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Lessons for Education, Engineering and Technological Literacy from the Experience of Britain's Vaccine Task Force (VTF)

Prof. John Heywood, Trinity College Dublin, Ireland

John Heywood is professorial Fellow Emeritus of Trinity College Dublin- The University of Dublin. he is a Fellow of ASEE and Life Fellow of IEEE. he is an Honorary Fellow of the Institution of Engineers Ireland. He has special interest in education for th

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Abstract

Recent events in the UK during COVID 19 have raised questions about the scientific and technological capabilities of civil servants that have a bearing on the meaning and scope of technological literacy, and therefore, for the work and purpose of the TELPhE Division of ASEE. This paper is based on the view set out at the beginning (section 1) that technological literacy is not a particular discipline of a study but a skill that enables a learner to bring together different components of knowledge and skills to the solution of technological and scientific problems in all kinds of human situation.

The argument is supported by a case study of Britain's Vaccine Task Force (VTF). "*The long Shot. The Inside Story of the Race to Vaccinate Britain* by Kate Bingham and Tim Hames. It recounts Bingham's experience of creating and leading the task force.

The origins the task force, the risks that would have to be taken, and the significance of the networks brought together by the members of the task force are summarised section 2. Persons capable of working in contingent situations and used to getting things done were recruited. For Bingham this created difficulties because she was not used to dealing with bureaucracy (civil servants) which was process oriented, risk averse, and often had an animus against industry.

Although the primary goal was achieved, Bingham regretted that several other goals were not (Section 3). This may be put down to short termism which is a characteristic of British political decision making (section 5). Two educational projects are described that might have produced a workforce more responsive to change are described that were not persisted with after the cessation of funding. The essence of these projects is necessarily a component of technological literacy as defined here.

Bingham recommended that there should be more science qualified civil servants at all levels, and that some experience of industry should be mandatory.

But as section 4 illustrated research on engineers in organizations shows that the ability to change is a function of organisational structure, and that it is possible to make closed systems less closed.

The sixth section argues the case for technological literacy as conceived here is an alternative to, if not necessary education for the generalists that are required in the work force or the education that is required to live in a technological society.

Key words: Capability, Change, Civil servants, Contingent, Engineering literacy, Enterprise learning, Organisational structure, Short termism, System(s), Technological literacy, Thinking (different ways of), Vaccine Task Force (VTF)

1. Introduction

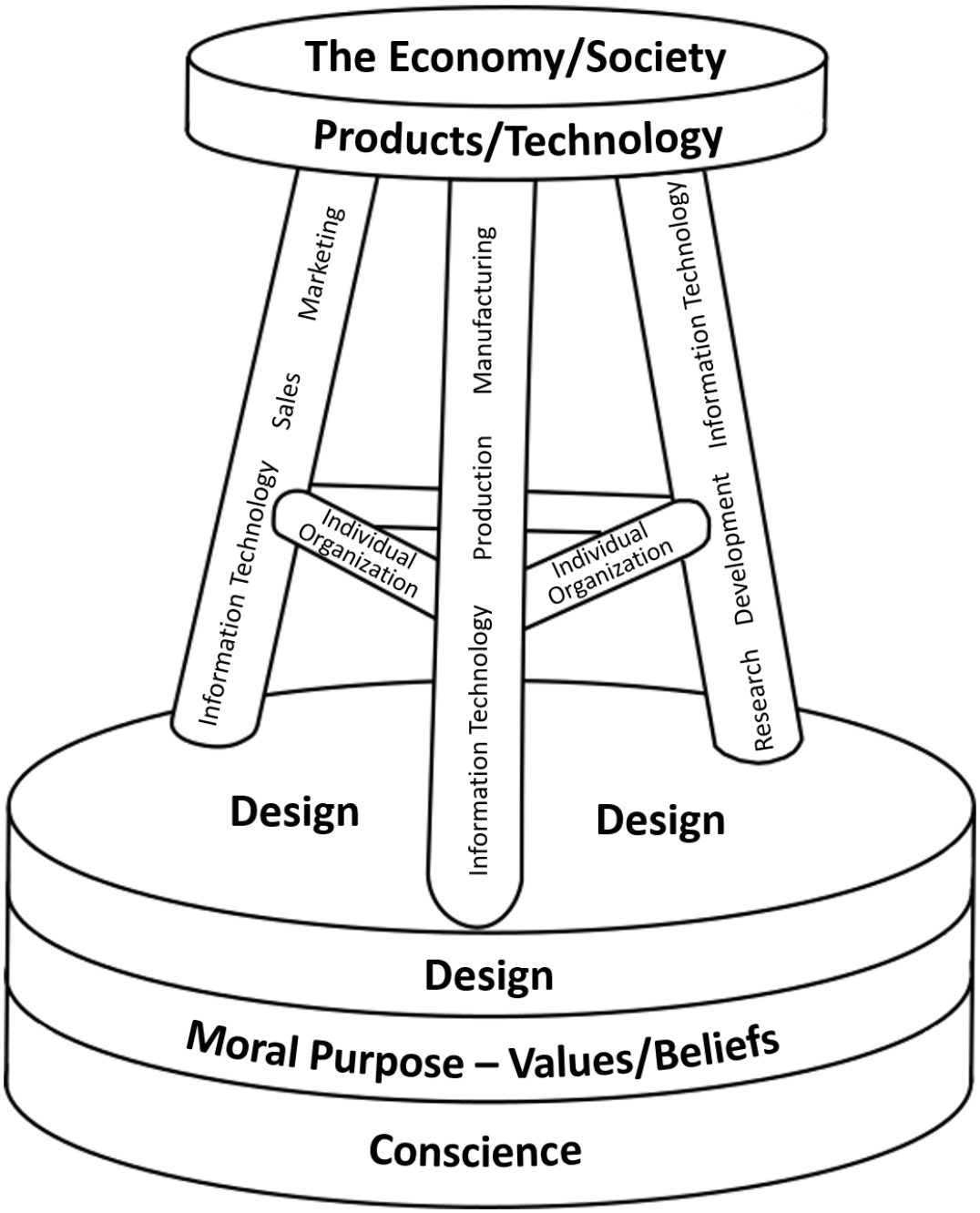
Recent studies of the Grenfell Fire [1] and Boeing 737Max [2] tragedies to determine the nature of technological literacy as a general educational initiative have showed that something more than a requirement for technical understanding (engineering literacy) is involved; in particular, an understanding of people behaviour in organisations. As such they affirm models of engineering/technology that embrace the philosophical and social (economic) factors underpinning design and manufacture as well as the organisational structure that brings about manufacture and production. In recent years they have sometimes been illustrated by a stool (exhibit 1) [3].

