see how technological change can be accommodated other than through relating new ideas to traditional practices.

Two: The Theory-to-Technology Stage [4]

The theory-to-technology stage of technical education, in contrast to the craft stage, is wide open to outside influences, particularly from science. From this perspective, technical education can be seen as the application of theoretical ideas to technology so that change will be on-going and technologies will be constantly transformed. Technical teachers are thus cast in a different role - that of relating theory to practice, rather than, as in the craft stage, practice to practice.

The theory-to-technology stage suggests that somehow technical institutes are not part of the process of knowledge-production, but are concerned with utilizing knowledge for particular purposes. Implicit in this perspective is the suggestion that Technical Institutes are organized to selectively utilize theories, especially scientific theories, for particular purposes. The theory-to-technology stage suggests that technical educators are, above all, knowledge utilizers, transforming theory into practical outlets. This perspective has a lot of appeal to technologists as it suggests a certain relationship between science and its utilization. There is, in this, the implication that this stage is superior to the craft stage, yet it has been pointed out recently that research on the relationship between science and technological development "indicates that there never has been a close connection between these two areas as proclaimed by the standard philosophies of science."[5] A major criticism of the theory-to-technology stage of technological education is that it is difficult to see how, in itself, it could take into account the particular social and cultural conditions of New Zealand. To adapt developments in scientific knowledge to changing social and cultural conditions is to require a great deal of teachers of technology.

Three: The Enlightenment Stage [6]

This stage of technological education is based on the utilization of knowledge for the enlightenment of teachers and students about the social conditions of their society. Rather than seeing technology as the simple application of scientific knowledge, the enlightenment stage seeks to find links between the producers and the users of such information. This perspective of technological education rejects the development of technology for unspecified goals and seeks to present it in humanistic terms. People are no longer simply adapters of an object known as "scientific knowledge", but accepted instead as its subject. This is based on the idea that people and their requirements should be considered much more in technological development. This perspective is idealistic but ultimately it can be related to a view that technology can lead to social enlightenment as long as it is constantly oriented to the needs of people as subjects rather than simply being an end in itself.

TECHNOLOGICAL EDUCATION IN NEW ZEALAND: A COMPARATIVE PERSPECTIVE

International comparisons of New Zealand's performance in post-secondary school education and vocational education as well as aspects of its economic performance suggest there is a possibility of a link between them.

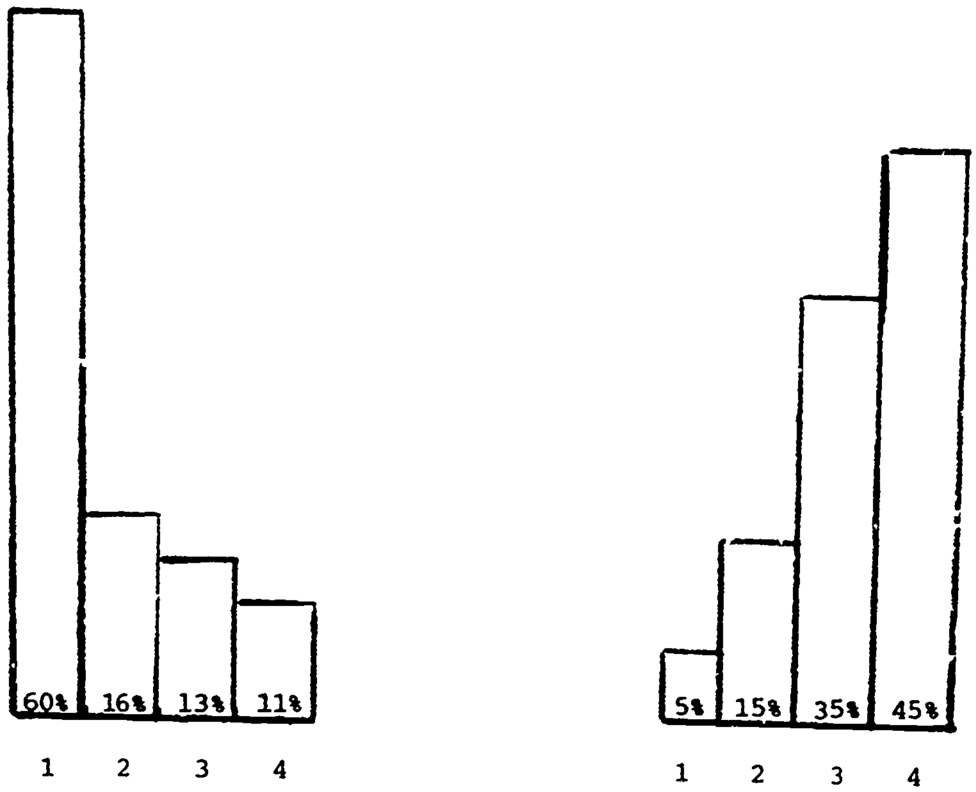
At the present time New Zealand school leavers have very different characteristics from their counte parts in other small OECD countries as shown in Figure 1:

