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What's in a Name? Technology and the Image of Engineering

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What's in a name? Technology and the Image of Engineering

Abstract

In some of the Western industrialized Nations there has long been a concern among their engineering communities with the poor take up of engineering as a career, and in consequence with its image. Engineering's products seem not to excite the imagination of teenagers. Surveys of the perceptions of engineering of young people have advanced a number of reasons for their lack of interest in engineering. It seems to be generally accepted that science has higher status than engineering, the work of engineering being reported as that of scientists. While science overshadows engineering, the proposition that technology might overshadow engineering more than science has been little discussed. In sum, both science and technology are used in the media to describe activities that are essentially engineering. In some countries the term technologist is used in preference to engineer or engineering in policy documents.

The term technology has a specific meaning in U.S. engineering education that it does not have in other countries.

World-wide developments in school technology and technological literacy programmes do not necessarily convey what engineering is to either the participating students or the public at large. Hence the importance of the distinction between technological and engineering literacy made by Krupczak and his colleagues. It is argued that the two need to be linked in educational programmes and in policy making.

This point may have been recognized by the Institution of Electrical Engineers for when it merged with the Institution of Incorporated Engineering (an institution for technicians) it became the Institution of Engineering and Technology Given the proposition that students as well as the public at large are unlikely to change their perceptions it might be propitious for ASEE to consider changing its name so as to incorporate technology, that is, Society for Engineering and Technology Education.

Note on textual supports. Supporting is to be found in numerous official and semi-official documents. These have been categorised into a series of exhibits for the purpose of supporting the argument. Each document has been assigned a bracketed number and is referred to as an "item" in the text e.g. item 16. Other references and notes are numbered in the text in the usual way,

The 'science' suppressed image of engineering

Commenting on an article in *The Washington Post* on July 5th 2017 with the title "From Ancient Rome, concrete lessons on producing stronger sea walls" The executive director of the American Society for Engineering Education Dr Norman Fortenberry wrote "The remarkable article on the staying power of ancient Roman concrete fell into the common trap of referring to engineers as "scientists".

"While engineers also engage in research, they are distinct from scientists. Engineering is often the "silent 'E' " in STEM, or science technology engineering and math, to the detriment of the discipline and to society. Scientists and engineers respect each other and work together constantly. It was engineering that got the rovers to Mars and facilitated their amazing discoveries.

"To meet the significant challenge of the 21st century, the world will need a skilled and creative engineering workforce. When engineering innovators are generically grouped together as "scientists," we lose opportunities to showcase engineering as an exciting career path for problem-definers and problem solvers who are creative and tenacious advocates for humankind." (*Washington Post* July 14 2017).

This confusion between science and engineering is not unusual. Indeed, since World War II it has tended to be the norm. In the United States in 1961 David Beardslee and Donald O'Dowd reported that the occupational stereotypes of scientists and engineers were remarkably similar as their account given in exhibit 1 shows. These were not dissimilar to those found among high school students in the U.K by G. Jones in 1963 (items 28 and 29). But in the U.K. the engineering profession was more bothered by D. G. Hutchings (item 27) who reported that students entering engineering studies from schools were less able, as measured by university entrance results, than those entering science studies.

It seems that findings such as these influenced policy making in the U.K. The 'poor' image of engineering bothered both educationalists and industrialists. The professional institutions held many meetings on the topic, and there was little doubt that concern for the image of the engineering profession contributed to the creation of the Council of Engineering Institutions (CEI) and the chartered engineer designation (C.Eng = P.E in the U.S) and qualification, and the drive. They led the authorities to make the courses more "scientific" with corresponding changes in the level of mathematics required, one consequence of which was the move to an all graduate profession educated in full-time courses.

Scientists […] is characterized by high intelligence dissociated from artistic concerns and sensitivities. This cool intelligence is linked with strong individualism in personal and political realms. Second, there is clear lack of interest in people on the part of the scientist. A good deal of self-control is implied by the description of the scientists as self-sufficient, rational, persevering, and emotionally stable. He has power in public affairs but he is rated only moderately responsible and quite radical. This suggests that uncertainty about motives and trustworthiness of the scientist, an uncertainty noted in younger people by other investigators lingers on in college students. The personal life of the scientist is thought to be quite shallow, his wife is not pretty, his home life is not very happy. But he is rewarded by great personal satisfaction, considerable success, and reasonable opportunity for advancement. Furthermore he enjoys moderate wealth and social status. In summary, the scientist is a cool, self-controlled individual. He is competent in organizing the world of things, but disdainful of the world of people. Materially better rewarded than the college professor, the scientist contrasts strikingly with him in aesthetic sensibilities and social skills.
Engineers Engineering is a less colorful profession for liberal arts students. The engineer is rated generally intelligent but not nearly so strong in this regard as the scientists. On the other hand, he is considerably, more socially adept than the scientist, though no social lion.

The engineer is quite successful and reasonably wealthy, but he gains less satisfaction from his work than the scientist derives from pure research. He is also more conservative, and more likely to be conformist. Except for these important differences, the engineer is almost identical with the scientist.

Exhibit 1. Analysis of occupational stereotypes among liberal arts students reported by Beardslee, D. C and D. D. O'Dowd (1964). The career has its shadow. On Sanford, N (ed). *College and Character. A briefer version of The American College*. Wiley, New York. The complete version of the paper is in Sanford, N (editor) (1962). *The American College*. Wiley, New York.

By the 1970's, aided by changes in the structure of technical education the professional institutions were working toward an all-graduate profession. In so doing the amount of science and mathematics required was increased. This meant that they began to close their doors to those who pursued Chartered Engineer (C. Eng) status from the technical colleges. The technical colleges were to produce technicians at two levels. Possession of a Higher National Certificate would be indicative of the higher level of attainment. In 1958 Stephen Cotgrove pointed out in a substantial publication that technicians and technician education had largely been ignored[1], and subsequently a case was made for the development of a professional institution for technicians in 1961[2], the author having in mind changes to the articles of association of the Junior Institution of Engineers.