This paper is grounded in the view that the process of innovation and its product(s) can only be understood from this broad perspective which is supported by the case studies referenced. In particular they show the importance of the human factor not only in the organisation responsible for an innovation, but in its use. While there is nothing particularly new in these propositions those responsible for engineering education have consistently undervalued them. They have not given them the recognition due, as for example, studies in the US by L. B. Barnes [4], Scotland by T. Burns and G. Stalker [5], and England by M. B. Youngman, R. Oxtoby, J. D. Monk and J. Heywood [6]. It is argued that the story (case study) that Bingham and Hames tell lends strong support to this view [7]

At the same time, such models challenge the idea that technological literacy is a subject that ought to be in the curriculum since they ask the question "what does it mean to be literate in technology? Technological literacy as conceived here is not a particular discipline of study but a skill that enables a learner to bring together different components of knowledge and skill in the solution of technological and scientific problems. The same may, therefore be said of science literacy. The two necessarily overlap and are distinguished by the type of problems they solve and the method they use, the method of engineering being different to that of science [8]. For this reason the study by Bingham and Hames is of considerable importance both to the TELPhE division of the American Society of Engineering Educators as well as engineering educators more generally since it describes a clash between two systems with different values whose philosophical foundations are deeply embedded in the past

In 2004 Steven Goldman offered the following explanation of these different philosophies: "*Mathematics is paradigmatic of what has been admitted in Western 'high' culture, namely reasoning that is abstract, necessary and value free, and problem solutions are universal, certain, unique and timeless. Historically 'demonstration, meaning mathematico-deductive argument is the form, of reasoning that the most respected philosophers from Plato and Aristotle to the early Wittgenstein have striven for, rejecting reasoning based on the probable, the concrete and the contingent". And science is based on the concept of necessity which is cognate with concepts of 'certainty', 'universality', 'abstractness', and 'theory'* " [9].

Academic engineering is firmly rooted in that tradition. Real engineering (the engineering done by industry) is by contrast *"characterised by 'wilfulness, 'particularity', 'probability', 'concreteness' and 'practice' "* [10] Manufacturing industry, and therefore, its training is rooted in the contingent, a fact that was not understood when sandwich courses were



developed in the 1960's. Academics evidently viewed training as a means of enabling students to apply the scientific knowledge learnt in college courses in industrial situations. There was no recognition of the fact that different ways of thinking were involved. It is argued that these different ways of thinking (epistemologies) and their conditioning, which form the ontologies (especially attitudes) of those involved, are at the heart of many of the problems experienced by Bingham.

2. From the story of Britain's Vaccine Task Force – *The Long Shot*

Before any Covid 19 cases had been reported in the UK, on Jan 27th 2020, an informal meeting of a small group of experts led by Sir Patrick Vallance, the Government's Chief Scientific Officer, concluded that the UK had to be prepared potentially for a pandemic. They also considered the options for vaccination knowing that the politicians would have to decide on the relative importance of vaccination in any strategy (p13).

For a variety of reasons recorded by Bingham and Hames, Vallance became convinced that a "*dedicated capability to focus on vaccine procurement, development and manufacture*" (p 15) was required not least because "*while senior officials had outside experts for scientific and clinical advice, they did not have equivalent advisers for pharmaceutical manufacturing and distribution*" (p15). Moreover he felt that any new agency should be separate from the Department of Health because the Department was overloaded with other problems that later came to be discussed in the media. So it came about that a nascent Vaccine Task Force (VTF) came to be established in the Department for Business, Energy and Industrial Strategy BEIS where he was based.

It began with the establishment of an External Advisory Board which comprised, to quote Bingham and Hames a "*rock-star list*" from the worlds of science and medicine, but also with experts able to give an industrial perspective. Bingham was asked to be a member of this group for the reason that much innovation happened in the world outside the mainstream pharmaceutical industry, a world in which she, a venture capitalist who was qualified in biochemistry and management, was a player.

Bingham soon came to the conclusion that as structured the task force could not do its job. a What was needed was *"an expert group with the authority to go out to the vaccine and manufacturing companies and sign deals"* (p 22). In other words an "industry-led VTF". The government agreed and the Secretary of State acting on behalf of the Prime Minister invited Kate Bingham to chair the group. In an electronic meeting with the Prime Minister on the 6th May she was "*given three very clear goals – to secure vaccines for the UK, to ensure vaccines were distributed equitably around the world, and to make the UK more resilient for next time. He wanted the UK to be at the forefront of vaccine R & D manufacturing and supply globally"* (p27). All of which were to be completed in the six months for which she was appointed. It is against these aims that she judges her success and failure. The scale of her task is illustrated by the risks that she had to take as measured in billions of pounds sterling.

The Risks

At the time of her appointment there was no tried and tested vaccine for Covid-19. Numerous efforts were being made by firms and universities to develop such a vaccine. One that made the headlines in Britain was a collaboration between AstraZeneca and Oxford University. But there were several other developments outside of Britain across the two main types of vaccine and two new types best known to the public as m(messenger)RNA. At the time, the best known model of this type in Britain was the Pfizer-BioNTech.