FIGURE 1: SCHOOL LEAVERS IN NEW ZEALAND AND OTHER SMALL OECD COUNTRIES[1]

(1) New Zealand

(2) Other Small OECD Countries

(Austria, Switzerland, Denmark)



Key

1 No formal vocational education/training

2 At the professional level

3 At the middle group level

4 At the trades level

The following picture can be constructed from Figure 1 about the vocational preparation of N.Z. school leavers:

1) 60% of NZ school leavers receive no formal vocational education or training prior to their destinations in the work force (or unemployment).

2) 11% enter an apprenticeship contract.

3) 13% enter a study programme leading to a middle level qualification (eg. technician certificate).

4) 16% embark on a study programme leading to a professional qualification.

An indication of the economic performance of New Zealand in relation to other countries is useful to consider in relation to Figure 1. Table 1 provides a ranking of selected countries by their 1982 per capita GNP, together with percentage growth rates for the period 1973 to 1982.

TABLE 1.: RANKING OF SELECTED COUNTRIES BY THEIR 1982 PER CAPITA GNP.[8] PERCENTAGE GROWTH RATES FOR THE PERIOD 1973 TO 1982 ARE SHOWN IN COLUMN 2.

	US$	%
Switzerland	16 960	0.8
Norway	14 270	3.2
Luxembourg	14 010	2.6
Sweden	13 840	0.8
U.S.A.	13 160	1.5
Denmark	12 350	1.5
Germany	12 300	2.3
Iceland	12 110	1.7
France	11 540	2.2
Canada	11 330	2.3
Australia	11 140	0.9

Continued on next page.

TABLE 1: CONTINUED

	US$	%
Finland	10 860	2.2
Netherlands	10 790	1.6
Belgium	10 480	1.6
Japan	10 050	3.3
Austria	9 790	2.7
United Kingdom	9 620	1.0
New Zealand	7 910	0.4
Italy	6 790	2.0
Spain	5 380	0.8
Ireland	5 050	1.3
Greece	4 280	2.2
Yugoslavia	3 100	4.3
Portugal	2 460	1.9
Turkey	1 360	1.4

A more specific picture of the relationships between technology and economic health can be seen in the following table which compares OECD countries in terms of:

1) Per capita total exports [9]

2) Per capita value of technology - based exports [10]

3) The percentage of technology based exports to total exports.

TABLE 2: 1983 PER CAPITA VALUES (US$) OF

	Total Exports	Technology Exports	% of Techn. Exports
Switzerland	3982	2426	61
Norway	4561	487	11
Luxembourg			
Sweden	3516	1060	30
U.S.A.	921	340	37
Denmark	3113	851	27
Germany	2795	1133	41
Iceland	3139	12	0.4
France	1695	551	33
Canada	3454	449	13
Australia	1551	73	5
Finland	2758	486	18
Netherlands	4553	1313	29
Belguim *	3536	1159	33
Japan	1415	571	40
Austria	2082	730	35

Continued on next page.

TABLE 2: CONTINUED

	Total Exports	Technology Exports	% of Techn. Exports
United Kingdom	1671	569	34
New Zealand	1700	110	6.5
Italy	1289	364	28
Spain	616	93	15
Ireland	2757	986	36
Greece	489	29	6
Yugoslavia	381	133	35
Portugal	512	86	17
Turkey	148	9	6

* Includes Luxembourg

The following table shows the enrolment rates of 16-19 year olds for both full-time and part-time study with New Zealand portion highlighted.