Twenty years later in the U.K., the report of a Commission of Inquiry into the Engineering Profession in 1980 lamented, "It is clear that in comparison with their counterparts in other industrial countries, engineers in Britain lack the special social standing which attracts young people to aspire to an engineering career, and that they are ill-served by a generic title which in Britain is not specifically associated with and reserved to a highly educated and vital professional group. Engineering is further regarded misleadingly as a branch of science, rather than as a culture and activity in its own right."[3]

This is not surprising for in the U.K., engineers have during the last hundred years or so distanced themselves from the technical education that grew out of the industrial revolution. In Britain where there is a considerable divide between the academic and practical or vocational, engineers and engineering educators sought to place themselves on the academic side of this divide through the provision of subjects that applied the principles of science, in particular physics, to the solution of problems regarded as engineering. Hence, engineering came to be understood as the application of science to a range of problems regarded as engineering. For example, in the universities metallurgy quickly became materials science after World War II while in the technical college sector it remained as metallurgy.

Of considerable significance was the fact that production engineering had very low status in industry, a fact that is exemplified in the 1960's by the failure of The Institution of Production Engineers to receive a Royal Charter while the British Institution of Radio Engineers was given one.

Similarly, in the 1960's many university educators believed that design could not be taught. There were no textbooks of the kind published by Krick[4] and Woodson[5] in the United States. Neither were the professional engineering institutions immune from criticism on this score. For example, the Feilden Committee on *Engineering Design* (1963) recommended that all candidates for membership of the Institution of Mechanical Engineers should be required to have experience in engineering design[6]. It should be noted that the Institution of Engineering Designers had low status and was seen as a society for technicians and draughtsmen. One outcome of this debate was the creation of a special unit in design at the University of Liverpool.

Since many of those who teach and research in engineering have never left the university environment it is not surprising they reinforce this image of engineering as applied science, and do not understand the complaints that are made about the engineering curriculum, or the demands that are made from time to time for it to change. This confusion is one of the reasons given for the poor (or suppressed) image that engineering has in a society that values the pure over the applied. It is no surprise to find that in the 1960's more able students should be attracted to study physics at university rather than engineering, if indeed they faced themselves with that choice, which is doubtful.

These images of engineering as science do not seem to have changed over the decades. They are reinforced by the media which continually confuse engineering and science. Engineering achievements are often cited as scientific achievements. Norman Fortenberry's recent letter in the *Washington Post* shows that such images and confusion occur as much in the United States as they do in the United Kingdom. However, the problem of the low status ascribed to engineering in Britain is something that is deeply cultural as comparative studies of the place of the engineer in British and German Societies show[7].

British culture and the status of engineering. British attitudes compared with German.

Comparative cross cultural studies are difficult to make, and often as difficult to interpret as the authors of a comparative study of British and German engineers at work undertaken in the 1970's make clear[8]. Nevertheless some conclusions seem possible. For example, it seems that a major difference between the U.S.A and the U.K. might be that the former possessed a much higher level of achievement motivation than the latter[9]. Similarly between Germany and the U.K. Hutton and Lawrence point out that in Germany there is a natural orientation toward national achievement that is, *Leistungsgesellschaft. "*And", write Hutton and Lawrence, "The sphere of German society in which devotion to *leistung* (achievement) is most conspicuous is again industry"[10]. Thus, in Germany the work of the engineer is both understood and given high social standing. In the words of Stanley Hutton and Peter Lawrence, Germany is hospitable to industry whereas Britain is not.

The value of comparative studies is shown by Hutton and Lawrence who point out that in the English speaking world two cultures are conflicted – the arts and the humanities and the natural sciences. This conflict does not help the image of engineering, indeed suppresses it (see exhibit 2). However, in Germany three cultures are apparent that are supportive of the concept of engineering. The first is *Wissenschaft* . It applies to all branches of knowledge and means that the term scientific can be applied to any branch of knowledge. The second culture is *Kunst* which relates to the domain of the aesthetic, and the third culture is *Technik* which relates to the domain of knowledge and skills relevant to manufacturing[11] (see exhibit 2).

It is perceived that the frequent use of "science" instead of "engineering" leads to a false image of what "engineering" is. In some countries this understanding has led to policy decisions that have influenced the curriculum. In the U.K. engineers also sought to raise the status of the profession in other ways, as for example, the creation of a Royal Academy of Engineering in 1983. It seems clear that the perceptions that people have are deeply cultural in their origins. But, just as in some countries engineering is “suppressed” by science so it is also “suppressed” by technology.

Changing a culture; the introduction of “Technologie” in France

Michael Murray reporting on the development of “Technologie” in the post-primary curriculum in France wrote that perhaps the most surprising feature of report published by a French Commission for Technology Education is that “technology education imparts a general culture. Technology education imparts a general culture. Technology education