The first tasks of the VTF were to determine which of the drugs was likely to be successful, how many doses would be required, and then to arrange for contracts of purchase to be drawn up.

A decision was taken by Bingham together with the Director General of the task force, (a civil service appointment [11]), to build a portfolio "*with the most promising vaccines representing each of the different formats so that we could increase our chances of securing at least one successful vaccine*" (p 84). Bingham set herself the 1st of December 2020 "*to have signed supply agreements for six vaccines, both domestic and international from at least three of the four different vaccine formats*" (p 88).

Set this goal against the fact that the earlier VTF Expert Advisory Committee, at a meeting in April 2020, had been told "*that it was only fifteen percent likely in each case that any vaccine would prove effective, and then only if the vaccine was already in clinical trials*" (p 75). Add to that the fact that up until then, vaccines had taken years to develop, some idea of the magnitude of risk involved becomes apparent. That level of risk could be reduced by ensuring that there was a wide range of expertise among the members of the taskforce and the networks they brought with them.

The Task Force and its networks

The key appointment that had to be made by the Cabinet Secretary was that of Director General of the Task Force. Such a person had to know how Whitehall functioned, and at the same time have strong commercial skill. Fortunately such a person was to be found in the professional acquisition and support division of the Ministry of Defence whose early army career had been as bomb disposal engineer. Between them they built the Task force which comprised role players for the functions listed in exhibit 2.

Roles

1. To bring together a small team of experts to identify the most credible vaccine contenders and advise on the broad strategy of VTF (p36).
2. Oversee the scale-up and manufacturing of vaccines and to ensure that everything that was needed for population-wide vaccination was in place (p37).
3. Run clinical trials to secure approval of novel vaccines from global regulators (p 39).
4. Negotiator with formal legal qualifications and commercial expertise (p 42).
5. Organization and management of the clinical trials (p 44).
6. Delivery and project management with responsibility for the security of the entire VTF operation (p 46)
7. Responsibility for international, inter-governmental and NGO relationships (p 49).
8. Deputy Chief Medical Officer for England.
9. Preparation of Business Cases required by the BEIS.

Exhibit 2. A brief summary of the roles of The Vaccine Task Force Team excluding the Chairperson and the Director General. Full details in chapter 3 of "*The Long Shot*".

Such was the uniqueness of the VTF with frame work of government that Bingham was able to appoint as her deputy a person from industry who had volunteered himself for the job of whose expertise she had had experience (exhibit 2. Role 1). He had been funded by her company to "refocus a *"(firm) to develop and manufacture therapeutic and prophylactic DNA vaccines for viral disease and cancer*" (p 34). He was so successful that a couple of years later Pfizer had made a bid for his firm that could not be refused. Apart from his own skills he had access to a network of experts and, could assemble a small team to offer advice on the selection of vaccines.

A network is a form of team and just as networks benefit from diversity so to do teams, although in either case there have to be common set of values to achieve agreed goals.

A major factor in the selection of the role players therefore, was the networks they inhabited in research and/or manufacture. They too had to form together as a network so as to bring together much *tacit* knowledge that would otherwise be unavailable.

Bingham and Hames show the importance of skill in liaison and coordination. In the pursuit of the Task force's goals. Just as the principles of networking are generic so are the skills of technical (scientific) coordination. Indeed Trevelyan believes they are the key skills in the engineer's repertoire *"Engineering itself is a large symphony of combined collaboration performances*" [12]. That could equally be said of the VTF as described by Bingham and Hames.

Finally, evidence supports the view that teams are more effective when their membership is diverse. Bingham reflected, "*I now realised that we did not have a traditional set of backgrounds. Instead we were relying on the likes of bomb disposal expert, an Indian rowing star, an Italian consultant, a submarine delivery agent, a former ambassador, a football pundit, and a venture capitalist to get the UK out of a pandemic"* (p 51).

The person in role 4 is reported as saying, "*We're all problem solvers, we tend to be heads down and get on with i*t" (p 51).They were capable of dealing with contingencies. In sum, a key skill of leadership is the ability to build a team able to pursue specified goals, and that implies a knowledge of people and how individuals and organizations interact.

3. Bingham's considerations of success and failure

Bingham looks back at what happened in the final chapter of the book. Her remarks are divided between regrets, reflections on working with government, and recommendations for improvements in the future.

In the following remarks which concentrate on the negative it is important to remember that in spite of being mauled by the press with false allegations that had to be withdrawn, Kate Bingham's Vaccination Task Force was seen to have achieved its primary goal with flying colours. The UK became the first country in the world to launch a Covid vaccination Programme. Proof that the vaccines worked was quickly established, and Bingham asserts that each of the AstraZeneca and Pfzer-BioNtech saved upwards of 5 million lives.

Her Regrets

First, a National Registry of persons willing to participate in trials was created on the NHS website. It helped deliver the largest Phase 3 vaccine trial ever run in the UK which placed the UK as a place where pharma companies would want to come and undertake trials with all the consequences that follow. In August 2022 Bingham was told that the Registry was to be closed down.

Second, the VTF was not able to solve the problem of those people whose immune systems would not respond to vaccination. Bingham put that number as half a million. She noted that the Government was not persuaded to buy AstraZeneca's long acting antibodies "*which will mean that many vulnerable individuals will have been needlessly infected or will have been forced to put their lives on hold*" (p 298).

Third, an economic opportunity was lost when the government did not take up the proposal for an industry partnership to build a bulk antibody manufacturing capability in the UK (p 299),

Fourth, it sold the Vaccine Manufacturing and Innovation Centre to an American company (p 299).

Fifth, an onshore manufacturing capability for mRNA was not created. But the government did sign a deal with Moderna to establish a research and manufacturing facility in the UK in June 2022 (p 299)

Related to these failures is an announcement in February 2023 that AstraZeneca propose to build a pharma ingredient plant at a cost of $369 million in Ireland rather than England because of corporate taxation and the NHS sales levy. It should be noted that Astra Zeneca is Britain's largest provider of R & D [13].