TABLE 3: ENROLMENT RATES OF 16 TO 19 YEAR-OLDS BY SINGLE YEAR OF AGE FOR THE LAST YEAR ( ) AVAILABLE. (FOR BOTH FULL TIME AND PART TIME STUDY).[11]

	Age in Years			
	16	17	18	19
Australia (81)	77.3	59.2	42.0	37.4
Austria (81)	87.1	83.7	76.5	45.6
Belguim (82)	86.5	75.0	57.0	43.0
Canada (81)	88.6	71.6	42.1	30.0
Denmark (80)	86.0	68.0	61.0	50.0
Finland (78)	87.5	75.4	58.8	34.5
France (81)	83.9	68.9	45.2	30.0
Germany (81)	92.1	89.3	71.9	45.9
Italy (81)[2]	69.1	70.3	51.3	29.4
Japan (80)[3]	94.0	94.0		
Netherlands (82)	97.8	84.7	62.8	43.7
NEW ZEALAND (82)	74.4	46.5	32.6	30.9
Portugal (77)	39.2	35.0	34.5	27.8
Spain (80)	53.4	50.1	37.1	27.5

Continued on next page.

TABLE 3: CONTINUED

	Age in Years			
	16	17	18	19
Sweden (80)	87.4	78.4	44.7	23.5
Switzerland (83)	85.9	81.6	73.1	52.8
United Kingdom (81)	68.0	52.8	37.0	23.5
United States (82)	94.3	87.1	54.7	40.9

[2] Excludes Apprentices

[3] Excludes University level enrolments

The relationship between investment in education and a country's performance as a producer of technology based exports can be seen in the two previous tables: The top nations in Table 2 are also amongst the top nations in Table 3.

Finally by examining New Zealand's position in Table 4 below, the problems that the country faces in maintaining, let alone improving its economic situation, are formidable.

TABLE 4: RANK ORDERING OF COUNTRIES BY ENROLMENT RATES BASED ON TABLE 1 AND FOR EACH AGE GROUP.

	Age in Years			
	16	17	18	19
1	Netherlands	Japan	Austria	Switzerland
2	United States	Germany	Switzerland	Denmark
3	Japan	United States	Germany	Germany
4	Germany	Netherlands	Netherlands	Austria
5	Canada	Austria	Denmark	Netherlands
6	Finland	Switzerland	Finland	Belguim
7	Sweden	Sweden	Belguim	United States
8	Austria	Finland	United States	Australia
9	Denmark	Belguim	Italy	Finland
10	Belguim	Canada	France	NEW ZEALAND

Continued on next page

TABLE 4: CONTINUED

	Age in Years			
	16	17	18	19
11	Switzerland	Italy	Sweden	France
12	France	France	Canada	Canada
13	Australia	Denmark	Australia	Italy
14	NEW ZEALAND	Australia	Spain	United Kingdom
15	Italy	United Kingdom	United Kingdom	Portugal
16	United Kingdom	Spain	Portugal	Spain
17	Spain	NEW ZEALAND	NEW ZEALAND	Sweden
18	Portugal	Portugal		

PROPOSALS FOR SCIENTIFIC AND TECHNOLOGICAL RE-ORGANIZATION

- Zealands' future prosperity, according to the recently published Report of the Ministerial Working Party (Beattie *et al*), lies in the promotion of science and technology. An urgent need to re-organize the existing system of vocational education was identified and a plan to achieve this was formulated. The following proposals to re-organize New Zealand's scientific and technological education require strong commitment by Government in the form of increased expenditure together with a closer relationship between classrooms and industry.

The Report calls for increased creativity in science and technology which has implications for teaching methods, particularly in secondary schools. It raises, further, the question whether New

Zealand should consider the establishment of centres of excellence for the teaching of science and technology. The authors noted that few submissions were received from the public about science and technology in New Zealand secondary schools, suggesting that either these matters are not understood or not considered to be important for the country's future. The need to produce students who are "scientifically and technologically literate" is emphasised throughout the report but several obstacles were noted: The recruitment and retention of science teachers, the need for evaluation of standards of teaching and the need to reconsider the status of the teaching profession. Longer schooling is advocated together with increased vocational training opportunities within the school system.