> “It might at this stage be helpful to move to a more general cultural consideration, concerning the way in which branches of knowledge are perceived and related. The simplest and most popular classification system, not just in Britain but in the English speaking world generally, is the idea of the two cultures, with the arts and humanities on the one side of a divide and the natural sciences on the other. This Anglo-Saxon thought pattern which counterposes Arts and Science, is not really conducive to the dignifying of engineering. This is partly because engineering does not fit unequivocally under either of the ‘two cultural’ headings, and partly because by labelling engineering ‘applied science’, the usual way out of the impasse one is assigning engineering to a subordinate and dependent status”.
>
> [….]
>
> “German thinking on the perception and classification of branches of knowledge offer an interesting contrast. The two-culture distinction does not exist in Germany, and the idea is difficult to formulate in German. It is possible to translate ‘applied science’ into German, but the result of this endeavour is culturally meaningless. The Germans have a three-fold classification scheme: this means not only that they have a ‘third culture’ but also that they draw the boundaries in different places”.
>
> “The term *Wissenschaft* covers all formal knowledge subjects, whether arts, science, or social science in our terms. This explains the rather casual use of the word ‘scientific’ by Germans when speaking English: in their view it can be applied as readily to historical scholarship as to nuclear physics. In the German scheme *Kunst* denotes art-not ‘the arts’ in the Anglo-Saxon sense but the ‘products’ of the arts. The criterion for inclusion is aesthetic not critical-intellectual. And the ‘third culture’ in the German scheme of things is *Techni*k. *Technik* is for the Germans and independent domain, embracing knowledge and skills relevant to manufacturing. Thus it is an autonomous cultural rubric tending to dignify engineering, and, and certainly serving to differentiate it from natural science”.

Exhibit 2. Extracts from Hutton, S. P and P. Lawrence (1981). *German Engineers. The Anatomy of a Profession* .Oxford, The Clarendon Press pp 107 & 108.

should provide an opportunity for understanding the influence of technology on culture. Education forms the producers, consumers and citizens and technology is the common link between these three categories of person. Thus, education must provide an orientation in technology. The report says that if the nation is to remain competitive it must produce and market products of a high level of technological sophistication. Therefore the school curriculum must ensure that these skills are developed. Thus from this fundamental rationale the purpose of technological education is to give knowledge and understanding as well as to give training in the skills of design, fabrication, testing and the use of equipment. It must aim to ensure that the producers of technology can be mastered and managed to promote social and economic well-being” (Item 55, p 69).

“An important principle which is enshrined in this report is the idea that the universal character of technology necessarily constitutes a unifying mechanism and levelling force between the social classes within the education system" (Item 55, p 70)Technology is seen to be something different to science, and a separate programme is required for its development.

To this end the French Ministry of Education decided to introduce a curriculum on Technologie in which the principal teaching method would be the project (Item 54). In order to introduce his programme in schools woodwork and metalwork would be withdrawn and those teachers wishing to be retrained would receive substantial professional development to help them adapt not only to the new knowledge required but to a new philosophy. The scale of the programme envisage was immense but that surely, is the only way to achieve a change in a pedagogical culture. Engineering is not mentioned in the French documentation. In that sense it is suppressed.

The 'technology' suppressed image of engineering

Legislation in the U.K. has favoured the use of the term technologist for technician as exhibit 3 (items, 1, 2, 3, & 4) shows. This is not altogether surprising because engineers were educated in both universities and technical colleges.

The first item in the exhibit is a report undertaken for the U.K. government by a committee. While its title includes the term "technological" the specific workforce requirement is for an annual output of "engineers" not" technologists". The subjects of the curriculum are frequently called "technological subjects". It was also convenient to use the term "technologist" because it embraced the activities of industrial scientists (i.e. those who, having obtained degrees in the pure and applied sciences, work in industry". The committee focused on the needs of industry, saw the technical colleges as a source of supply, and proposed that a limited number that would provide degree level graduates should be called "colleges of technology". This usage of the terms "technologist" and "technology" continues in subsequent documents on technical education (exhibit 3, items 7 and 9), and is used by G. L. Payne in his report for the U.S. President's Committee on Scientists and Engineers (exhibit 3, item 8).

Only one item in this list includes the term engineering in its title, and it was not an official document (item 10). It was an international document and is included because in it the engineering associations from Western Europe and the United States defined the terms "technologist" and "technician".

Throughout the period 1950 to 1970 The Government appointed Councils to advise it on Scientific Policy. Reports relating to manpower requirements and recruitment into higher education were published at two yearly intervals. The reports of 1952 (item 11) and 1961 (item 15) used the term "scientific" to cover both engineering and technological manpower. The 1952 and 1956 (item 13) were on scientific and engineering manpower. In the 1963 report (item 16) "technological" replaced "engineering" as it did in the 1965 (item 18) report but in 1965 the title was the phrase "Engineers, Technologists, Scientists and Technical Supporting Staff".

The most that can be said of these reports in respect of the argument offered here is that with the exception of "science" and "scientific" they were inconsistent in their use of terms. This supports the views of those who hold that science suppresses engineering. Similarly, the reports of the manpower committee were undertaken for the Advisory Council on Scientific Policy which became the Council of Scientific Policy. Given the comments on industry in the reports it is of significance to note that membership of these committees was made up primarily of Fellows of the Royal Society with the occasional representative from large industry[12]. There were no members from medium or small scale industry.

Of particular interest are the two enquires into the flow of candidates in science and technology in higher education (1966 (item 20), 1968 (item 22)). These did have an impact, certainly in the media. Schools were not considered to be fostering the growth of scientific talent or producing sufficient numbers of potential scientists, engineers and technologists to meet the needs of society.