Finally Bingham and Hames write"

"*The ethos of the VTF team, originally with the approach of working with vaccine companies and manufacturers, seem now to have shifted from 'partner' to 'adversary', when the VTF moved from BEIS into the department of health on my departure. I've already flagged some of my views about this department. It seems that the VTF project teams are no longer led by industry experts working closely with vaccine companies to deliver shared goals. Now the teams seem to be led by generalists with an arms-length, often adversarial approach – acting as policemen and marking homework, rather than offering valuable an expert support for the partner*" (p 300).

In these circumstances the possibility of a national strategy seems to be remote: yet, without such a strategy Britain will not be a world leader in this field.

Her Reflections on working with government

Bingham's reflections on working with government have to be judged primarily against the last sentence of the 'Prologue' of Bingham and Hames book which reads "*I'm a practical person. A scientist and a business woman. I'm interested in outcomes, not processes, and I call things as I see them*" (p 4). The reflections are presented under the headings – Focus on process not outcomes – Lack of relevant skills – Government's fragile relationship with industry.

Concerning the impact of process on action Bingham and Hames write "*Official paranoia about how to handle the media and the media's possible reaction held back the pace of execution* (see the appendix*), as did hesitancy over risk. It's much safer for officials who focus on political and presentational risk but generally know little or nothing about actual commercial or scientific risk to drag their heels regarding complex decisions rather than risk career suicide by pushing ahead with an even vaguely controversial task*" (p 302).

Bingham draws attention to the fact that not only do civil servants lack relevant skills but that only one Minister had a genuine interest in the life sciences sector: he had a degree in engineering and understood *"the operational aspects of our work and the commercial dynamics we faced"* (p 304) but he had been in business. Coupled with that in the Ministry in which that Minister was serving, The Department of Business, Energy and Industrial Strategy (BEIS) there was almost complete lack of scientific, industrial, commercial and

manufacturing skills. She wrote that, "*Very few Permanent Secretaries, the senior civil servants who are ultimately responsible for commissioning the work, have ASTEM degrees. Less than ten percent of graduates entering the Fast Track scheme have STEM backgrounds. Instead Whitehall is dominated by historians and economists, few of whom have ever worked outside the official and political worlds*" (p 305). This would have come as no surprise to the controversial historian Correlli Barnett (see exhibit 3(b)).

Finally, Bingham detected an animus among civil servants toward industry (see exhibit 3(d).She gives the example of a vaccine contract that was cancelled before its phase 3 trial results had been received on the advice that it would never be approved given by some unknown official. The trial showed the vaccine to be highly effective and safe as the Task Force had predicted.

A. "Much of the trouble arises from the isolation of civil servants from outside experience. Not for nothing are the heads known as mandarins, for the latter made the same mistake of isolating themselves from productive activity, wearing their finger nails long to show that they never physical work. Although the American system, where senior civil servants change with the politics of government, has obvious faults, this at least has the merit that they are perforce exchanged between the civil service and industry and other forms of administration, forming a corpus of men at each side who have experience of working on the other" R. V. Jones, War time civil servant and distinguished scientist. Letter to *The Times*. 17: 12: 1980.

B. Of the Permanent Secretaries in 1945, all from Oxford or Cambridge, Barnett wrote that they had "risen to the top by shining as committee men and writers of memoranda (a continuation of the Oxbridge essay by other means) rather than as executive problem solvers – their minds judicious, balanced and cautious rather than operational and engaged: their temperaments akin to the academic rather than the man of action, their culture profoundly literary" [21, p 183]

C. The 1966 Fulton report on the Civil Service "Remained fixated on the administrative class and refused to recognize the enormous power and authority of the professionals. For it was they who were critical in pushing the *grands projets* of the post-war state, from nuclear weapons to nuclear reactors to Concorde…etc"(David Edgerton [13 – p396]

D. Bingham reports that there is among senior civil servants an animus toward industry. She had learnt from another project involving industry and academia in the evaluation of existing drugs for therapeutics. *"The industry had been very keen on moving swiftly ahead to lead the exploratory Phase 2 studies. The academics were far more wary. There were some very senior officials in government who had instinctive suspicions about the motives of the industry experts. One official even asked an industry volunteer: 'What are you going to get out of this?' as though every commercial expert in the area was in it for the money"* (p 80).

Exhibit 3.

Her recommendations

Excluding her recommendations relating to future pandemics she made three recommendations concerning the functioning of the civil service. First was that outcomes and not process should be rewarded. "She would punish for failing to act" (p 307) and change the current structure to reflect proven practice in the private sector. This would involve the complete overhaul the recruitment, professional development and associated incentives of civil servants.

Second, she would require middle range civil servants to be seconded to industry and commerce as a condition of promotion.

Third she suggested that Ministers should be trained in commissioning business and financial skills but how that could be achieved in the political system is difficult to imagine especially Ministers are in their jobs for such short periods of time.

She was surprised to find that when purchasing vaccines while numerous analyses had to be done relating to legal, economic, finance and management matters, science was not considered. She argues that the science case should be central to all policy and decision making but does not mention technology.

In sum, Bingham and Hames study leads to the view that the government and its civil service advisers took steps that diminished its world standing, which, it may be argued, is in keeping with the extensive literature on Britain's industrial decline to which this book clearly belongs. Therefore, considerations of change as a function of organisational structure which will be considered next, have to take into account the climate of society, which some call culture, of which they are a sub-system.

4. Change as a function of organizational structure

Given the animus that Bingham detected among civil servants any change which suggests that the best practices of business should be adopted by a bureaucracy is likely to be resisted. The question to be resolved is whether sufficient change can be brought about in the bureaucracy to enable a facilitating response in challenging situations such as those described by Bingham. Only then does the issue of qualifications arise. Early research on engineering organisations suggests that there might be, since in firms run on bureaucratic lines there was evidence of innovation not as something *ad hoc* but something that is a function of the 'will' of the organisation. That 'will' results from the fact that each of the role players is a psycho-social system.