In considering the role of Technical Institues in New Zealand education (the equivalent of TAFE Colleges in Australia) it was pointed out that at present a negligible amount of research and development work is undertaken by Institute tutors although many are well qualified to do so. This waste of a national resource is unfortunately not a matter that was investigated in detail. The potential for scientific and technological research in Technical Institutes is, however, a matter that the authors believe should be further considered, together with the "alarming mismatch between job vacancies and suitable applications ... (because) industry cannot recruit young people with basic knowledge and work enthusiasm." The government was advised by Beattie et al to remove the necessity of having a job for trade training as a way of enabling more people to gain technological skills and to provide more young New Zealanders with access to technological training irrespective of age, sex, location or level of secondary school certification. The lack of access to scientific and technological careers is highlighted in the University system where, because of a lack of funding, many young people cannot proceed to research degrees. The message of this report is that New Zealand's future prosperity lies in the promotion of science and technology. It proposes that government initiate a major increase in research activity and funding. The need for a new perspective of science and technology in New Zealand is implicitly advocated by the report and this is likely to require a new awareness by scholars in the humanities and the social sciences.

(1) Proposed Mechanisms for Implementing National Science and Technology Policy

(a) Appointment of a minister for Science and Technology together with a cabinet committee on Science and Technology;

(b) Establishment of a Science and Technology Advisory Board to report to (a);

(c) Increased public awareness of the importance of Science and Technology in economic and social development in N.Z. This would in part be a function of (b).

(2) Proposed Government Investment in Science and Technology:

(a) Doubling overall expenditure on research and development in the public and private sectors by 1993-94;

(b) Major changes to primary and secondary school science, technology and mathematics;

(c) Longer secondary schooling to allow for increased opportunities for vocational training within the secondary education system;

(d) Removal of the prerequisite of having a job for entry to trade training;

(e) Increased availability of post-secondary school technological training;

(f) Co-ordination of in-house data bases in public and private sectors.

(3) Proposed Re-organization of Scientific and Technological Institutions

(a) A Science and Technology Research Council, under its own act, to fund basic and strategic research projects;

(b) A Social Science Research Council, under its own act, to fund research projects in Universities, Government Departments and Communities and Local Bodies;

(c) A Medical Research Council to report to and be funded through the Minister for Science and Technology;

(4) Proposed Government Support for Research and Development in Industry ;

(a) Recommended 150% Tax Deductibility for expenditure on research and development;

(b) Recommended flexible range of incentives to increase research and development in Industry and measures to improve availability of venture capital.

(5) Information Flow Between Proposed Science and Technology Advisory Board [12]

(See Appendix 1)

(6) Proposed Organisation and Funding of Scientific and Technological Research by Government [13]

(See Appendix 2)

The educational implications of the Report of the Ministerial Working Party can be summarized briefly as follows;

(1) Secondary Schools

(a) Longer Secondary Schooling;

(b) Re-organization of science and mathematics education;

(c) More on-the-job experience opportunities.

(2) Universities

Increased funding to attract greater numbers of research students in science and technology

(3) Technical Institutes

(a) Up-grading of the apprenticeship system;

(b) Improved co-ordination between vocational education and employment opportunities;

(c) Improved liaison with Government and Industry by Technical Institutes.

CONCLUSION: THE DIRECTION OF SCIENTIFIC AND TECHNOLOGICAL EDUCATION IN NEW ZEALAND

The philosopher A.N. Whitehead believed that the antithesis between a technological and a liberal education was fallacious - "there can be no adequate technical education which is not liberal, and no liberal education which is not technical: that is, no education which does not impart both technique and intellectual vision".[14] Whitehead based his argument on the idea that in any national system of education "three main methods are required"[15] - the literary curriculum, the scientific curriculum and the technical curriculum. It is of particular interest to note that Whitehead believed "each of these curricula should include the other two".[16]

It has been acknowledged that technological education in New Zealand has developed without a coherent philosophy.[17] Without a philosophy, teachers and administrators do not have the means to interpret what they do and, more importantly, why they do what they do. To put it another way, without a philosophy of technological education, teaching is likely to be determined by other forces - political, economic, social and cultural.

An alternative view is one that is based on a philosophy grounded in technology. Rather than developing along pragmatic lines, a technological philosophy would enable science and technology teachers to interpret and subsequently react to their social, cultural, political and economic environment. In doing so they would influence rather than simply be influenced. The craft stage suggests a perspective of technological education that is not open to any interpretation other than small modifications relating to practice. Even to the most uninformed layperson, such view of education, by itself, is no longer likely to be acceptable. A more flattering perspective of scientific and technological education is one based on the link between theory and technology. The search for a philosophy of technological education, however, must somehow answer the questions: "Why an I doing what I am doing?", "To what ends?", "For whose benefit?". Technological education, according to Whitehead, is "creative experience while you think, experience which realises your thought, experience which teaches you to co-ordinate act and thought, experience leading you to associate thought with foresight and foresight with achievement. Technical education gives theory, and a shrewd insight as to where theory fails".[18]

The Report of the Ministerial Working Party is a significant document in New Zealand education in that it attempts to co-ordinate the three stages of technological education that have been outlined.