Date	Document and type	Comments
1945 (1)	**Higher technological education (Percy report)** Report of a UK Government Committee.	Primary concerned with the education and training of technologists for industry. Technologists are seen to be those who apply science. The engineering industry's needs are classified into 5 categories of which there are two categories of engineer. The first category is senior administrator. Engineers are equated with technologists.
1950 (2)	**The Future of Higher Technological Education** Report of the National Advisory Council on Education for Industry and Commerce to Minister for Education)	Proposed a Royal College of Technologists
1950 (3)	**Higher technological education- Statement of Government policy for the development of higher technological education** (HMSO Cmd 8357).	Rejected idea of establishing a technical university. Accepted recommendation to provide more financial assistance for selected colleges and courses in the technical college sector, and for the establishment of an award-granting College of Technologists.
1955 (4)	**Minister of Education**	Establishes National Council of Technological Awards (NCTA) as a self-governing body
1955 (5)	**Technical education- Its aims, organisation and future development.** Book by P. F. R. Venables, London, Bell.	Title is self-explanatory. Written by an academic leader in technical education (college) sector at that time.
1958 (6)	**Technical education and social change** Book by S. F. Cotgrove (London, Allen and Unwin)	Major study of the technical education (college) sector in the U.K. He drew attention to the neglect of technician education.
1956 (7)	**Technical education** (White paper Cmd 9703)	Establishes a four tier system of technical colleges. Colleges of Advanced Technology (CATs), Regional Colleges, Area Colleges and Local Colleges. The terms Technologist, Technician, Craftsman and Operative are defined. Professional engineers are classified as technologists.
1960 (8)	**Britain's scientific and technological manpower** Book By G. L. Payne (Stanford/Oxford)	Undertaken at the requests of the US President's Committee on Scientists and Engineers. The most informative report on the status of higher technological education in the UK its practices and problems. Contains an annotated bibliography of official documents.
1961 (9)	**Better opportunities in technical education** (White paper Cmd 1254)	Primarily concerned with improving technician education in the technical colleges. Marks the change to full-time higher education

1961 (10)	**Report on the education and training of professional engineers** Vol 1. London. IEE for EUSEC (Conference of Engineering Societies of Western Europe and the United states of America	The definitions of technologist and technician in the 1961 whitepaper derive from work undertaken in the 1950's by EUSEC

Exhibit 3.

Date	Title	Comments (some points made in the various reports)
1952 (11)	**Report from the Committee on Scientific Manpower**	
1954 (12)	**Report on the recruitment of scientists and engineers by the engineering industry.** Committee on Scientific Manpower	Based on vacancies shows recruitment was 25% below requirements
1956 (13)	**Scientific and engineering manpower in Great Britain**. Ministry of Labour and Advisory Council on Scientific Policy	To meet long term demand for scientists and engineers the present rate of output would have to be doubled. (re-issued 1957)
1959 (14)	**Scientific and engineering manpower in Great Britain, 1959.** Report of the Committee on Scientific Manpower HMSO. Cmd 902	
1961 (15)	**The long term demand for scientific manpower**. Committee on Scientific Manpower. HMSO Cmd 1940	Highly controversial report which said that by 1965 the supply and demand for scientific manpower should not be much out of balance.
1963 (16)	**Scientific and technological manpower in Great Britain, 1962**. Committee on Scientific Manpower. HMSO Cmd 2146	Report discusses the shortcomings of previous surveys. They doubted whether employer's statements about their future requirements could be regarded as fully valid, and considered there would be shortcomings in the supply of technologists.
1964 (17)	**Annual report of the Advisory Council on Scientific Policy** HMSO Cmd 2538	Further criticism of industry and the need for industry to employ more scientists and engineers.
1965 (18)	**A review of the scope and problems of scientific and technological manpower**. Committee on manpower Resources for Science and Technology. HMSO Cmd 2800	
1966 (19)	**Report of the 1965 triennial manpower survey of Engineers and technologists, scientists and technical supporting staff**. Committee on Scientific Manpower. HMSO Cmd 3103.	The demand for persons functioning in these fields is unlikely to be met. There was a long term problem in the supply of supporting staff.
1966 (20)	**Enquiry into the flow of candidates in science and technology into higher education**. Council for Scientific Policy HMSO Cmd 2893.	Showed that available statistics were incomplete and argued they had been misinterpreted. They showed that there had been a considerable growth in social studies at the expense of both the sciences and the arts.

1967 (21)	**The brain drain.** Committee on Manpower Resources for Science and Technology HMSO. Cmd 3417.	Concern with the outflow of scientists and technologists to foreign countries.
1968 (22)	**Enquiry into the flow of candidates in science and technology into higher education**. Dainton Report (a report to the Council for Scientific Policy. HMSO Cmd 3541)	Predicted continuing decline in numbers entering science and engineering departments in university which they viewed with alarm. Recommended that all students should study of mathematics to end of secondary school
1968 (23)	**The flow into employment of scientists, engineers and technologists**. Committee on manpower resources for science and technology. (The Swann report) Committee on Manpower Resources for Science and Technology. HMSO Cmd 3760.	Universities should re-examine the nature and structure of the Ph.D. Graduates with higher degrees going into school teaching should receive a merit addition to their salary. Universities should consider the possibility of making the first degree courses in science, engineering and technology broad in character. All students of society should gain some understanding of the society in which they live. Universities should come to regard post-experience courses as part of their normal provision.
1970 (24)	**The survey of professional scientists, 1968**. Studies in Technological Manpower. Ministry of Technology HMSO	
1970 (25)	**The Survey of professional engineers, 1968**. Studies in Technological Manpower. Ministry of Technology. HMSO	More than a quarter of engineers were in general technical administration but not necessarily in engineering management.
1971 (26)	**Persons with qualifications in engineering, technology and science 1959 to 1968**. Department of Trade and Industry. HMSO	Confirmed a trend for qualified personnel to find employment in occupations other than those demanding a direct technical expertise.

Exhibit 4. Official documents relating to scientific, engineering and technological manpower showing changes in the terminology used in documents titles. Sources. Up to 1960. Payne, G. L. (1960). *Britain's Scientific and Technological Manpower*. Stanford. Stanford U.P. From 1960, Heywood, J (1971). *Bibliography of British Technological Education and Training*. London, Hutchinson. The comments are indicated to show that many issues continue to be discussed.

The "technology" suppressed image of engineering in schools (exhibit 5).

The belief that schools can influence the careers that students take is deeply embedded in the U.K. The perceptions that teachers, parents and their children have of the value of subjects particularly in career terms is therefore of importance to those who want to attract students to study their subject. In Britain in the 1960's and 1970's there was a clear divide between the humanities and the sciences although by the middle 1960's a break in this pattern began to appear with the emergence of the social sciences into the curriculum (item 20).) when they began to take students away from both the humanities (commonly called arts) and the sciences.