Key features of Weberian Bureaucracy are hierarchy and precise definition of roles (see exhibit 4). It is risk averse; role players exercise the rules of their roles and only those roles. To do otherwise might affect their promotion prospects. The system is designed to ensure that the process functions smoothly. Acting together they create what is sometimes called a 'culture'. The question Bingham asks may be expressed in terms of how is a culture created that has a positive attitude toward science?

Burns and Stalker who studied the Scottish electronics industry in the late 1950's identified organisations that had many similarities with bureaucracies [14]. They called them 'mechanistic' the characteristics of which are shown in exhibit 5 A.

In 1960, Louis Barnes of the Harvard School of Business Administration in a much neglected study of engineers in organizational groups described a closed system that had very many similarities with the mechanistic organization of Burns and Stalker (Exhibit 5 B) [15]. Burns and Stalker also showed that there were organizational structures that fostered innovation. These they called 'organic'; their characteristics are shown in exhibit 6 A. Similarly Barnes found that 'open' systems whose characteristics are shown in exhibit 6 B are more open to innovation.

1. Operates according to a body of laws or rules which are consistent and have normally been established.
2. Every official is subject to an impersonal order by which he guides his actions. In turn his instructions have authority only in so far as they conform to this generally understood body of rules: obedience is due to his office, and not to him/her as an individual.
3. Each official has a specified sphere of competence, with obligations authority, and powers to compel obedience strictly defined.
4. The supreme head of the organisation, and only h/she occupies his/her position by appropriation, by election, or by being designated as successor. Other offices are filled in principle by free selection, and candidates are selected on the basis of 'technical' qualifications. They are appointed not elected.
5. The system also serves a career ladder. Promotion may be by seniority or achievement.
6. The official is excluded from any ownership rights in the organisation, and is subject to discipline and control in the conduct of his office.

Exhibit 4. The Bureaucratic organisation

At the time of these studies it was held that the majority of firms were of the mechanistic type with some moving to a more organic structure. It also seemed that there was some room for movement from the strict requirements of the role in relatively closed systems. Ten years later a study of an innovative engineering organisation in the UK's engineering industry showed it to be in this category [16]. It seemed that it was not possible to completely define roles or to define precise communication links between roles. Role players had to step outside of their roles and communicate with others to get jobs done (exhibit 7 B). An informal organization existed in order to get things done. One of the group that undertook this study pointed out that in making decisions to act informally, individuals, whatever their position in the hierarchy were acting as managers; that is, they were exercising direction and control

A.
In a mechanistic organisation (Burns and Stalker)
1. There is specialised differentiation of functional tasks.
2. Each task is pursued with technique and purposes more or less distinct from those of the concern as a whole.
3. The reconciliation of these different performances is achieved by a supervisor.
4. There is hierarchical structure of control, authority and communication.
5. The location of knowledge is at the top.
6. There is minimum interaction between peers.

B.
Closed system (Barnes)
Characterised by a supervisor in charge of several sections each with its own head, engineers and technicians (1). The early assignment of individuals to a particular section limited their scope and sphere of potential influence.
Individuals were unable to communicate technically with individuals in other departments.
Potential for influence limited to persons with less knowledge than they had.
(2) Each individual was highly dependent on their section head for advice and interesting assignments.
Section leaders set, enforced, and policed section schedules.
(3) Engineers and technicians had little control over their schedules, interactions with clients (via section heads), or rewards for good work

Exhibit 5. Characteristics of mechanistic organisations and closed systems

A.
In an organic organisation (Burns and Stalker)

1. The contributive nature of specialised knowledge and experience to the common task of the concern is understood.
2. The 'realistic' nature of the individual tasks is seen as set by the total situation of the firm.
3. There is adjustment and continual redefinition of individual tasks through interaction with others.
4. There is a spread of commitment to the concern beyond and technical difficulty.
5. The network structure of control, authority and communication derive from presumed communities of interest and less from contractual relationships.
6. Omniscience is no longer imputed to the head of the firm.

B
Open System (Barnes)

Characterised by a single group of engineers in the charge of a supervisor and assistant supervisor, and supported by a group pf technicians.
1. New entrants given a variety of projects bringing them into contact with most of the engineers and technicians. Individuals develop their own experience and gain from the experience of others,
2. Individual engineers depend on the supervisor only for assignments. Other engineers could provide technical advice if required. High interest was sustained by the variety of projects. They were responsible for quality and had to deal with customers directly via the supervisor.
Schedules were 'policed' by an office engineer.
The engineers were "placed in a position where they could both help others and continue to develop their own competence and knowledge".
3. Work was arranged and scheduled so that individual engineers had some freedom to choose what it was they wanted to do at a particular time. Ownership of the projects was thereby encouraged.

Exhibit 6. The characteristics of 'organic' and 'open' systems

over others as their activities sought to meet the goals of the organization (exhibit 6 A) [117]. More generally, they were often responding to a contingent situation.

Movement toward (conforming with) existing value systems or in another direction in response to new value systems necessarily takes place in all social systems for each individual is a psycho-social system (exhibit 6 C). This means that those in positions of authority can change an organisations value system, as Barnes established. It does not mean that this is independent of the experience, skills, qualifications and values that individuals bring to the organization.

In sum, it seems that organizations through their management (leadership) may shape attitudes; for example, though a person may dislike contingent situations, they may be forced into the 'can do' attitude by such situations. Attitudes of civil servants and politicians certainly both helped and hindered the pursuit of the goals of VTF as they often did during World War 2 (Exhibit 3A). Edgerton, for example, has highlighted the importance of Director Generals and their importance in obtaining technological goals during the second-world war. The Director General for the VTF powerfully illustrated Edgerton's point. But key role players can also hinder important activities as Bingham shows (pp 271-2 and 279-83).