In doing so, it provides a framework within which Whitehead's vision could possibly be realized. The responsibility for this now rests with the New Zealand government.[19]

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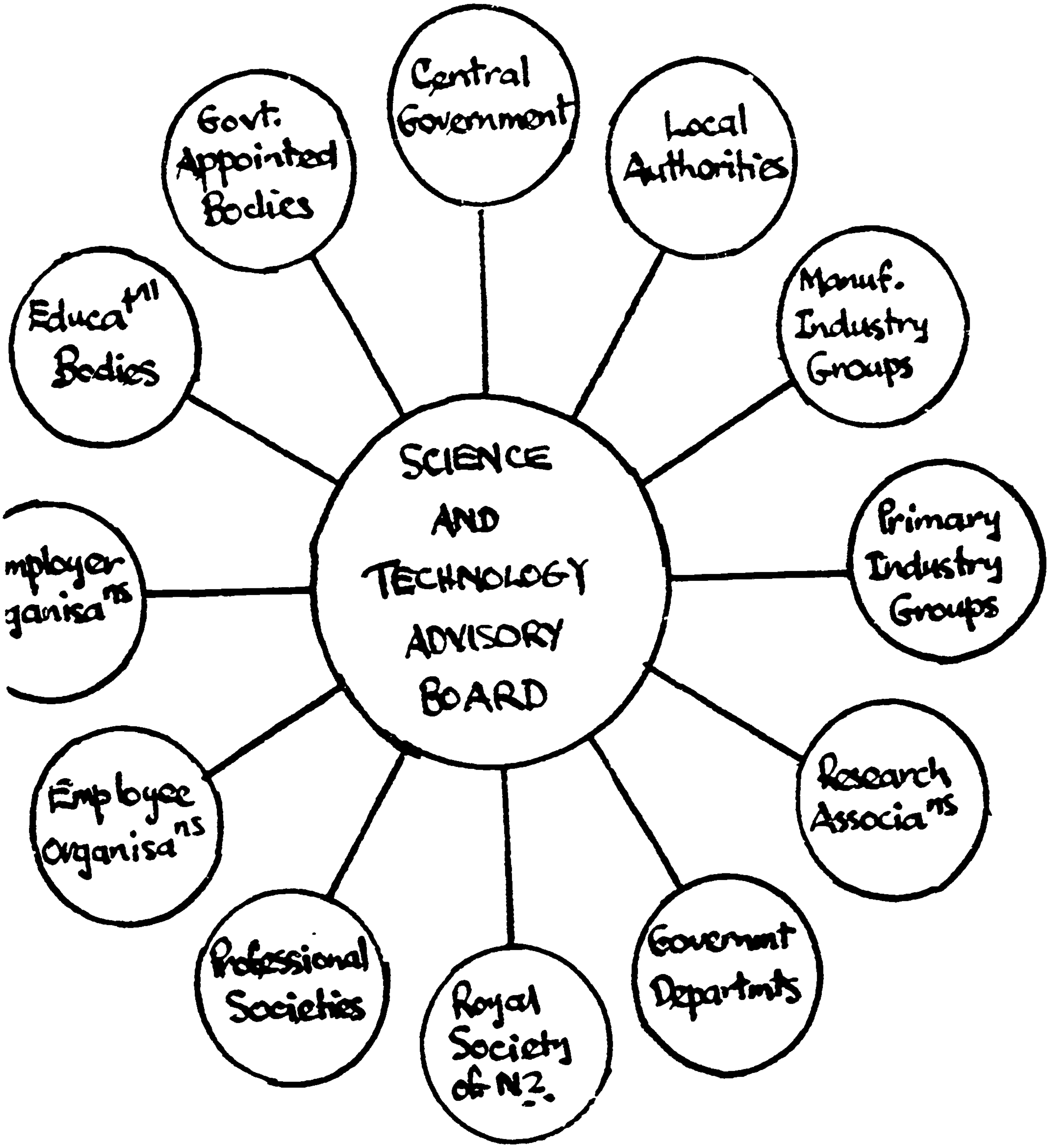