From the perspective of engineering a blow was administered to engineering education just prior to the publication of the Robbins report on Higher Education in three publications by D. G. Hutchings on the attitudes and capabilities of sixth formers (levels 10 through 12) seeking to study science and technology at University. His study showed that the capability,of students entering the sciences, (as measured by the grades obtained in 'A' level examinations (as used for entry to University), was higher than students seeking entry to technology subjects. It is not without significance that Huitching's first publication was titled "Why so pure? (Item 27). It reflected a deeply held division in English culture. But of greater significance to the thesis offered here is the fact that the term "technology" is used in his major report (item 29), and this is taken to be synonymous with "engineering". At the time there were very few departments with technology in their titles in the universities but very many departments of engineering of one kind or another.

Given that schools were repeatedly asked to address the attention of the shortage of engineers it might have been supposed that engineering would have been the term that was used. Not so. With three exceptions the term technology is used in official documents and other publications of the period.

Date	Title	Comments
1962 (27)	Why so pure? D. G. Hutchings. *Technology*. June 1962	
1963 (28)	Why ablest boys spurn technology. D. G. Hutchings. New Scientist, January 1963	
1963 (29)	**The sixth form and technology** D.G. Hutchings. Oxford University Department of Education	This report among several others published at the same time was the most discussed. It suggested that it was only the less able grammar school boys who choose to take technological studies at university.
1963 (30)	**Sixth formers' attitudes to technology**. G. Jones. *New Scientist* 31 January 1963	A study of the stereotypes of engineers and scientists held by high school students
1963 (31)	**Why is there a shortage of engineers?** G. Jones. *Engineering*, 13th September 1963.	Derived from the same data as item 28.
1964/65 (32)	**The Schools Council**	A Council newly formed by the UK Department of Education to advise it on the curriculum and to implement research and development in the curriculum. Became very powerful.
1965 (33)	**Engineering among the schools** G. T. Page. A report to the Institution of Mechanical Engineers	A small number of grammar and private schools were offering some form of engineering or technological study. Reports an extensive inquiry into these activities with details of syllabuses and where offered public examinations
1966 (34)	**The Schools Council Project Technology**	Initiated to "to encourage technological activities in schools and thereby develop a range of abilities and provide motives which are often overlooked by more traditional approaches"
1966 (35)	**The schools and technology**. J. Heywood, V. Mash and J. Pollitt. *Lancaster Studies in Higher Education* April, No 1	Study of the attitudes and perceptions of head teachers, teachers and students in grammar schools to the Colleges of Advanced Technology, and technology in general.
1967 (36)	**The schools and technology** Report by D. Porter HMI to the Schools Council. Schools Council Bulletin no 17.	Among the findings – the subject is taught to achieve a number of differing and sometimes conflicting objectives, and it has evolved into a widely accepted part of general education for all pupils in maintained schools. (These points are illustrated in the Page report but that report concentrated on engineering and applied science schools).

1967 (37)	**Syllabus. Engineering science at 'A'Level.** Joint Matriculation Board, Manchester.	This syllabus was created as an alternative to physics with a view to attracting more able students into engineering (see item 38).
1968 (38)	**Technology in the sixth form** H.Edels *Trends in Education*, No 10. (Department of Education)	Professor Edels was chairing a committee charged with developing an examination at the advanced level of the General Certificate of Education in Engineering Science for the Joint Matriculation Board. This paper describes the philosophy behind the development – engineers have a different way of thinking to scientists and if students understand this they should be attracted to university engineering departments.

Exhibit 5. The use of the term "technology" as a synonym for "engineering in official, semi-official and research documents relating to engineering and technology in second-level education in the UK.

In one case the term technology is used correctly in that it relates to Colleges of Advanced Technology (item 35). The first exception relates to the report of a working group established by Institution of Mechanical Engineers to investigate the extent of studies related to engineering were to be found in schools (item 33). In parallel with this enquiry the Government was establishing a Schools Council for the Curriculum (item 34) who as one of their first activities employed an Inspector of Schools – D. Porter to investigate technology in the school curriculum (item 36). There were discussions between the Institution of Mechanical Engineers and the Schools Council and soon after the Schools Council established its first curriculum project which was in technology (item 34).

In the meantime the Dean of the Faculty of Engineering Science at the University of Liverpool Harry Edels had concluded that one of the reasons able students in the Grammar Schools did not put themselves forward for engineering was that they had no idea what engineering was about. In a seminal paper (item 38) he argued the case for engineering science as an alternative to physics for university entry on the ground that engineering was a different way of thinking to science even though it was firmly grounded in science. It is striking that the paper was titled "Technology" and not "Engineering" in the sixth form. Perhaps it was the association that many people made between "metalwork" (which was a subject) and "engineering". Engineering science as a subject for examination (item 37) developed in parallel with and was supported by project technology (item 39).

The UK professors of engineering very much favoured Project Technology. They thought that if pupils did project work as part of their general education rather than as an examined subject students would learn what engineering was all about. They did not appreciate that project work could be undertaken without engineering being mentioned. Neither did they much like the idea of an engineering science examination. After all if it was simply another way of teaching physics so why not stick with what they understood. They were not persuaded to accept engineering science as "the" prerequisite for entry to engineering departments.

It is claimed that the development of engineering science was responsible for changes in the physics curriculum for by 1986 all of the components of the engineering science assessment structure with the exception of the project design paper and the project were to be found in physics examinations (item 44). Notwithstanding the fact that there was a more general move toward multiple strategy examinations the claim may be made that engineering science led the way, and more specially its approaches to coursework assessment. But even though it had a project design paper and a project there was no formal syllabus component for design which many consider to be the heart of engineering. It failed to become economically viable and after about twenty years became Physics B whilst retaining the project.