There is no easy solution to this problem. One idea suggested from the VTF Team's experience is to have people within the organization who can bridge the gap. Just such a person was employed by the Director General for the precise purpose of helping the team

prepare the business cases in the form required by the bureaucracy (exhibit 2, role 10) Such persons are able to converse in two languages and understand different ways of thinking.

A.
"[…] During the interviews in the main survey it became apparent that the major characteristics of performance were the ways in which individuals exercised direction and control. The difference between individuals lay not so much in skills used, but in the content of the decision making process and the ability to handle the content, complexity being a function of the interaction of the content and the individual's ability, personality (especially interpersonal relations aspects), interests and location in the organisation decision making process […]"

B
"An impressive feature of the interviews was the way in which, even at lower levels, individuals needed to widen the scope of their initial brief through skills of communication and liaison in order to take some action. It would appear from analysis of the fourteen engineering activities that communication is a complex skill the nature of which varies with the activities. During the interviews it seemed that persons were appointed to roles which they had to change in order to communicate. The organisation was rather more a system of persons in relations than a hierarchical structure. It is in such circumstances that feelings of responsibility are acquired […]"

C
"A person is a psycho-social system. Within the boundaries of that system. Most individuals wish to be 'organic' to use a term first suggested by Burns and Stalker (1961). They wish to be able to take actions and decisions as well as mature. The boundaries of these psycho-social systems arise as a function of the needs of the job and the needs of the person. When these are matched for each person in the organisation a hierarchic system becomes structured by individuals who are organic within their own system. The system itself becomes organic if it can respond to the needs of the individuals. Both systems have to be self-adjusting".

Exhibit 7. Slightly revised by Youngman, M, B., Oxtoby, R., Monk, J. D., and J. Heywood in *Analysing Jobs* (1978 pp 114-5). Gower Press from Heywood J. (1976) Engineers at work: an "illuminative evaluation". *The Vocational Aspect of Education*, 27(69), 26 -38.

Bingham thinks that mid-level civil servants should not be allowed to climb the civil service ladder without "*at least two years of productive industrial or commercial experience and public sector operational delivery experience*" (p 306). Unfortunately the experience of in-company training in manufacturing industry during the nine-teen sixties was that if management did not utilise the ideas that were brought back from these experiences, which was more often than not the case, there was a reversion to type and the enthusiasms gained, lost [18].

One lesson of the particular organizational studies discussed that is confirmed by the VTF experience is that in situations demanding contingency planning and/or action a diverse team is likely to be more successful, just as an open system is likely to be more effective than a closed system especially in enabling effective communication.

But 'local' cultures often derive from the prevailing social culture. The controversial literature on Britain's industrial decline to which *The Long Shot* clearly belongs describes a culture devoted to short termism which would account for the closure of the Registry and the change in ethos of the VTF [19].

5. Short termism

James Hamilton-Paterson, a novelist and writer of non-fiction, contributed *"What We Have Lost"* to the declinist literature which begins with a detailed description of these opposing theses [20]. He concluded that the truth contained elements of both

At the same time he argued that it still needed "*to be explained why we seem to be so hopeless at translating our native inventiveness into cash*" (p 38). He went on to write that "*Indeed we have always overvalued our inventions (radar, jet engines and all the rest of it) as though their discovery alone guaranteed a bumper crop on the money tree. But they never do"* [21]. He was led to the view that it was due to national character, a character that was resistant of change, and apprehensive of commitment. "*We are unquestionably conservative with a small 'c', disliking change for change's sake. Most human beings share this dislike, but some societies are better at overcoming it than we are. We are also deeply apprehensive of commitment, preferring to see ourselves as autonomous individuals with a horror of being tied down. Again, such individualism is vastly less apparent in Far Eastern societies where the idea of the common good takes precedence. Both these characteristics are precisely those that tend to hinder commerce, which generally entails a degree of risk taking*" (p 59) […] "*Business demands brisk decisions, firm commitment and now and then timely government backing, none of which has ever described the British system except in wartime*" (p 60).

In an article in *The Times* on the 16th January 2023 Nathan Benaich, appealing for more support for university spin-outs drew attention to a report of the House of Lords select committee on science and technology. It had written in 2022, '*that the government appears to lack an overarching plan for the strategic development of UK science and technology' Its report lays bare a morass of oversight bodies and strategic chopping and changing alongside repeated and often unfulfilled promises to change policy in areas such as government procurement and tax incentives for research spending*" [22].

This seems to be the experience recorded by Bingham and Hames which seems to be well illustrated by the changes made to the VTF. They doubtless would agree with Hamilton-Paterson's conclusion that the one feature that stands out is "*the want of any serious, thoroughgoing plan. No social plan; no economic plan; no industrial plan; no overall vision, no nothing. All is casual, all is amateurish, as though there will be a safe outcome between those who govern and the outcome of their policies*" (p 294).

The current demands in the media for an industrial strategy will in all probability lead to short term fixes [23]. No one takes any notice of what has gone before, and remarkably the same problem expressed in terms appropriate to the time appears every decade or so. Edgerton noted that "*an important feature of the technocratic literature is a lack of awareness of continuity in its arguments. There has been a 'disinvention of tradition'. As one historian writing in the early 1970's has noted*" [24]

"Statements made by shipbuilders and engineers over the second half of the nineteenth century give the modern reader a sense of dejà vu. They were continually aware of the poor quality of apprenticeship programmes and of the need to supplement with technical education. The Transactions of the professional societies contained frequent laments on the existing arrangement and suggestions for improvement, yet the comments have a curious static quality. For over fifty years each new generation found the same conditions, proposed

the same broad remedies and cited much the same reasons for failure, and each time their remarks were greeted as original and salutary" [25]

"*One reason why arguments appeared 'original and salutary' is that writers ignore their antecedents, except to argue that there were a few prescient characters who saw straws in the wind*" [26].