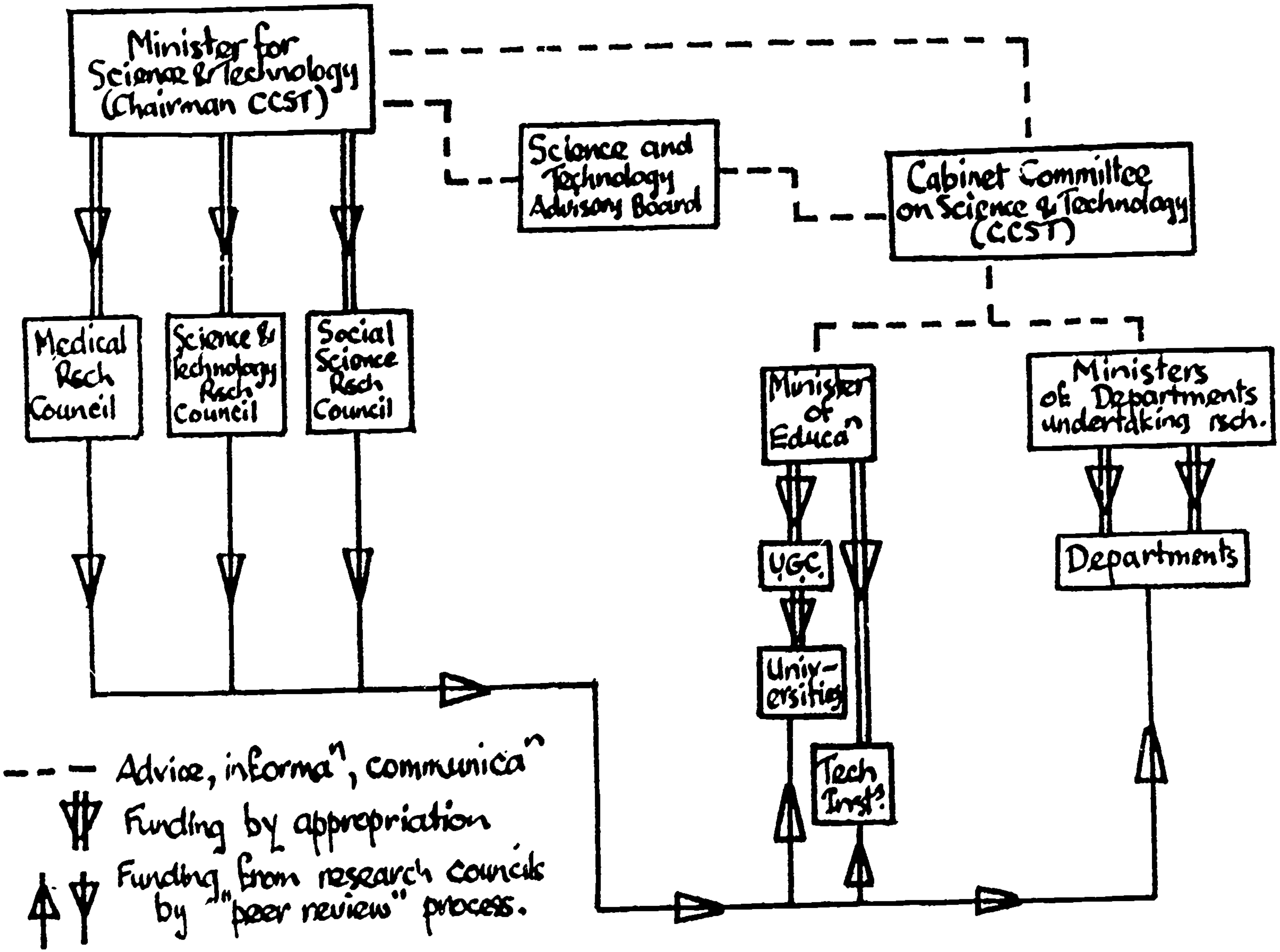


— INFORMATION FLOW BETWEEN S.T.A.B. AND OTHER ORGANISATIONS —

APPENDIX 1

Beattie D et al, Key to Prosperity - Science and Technology



— PROPOSED ORGANISATION AND FUNDING OF GOVERNMENT RESEARCH —

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