It is of interest to note that when the Assessment of Performance Unit of the Department of Education first discussed the possibility of creating an instrument for the assessment of engineering in schools the scientists held that they developed all the skills that those engaged in engineering science and school technology claimed differentiated their subject from the sciences, in particular physics (see below).

There is evidence that had the "content and standards of engineering science been changed to accommodate the needs of craft teachers there might well have been a rapid increase in numbers since the craft teachers were at that time attempting to find a syllabus and title which would increase the status of their subject. Support for this view may also be adduced from the rapid growth in numbers taking design oriented subjects at the ordinary and advanced levels of the General Certificate of Education" (item 44, page 78).

Date	Title	Comment
1968 (39)	**Technology and the schools**. Schools Council, HMSO. Working paper No 18	First report of the Applied Science and Technology Project written by the Director G. Harrison.
1972 (40)	**Notes for the guidance of schools and syllabus of Engineering Science at 'A' level**. Manchester, Joint Matriculation Board.	Unusually for the Joint matriculation Board assessment procedures were properly developed and evaluated, and several papers published (items 41 and 42), and one as recently as 2014 (item 43). There was much consultation with teachers, an experimental examination was trialled, as were coursework assessment procedures. The results were published in a series of pamphlets which were brought together in this document. A substantial evaluation was carried out in 1986 (item 44).
1972 (41)	**Teacher attitudes to projects in 'A' level engineering science**. D. Hiles and J. Heywood. *Nature*, 236, 61-63	
1973 (42)	**The evaluation of course work-a study of engineering science among schools in England and Wales.** J. Heywood and D. T. Kelly in *ASEE/IEEE Proceedings Frontiers in Education Conference* pp 269-276.	
2014 (43)	**The evaluation of a criterion referenced system of grading for engineering science coursework**. ASEE/IEEE Proceedings Frontiers in Education Conference, 1514-1519.	
1986 (44)	**Case Study in curriculum assessment. GCE Engineering Science (Advanced**). Manchester. Roundthorn. Press	

Exhibit 6. The Rise and fall of engineering science in High Schools in the UK

The decline of the industrial arts and the rise of design and technology

The industrial arts is a term that is peculiar to the U S. It embraces woodwork and metalwork as well as other crafts. As indicated, craft teachers in the U.K were trying to raise the status of their subjects which they did by embracing a design orientation. In 1974 The Schools Council sponsored a design and craft project (item 45). As the number of students taking design grew, interest grew in technology, and a curriculum grew under this title that included electronics, hydraulics, pneumatics that required only elementary mathematics. It incorporated a design and make project. In this way the subject CDT (Craft, Design and Technology) was born and became a subject within the national curriculum. The Nuffield Foundation funded a design and technology curriculum project in 1985 (item 46). By 1989 there was a sufficient number teachers to found a new association DATA (Design and Technology Association) with its own journal (circa 1990) At the same time a conference at Loughborough University yielded sufficient research to merit the founding of an academic journal for the field with Professor John Eggleston as its chairman and this writer as its editor (*The International Journal of Technology and Design Education*). Coincidentally the developments in the field can be seen from the titles of the journals that were developed in that period, all of which were associated with Professor John Eggleston (item 47).

In 1985 the Assessment of Performance Unit took up the cause of the new subject of "Design and Technology" by forming a unit at Goldsmith's College to develop instruments for the assessment of performance in that subject. Its final report was completed in 1990 (item 51).

Worldwide developments in design and technology

During 1984-85 the Christian Brothers sponsored a survey of developments in school design and technology in Europe including the United Kingdom (item 53).Not only did this study reveal the developments of "Technologie" in France (items 54 & 55) but it also discovered the Arbeitslehre (education for work) programme in Germany (item 56).In the years that followed there were developments in technology education in Germany that were reported at a conference in 1991 when a German association for technology education was founded (item 57). The authors of the Irish study did not know about the research that was being conducted concurrently in the Netherland's into pupil's attitudes toward technology (PATT) by Jan Raat and Marc de Vries. Following that study. There followed a series of PATT conferences. The 1992 conference was organized with the U.S. based International Technology Association (ITEA-item 59). Prior to that conference, in the same year, the first international conference on technology education took place in Weimar (item 60). None of the papers at the ITEA/PATT conference include "engineering" in their title. Although the term "technological literacy" is used in the title of the Weimar conference the term" technology" is used in most papers but there is only one paper which deals with concept of technological literacy in detail (Dyrenfurth, M. the structure of technological competence 397-402) A synthesis of the bulk of American work on technological literacy led Dyrenfurth to conclude "that there is a remarkable convergence between what the private sector calls for and what the core of the technology education profession seeks to deliver. The recently identified German work into new qualifications also supports this convergence in another country. (Qualifications as used by the Germans in their English translations should be translated as competencies).

Only one of the 100 papers presented at the Weimar conference includes the term “engineering” on its title. It lamented the shortage of able young students putting themselves forward for engineering. Just as in the sixties Matthews its author noted the British cultural problem of decrying “practical ability at the expense of academic achievement”. He began his article with an attempt to distinguish between technology and engineering which is very similar to that derived by Krupczak and his colleagues (exhibit 10).