Disinvention or recycling as some call is certainly a feature of British life it may be a characteristic of history. True or false, a matter that is contested by historians we are repeatedly told that Britain's industrial capability is in decline or that there is shortage of qualified persons in the workforce. Similarly as Edgerton noted the arguments put forward for solution appear original and salutary, their antecedents unknown. For instance, it is currently argued that every student should study mathematics throughout their schooling but so it was in 1966.

One example of disinvention of great concern to this paper is that graduates are inadequately prepared for the world work (1979, 1988 – the present). In 1979 the Royal Society for Arts published an Education for Capability Manifesto and sponsored projects across the curriculum including engineering that would prepare students for life and work. Some excellent projects were designed and implemented to achieve the manifesto's goals (exhibit 8) [27]. Unfortunately it did not spread and did not become a feature of higher education. Similarly with the Enterprise in Higher Education Initiative (EHEI) although it left some legacies including the idea of core skills. Again the result of complaints by industry to government it invited universities to develop skills of enterprise learning among all the subjects of the curriculum. Its objectives were expressed in its Notes for Guidance (Exhibit 9) [28]. Its ideas about assessment were circulated to participating universities in 1991. Universities that agreed to participate were given £1,000 000 each for a period of five years, and that was that. The expected outcomes are shown in exhibit 10. It was not followed up and did not get built into the curriculum in spite of a number of excellent projects.

There is a strong case for arguing that if a university education achieves these goals irrespective of subject that a work force is produced that it is problem oriented and skilled enough to learn new subject matter quickly. That surely is what wanted of civil servants who have competent specialists to advise them in the quick pursuit of knowledge so that they are able to evaluate its significance, in the case of Covid 19 its immediacy. In such a curriculum learning is not something achieved by osmosis but something actively promoted, learning-how-to-learn being an active goal of higher education.

The capability movement end the Enterprise in Higher Education Initiative were predicated on the view that these skills and attitudes could be developed within subjects, and there is much evidence to support this approach but given Post Covid-19 society the question arises, especially for so called generalists, on what knowledge should that generalism be based?

6. Post Covid 19 and the curriculum

Of the many things that happened during Covid 19, its impact on the lives of people who caught it was profound. At the same time, largely hidden from view the complexities of

Criticism of higher education in the manifesto
It produces a "scholarly individual who has neither been educated or trained to exercise useful skills; who is able to understand not to act".

Higher education should be judged by the extent to which
(1) It gives students the confidence and ability to take responsibility for their own continuing personal development.
(2) Prepares students to be personally responsible within the circumstances of their lives and work.
(3) Promotes the pursuit of excellence in the development, acquisition and acquisition of and application of knowledge and skills.

Exhibit 8. Education for capability [27]

(a) Every person seeking a higher education should be able to develop competence and aptitude relevant to enterprise.

(b) These competencies and aptitudes should be acquired at least in part through project based work, designed to be undertaken in a real academic setting, and they should be jointly assessed by employers and the higher education institution.

The intention is that enterprise programmes offer more than simple, bolt on modules of business studies. There should be an attempt to integrate the new programmes with the education provision already offered to the students. The initiative is not a narrow vocational substitution for broad academic education and does not displace the need for high level expertise and professionalism in any number of specialisations.
Associated staff development is a critical feature of the initiative and it is expected that institutions will design training programmes for staff to deal with the needs generated by the programmes. As well as being qualified in a particular discipline, students who have attended a course which includes enterprise will have;
-a positive attitude to enterprise activity.
-have developed personal transferable skills
-be better informed about employment opportunities, aims and challenges and make better career choices
-be better prepared to contribute to and take responsibility in their professional and working lives.

Exhibit 9. From the Notes for Guidance on the Enterprise in Higher Education Initiative (UK Employment Department) [30].

There are four broad areas of learning that are important for equipping students for their working lives

Cognitive skills. Social Skills, Managing one's self: Learning How to learn

Examples of predominantly cognitive skills are handling information, evaluating evidence, thinking critically, solving problems, arguing rationally, thinking creatively.

Examples of predominantly social skills are working with others in varied roles, including as leader and as team members, and communicating with others.

Managing one's self includes initiatives, independence, risk taking, achieving willingness to change, adaptability, knowing one's self and values.

Learning to learn includes knowing how one learns in different contexts and being able to deploy a range of appropriate styles of learning.

Exhibit 10. The statement of suggested learning outcomes (objectives) in *Assessing Enterprise Learning.* REAL group. Employment Department, Sheffield, 1991.

living in an age of technology increased. There is a particular focus on the use of abuse in social media and how to prevent it through legislation. But, this seems to be one of many aspects of the social media that need to be controlled, so many people think. Each of us makes an ethical judgement in response to the problem. Medical doctors come face to face with the study of medical ethics during their training since they have to make life and death decisions. Engineers will have been told about their codes of practice. By and large, however, a curriculum that is focused on preparation for work gives little attention to ethics, which is not perhaps surprising in a world that Hamilton-Paterson thinks has little or no conception of a common good.

Yet among the younger generation there is some understanding of the common good in their efforts to cause us to change our behaviours so as to reduce the impact of climate change. But that conception is limited because it only focuses on one aspect of human behaviour. Underlying all human action is a set of values that help us to say yes or no to the actions that join us one to another interpersonal or through object design. Thus in the model of technology presented in exhibit 1 the basis of technological design, for that matter all design, is the value system of the designer(s). Developing a value system (call it philosophy, theology, ethics- what you will) is part of human development, and therefore, part of human learning [29], and should therefore, be part of any curriculum. It is problematic. As such, it is inexcusable to argue that universities enable that development takes place in the informal settings of its corridors, and that is has no place in formal learning, however it is done. Development is something takes place over time for which traditional curricular are not well suited. It is to be distinguished from development in a subject, as for example, from novice to practitioner although it may be related.

Particularly, the teaching of design, be it creative or engineering, or human activity more generally, inevitably begins with value propositions, or it should.