Subsequently Professor Bill Dugger and the ITEA developed Standards for Technology Education, and The American Society for Engineering Education created a division for “Pre-college Engineering Education” to embrace developments in K-12 engineering and technology education. The ITEA subsequently reversed the exclusive usage of technology by equivalent organizations and changed its name to become the International Technology and Engineering Education (ITEEA). In the U.S at least engineering had achieved separate recognition to technology in primary and post-primary education. However, engineering like technology has had to contend with the belief that they are IT, and this impacts on our understanding of technological literacy

Date	Title	Comment
1974 (45)	**Schools Council Design and Craft Curriculum Project**	Directed by Prof S. J. Eggleston
1985 (46)	**Nuffield design and technology project** begins	Directed by P. Black and G. Harrison
1968 (47)	**1st issue Studies in Education and craft** Journal of the College of Craft Education	First of a series of Journals in the field created and edited by Professor S.J. Eggleston. The titles of subsequent developments in the field eg. *Studies in Design Education, Craft and Technology.* *Journal of Design and Technology Education.* *International Journal of Technology and Design Education* This issue sets a new direction includes research, and philosophy related to craft and technology.
1988/1989 (48)	**Establishment of a National Curriculum** In England, N. Ireland and Wales by the Department of Education	Technology was included as a core subject. The contributory subjects were art and design, business education, design and technology, home economics and information technology. “the area of the curriculum in which pupils design and make useful objects and systems with a range of materials and technologies, including those in use in modern industry. Students were to learn effective methods of working, including the use of ICT and also to work within realistic financial and technical constraints” (Barlex cited by Toft). Development of the goal of “know how”. Technological capability is “essentially practical and creative, and is more concerned with shaping the world we live in than with understanding ot.” (Barlex cited by Toft)
1988 (49)	**First design and technology education and research conference (DATER)** Organized by J. Smith and Loughborough University.	J. Heywood and J Smith recognized that research in Design and Technology was a growth activity that merited a journal. Prof S. J. Eggleston took up the idea and founded *The International Journal of Technology and Design Education* with J. Heywood as its first editor. First issue published in 1990.

1988 (50)	**The relationship between Design and Technology.** J. Mattick, *Studies in Design Education, Craft and Technology*, 20(2), 77	"I suggest that to be a person today means having some perception of technology, some awareness, understanding and capability." (cited by Toft. Mr Mattick was a member of Her Majesty's Inspectorate)
1990 (51)	**Assessment of performance in design and technology**. R. Kimbell et al. London. HMSO/School Examinations and Assessment Council.	Report of a project initiated by the Assessment of performance unit in 1985.
1992 (52)	**England and Wales** Technology in the Curriculum Report by A. Smithers and P. Robinson for the Engineering Council	The main reason why technology in schools seems so elusive is that it embodies the aspirations of a number of interest groups which have been kept together only by pitching its objectives and content at such a high level of generality that it can include almost anything. If it is to be given shape and substance as a subject then agreement will have to be reached at the much more difficult level of detail.

Exhibit 7. Documents related to the development of design and technology in England and Wales.

Date	Title	Comment
1986 (53)	**Ireland** **Technology, society and the school curriculum. Practice and theory in Europe**. Edited by J. Heywood and P. Matthews. Manchester, Roundthorn Press.	Conference papers
1985 (54)	**Colleges: programmes et instructions**. CNDP, Paris . Ministère de l'Éducation Nationale	Contains syllabus for Technologie
1986 (55)	**Recent developments in the school curriculum in France**, M. Murray in item 53.	Description of philosophy and practice.
1992) (56)	**Arbeitslehre in the Federal Republic of Germany** H. Steffens in item 58.	
1991 (57)	**Germany** **Current topics of technology education in Europe**	Conference organized by Europaische Gesellscjhaft fűr Technische Bildung. Report edited by M. Kussmann and Helmut Steffen. EGTB Report No 1.
1992 (58)	**Germany/International** First international Conference on Technology Education	D. Blandow and M. Dyrenfurth (eds) *Technological Literacy, Competence and Innovation in Human Resource Development* Proceedings First International Conference on Technology Education (ISSN 08633401).
1992 (59)	**USA/Holland** **A global technology education perspective**	ITEA-PATT International Conference. Reston, VA Proceedings edited by E. Allen Bame, W. E. Dugger Jr. Much convergence with the 1992 international conference.

Exhibit 8. Some international developments.

Date	Title	Comments
1993 (60)	**Project 20161: benchmarks for science literacy**. American Association for the Advancement of Science. Oxford U.P.	Emphasizes that technology is a human activity that shapes our environment and lives.

1996 (61)	**The national science education standards**. National Academies.	Includes a section devoted to technology and highlights the significance of the design process.
2000 (62)	**Standards for technological literacy**. International Technology Education Association	The ITEA subsequently changed its name to the International Technology and Engineering Education.
2002 (63)	**Technically speaking. Why all Americans need to know more about technology**. Editors G. Pearson and A. T. Young. National Academies Press.	
2008 (64)	**Changing the conversation: Messages for improving the public understanding of engineering**. Committee on Public Understanding of Understanding of Engineering messages. National Academies Press.	

Exhibit 9. Significant American documents.

Technological and engineering literacy

Although the idea of technological literacy has been around for fifty or so years and possibly led to the development of programmes in science, technology and society as well as research on technology and society, ask anyone today what they think it means and the probability is that they will associate it with high level skill in computing.

As a subject like science literacy, that is a subject that deals with the content of technology and the interactions between technology and society it appears to be a singularly American activity although references to it can be found in academic discourse outside of the U.S.A. but, as with school technology there are differences of opinion about what it means, and these continue to this day.

In 2006 ASEE founded a division for technological literacy (TELPhE) and numerous papers have been presented at its meetings many of which are attempts to teach engineering to non-engineering students. The idea of engineering literacy seems to be a more recent development. One of the members of the division has in the past use the same definition for both engineering and technological literacy, and used them as a function of the audience being addressed[14].

Given the problem of differentiating between technology and engineering it is not surprising that there should be difficulties in defining the literacies associated with them.

As indicated above Matthews attempted to distinguish between engineering and technology at the 1992 Weimar conference. Most recently John Krupczak and his colleague in the TELPhE division also attempted to draw a distinction between technological and engineering literacy with the consequence that engineering literacy was incorporated in the divisions title. Inspection of exhibit 10 shows there are many similarities between the definitions suggested by Matthews on the one hand, and on the other hand by Krupczak et al., although Krupczak et al look at the problem from several different perspectives. These definitions have the advantage of leading to an identifiable curriculum. But, it has been argued that the “literacy” that should contribute to the curriculum is an integration of both, hence the significance of the revised name of the TELPhE division – Technological and Engineering Literacy/Philosophy Division.

Given the discussion that preceded this section there is no evidence that these names will make the "E" in STEM loud. It may however be the case that associating engineering and technology in the same definition as the London based Institution of Electrical Engineers and the Institution of Incorporated Engineers have done may better highlight the contrast between science and engineering and technology.

Matthews definitions	Krupcak et al definitions
Technology is the systematic harnessing of knowledge and experience to result on something practical and commercially useful- a product, a manufacturing process, a system, a service**.**	**Technology** might be seen as the product of the process. It is the created device, system or component that is brought into existence by human beings engaging in a creative problem solving process.
Engineering is the vehicle which is central to the successful delivery of technology	**Engineering** can be viewed as a process. The process of creating physical artefacts and procedure that meet human needs and wants
Education is the process which we all go through, to varying degrees which trains out thinking and logic.	

(a)

Engineering Literacy	Technological Literacy
Process	Product
Verb (actions)	Noun (objects)
Narrow focus	Broader focus

(b)

Exhibit 10. Matthews and Krupczak's definitions of engineering and technology and their associated literacies compared.

The Institution of Electrical Engineers (IEE), and the Institution of Incorporated Engineers (IIE).

In 2006 the Institution of Electrical Engineers in the UK made what might be described as a surprising move and merged with the Institution of Incorporated Engineers, (itself a merger of several technician institutions), to become the Institution of Engineering and Technology (IET). In so doing it became the second largest professional association for engineers in the world after the IEEE.

The term "engineer" is replaced by "Engineering", and the term "Technology" introduced. While "technology" may relate to American usage in which a degree in "engineering technology" is a higher technician degree, it is surely of more significance from the perspective of image that engineering and technology are combined in the same title. Since it is not unreasonable to hypothesize that the term "technology" will come to prevail in the future it is possible that if ASEE were to follow this model and call itself the Society of Engineering and Technology its image would be enhanced.

Conclusions

Norman Fortenberry in a letter to the *Washington Post* lamented the silence of the letter “E” in “STEM”. Too often great artefacts that were self-evidently the result of engineering were attributed to the work of scientists. In many English speaking countries engineering is perceived to be synonymous with applied science. Engineering is perceived to have lower status than science, particularly by school teachers. It is evident, in the U.K at least, that science policy making covers engineering, and to some extent this is true of policy making in the U.S. The media contribute greatly to the mix-up.

The image of engineering is suppressed in favour of science, and this is held to be harmful to the image of the profession particularly its ability to attract more able students to its study. Focusing on the scientific model in its application at the expense of manufacturing and design contributes to this state of affairs. For example, in the U.K in the 1960’s engineering educators in the Colleges of Advanced Technology rebuffed exhortations from industrialists to orient the curriculum more towards the needs of industry

However, such arguments are difficult to sustain because there is continuing flow of students into engineering schools and engineering schools that persists. It is probably true that in some countries the pool of both scientists and engineers has declined in favour of other studies some of which have been frowned on by the academic community.

There is little evidence that changing the middle and high school curriculum to include engineering oriented studies, however educationally desirable that may be, encourages a much greater number of high school students into engineering.

However, just as the “S” in “STEM” is loud so too is the “T”, and there is just as much confusion between the public perceptions of technology and engineering as there is between science and engineering that are also aided and abetted by the media. Technology and engineering are taken to be synonymous, but there is also a public perception that technology is IT and robots. In official documents “technology” is often used instead of “engineering”. This suppression of “engineering” by “technology” may be more significant than the suppression of “engineering” by “science”. But, should we be worried about this state of affairs?

Clearly this situation is not going to change. A combination of policy makers and the media will ensure that that is so. Fortunately, as already indicated there is nothing to suggest that the viability of engineering schools is harmed by this state of affairs, or that the profession, that is, those who make it viable (e.g industry) are suddenly going to stop using the term “engineer”, and where there is some protection of the term this will remain.

Frustrating though it may be there would seem to be little reason to worry on these accounts. A case may be argued for changing the name of ASEE to Society for Engineering and Technology so as better to reflect the range of studies that are represented by the organization as well as the public preference for the word “technology”.

The TELPHE division has performed an important service in clarifying the difference between engineering and technology even though as its recent work shows these confusions still exist[15].

Such attitudes and perceptions are difficult to change because the different epistemologies they embrace are deeply embedded in the culture One effect of the holding of such beliefs would seem to be on engineering educators attitudes towards the curriculum which are deeply embedded, and equally difficult to change, a position that is hardly acceptable in a time of rapid-socio-technical change.

Notes and references

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7. S. P. Hutton and P. Lawrence. German Engineers. The Anatomy of a Profession: Oxford, Clarendon Press. 1981.
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9. Achievement Motivation is a concept due to D. C. McClelland. In addition to its relevance to the motivation for learning, D. C. McClelland applied the idea to societies and their success. A successful capitalist society would have a higher level of Motivation than a less successful one. D.C. McClelland. The Achieving Society:New York, Free Press, 1969.
10. loc.cit.
11. ibid.
12. J. Heywood. An Evaluation of Certain Post-War developments in Higher Technological Education: Thesis 2. Vols. Lancaster, University of Lancaster Library, 1969.
13. At first the subject became a catch all subject and included within its divisions aspects of home economics such as food technology that were considered relevant.
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