Participation in a team design project may provide a participant with an understanding of a social environment on which the skill of cognate transfer can be developed by analysis of other social situations, as for example in a restaurant or in the civil service, in order to develop a generalised view of behaviour in organisations, and reflect on one's own behaviour. Design is a social process: "*while they (the team) all share a common goal at some level, at another level their interests will conflict. As a result, negotiation and 'trade-offs' are required to bring their efforts into coherence*" [, p 9)]. Much else is learnt about interpersonal relationships, such as whom and who not to trust, who to allow to manage etc. Cognate transfer is aided by some formal; understanding of what to look for, how people learn, and self-assessment [30].

Current responses, among all age groups, seem to involve a changing value system that is moving away from the idea that life is primarily about work and that the intention of education is to prepare us for work toward something that is more personal. Moreover, they believe they should have some command over their work life balance. Technology has facilitated such attitudes.

At the same time the idea that education is for work is being challenged by numbers of students who study for degrees that politicians regard as useless and worthless. It is worth remembering that the current demand for students with STEM and vocational qualifications that the creative arts are a huge earner of GDP.

While the technology of social media has and is creating many social problems, technology *per se* is impacting on the structure of work. For example, the change from petrol (gas)/diesel engine automobiles to electric automobiles will, because of the smaller number and types of parts required, change the structure of the workforce, not merely at the production level but in design and development [31]. Designers will have to cope with psycho-dynamics. For example, the design of AI substitute aircraft co-pilots has to respond to the impact it will have on the psychodynamics of the pilot. Such changes are likely to take place at all levels, in a variety of organisations, and more people are likely to seek jobs beyond the skills and knowledge currently possessed. They will have to exercise non-cognate (also called cross-domain) skills that are directed to learning new expertise [32]. The provision of environments that can facilitate such learning is one of the reasons that higher education is viewed by some educationalists as lifelong provided for by a form of insurance [33]. They envisage some restructuring of the period of full-time higher education.

A technologically literate person will therefore have had an introduction to all the areas of knowledge that make up the socio-technical system that is technology as in exhibit 1. As denied in the introduction technological literacy is a skill that enables a learner to bring together different components of knowledge and skill in the solution of technological and scientific problems. It is therefore a high order skill to know what new knowledge will be required and obtain it. In such contexts the engineering method will be as important as the scientific method. [34]

7. Conclusion

Complaints about the civil service, shortages of STEM graduates, criticisms of arts graduates and economists who have no experience of work are not new. They regularly raise their head in some form or another; suggestions for solving the problem are made and actions are taken and forgotten. They are not remembered when the same or similar complaints re-surface. Each time there is a confusion in the vocabulary which, according to Edgerton, often fails to distinguish between science and technology in general and innovation [35]. Engineering is squeezed out of the discussion and in the UK there is no discussion of its distinctive method or the fact that design is its essence.

The fault lies in satisfaction with what has developed as a university curriculum which assumes that its purpose is the conveyance of knowledge, all that is available being squeezed into the shortest time possible, and the hope that assessment will reveal critical thinking even though no provision has been made for learning environments that might better achieve the limited goals that are set. That there is much to be learnt about learning and behaviour in organizations is ignored and left to osmosis.

It is argued here that the debate about the nature of technological literacy in the past few years in TELPhE leads to the view that it is a programme, not a subject which provides the skill and knowledge that will enable individuals to cope with life, and continually learn whether it be at home or in the workplace. Such a programme will have to cope with the inter-disciplinarity that complex problems require for their solutions, it will have at the same time to prepare students for contingency based learning. Such a programme is likely to be multi-problem based from a wide variety situations in order that students are able to exercise transfer across a range of disciplines and acquire the knowledge essential to the problem. In

the special case of the civil service, that is what it needs. The principles of the design of such programmes have been suggested elsewhere [36]

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Colloquialisms

"No 10" (Downing St). The Prime Ministers official residence, incorporating the Cabinet Office.

"Whitehall" – Whitehall is the main road that links Trafalgar square to Westminster and the Houses of Parliament. Many buildings on the right hand side in that direction house department of government (i.e the civil service). This translates into the usage of Whitehall to describe the Mandarins who run the civil service.

"Westminster" – used to describe parliament and parliamentarians. Sometimes referred to as the Westminster village.

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Appendix

An 'A' Level student's question

During an after-school video talk that Bingham gave toward the end of her tenure in November 2020, she was asked by a sixth-former, "*What has been the most challenging obstacle you had to overcome during your time to find a vaccine*?" (p 258). Whatever her answer was it is clear from the opening sentence of the chapter in which it was reported (Ch 14) that dealing with government communication teams was "*the hardest part of the job*" (p 258).

"*I really struggled with the political side. There seemed to be an obsessive desire for political messaging and political angles, which massively got in the way of what we were actually trying to do: tell a simple story that would inform people, calm fears, enlist the support of business and attract volunteers*" (p258) for the vaccination trials.

There were apparently 7 different communication teams focused on vaccines but apparently no coherent strategy. Given that VTF was the only organisation to have the up to date facts it is surprising to find that in so far as Bingham knows none of the teams apart from one tasked with supporting them ever contacted her, leaving open the question as to where they got their information from.

Approvals had to be obtained from both BEIS and No 10. Because of the speed of modern communications opportunities were lost.

Part of the VTF communications strategy was to keep academic and industry experts and life science entrepreneurs informed so that when she was asked to present an opinion piece in *Nature* and to join a Q & A round table in *Nature BioTech* she accepted. The latter's purpose was to provide an authoritative view "*of the critical issues facing governments and NGO's seeking to vaccinate a substantial proportion of the world's population*" (p268). That of the former was to show how "*we could operate more quickly next time if we could remove more quickly next time if we could remove some of the key bottlenecks in vaccine manufacture and development"* (p268). In what was a fast moving scene *Nature* was a most appropriate vehicle for the communication of such material, so it is surprising to read that the article was held up for weeks by the No 10 press team who thought that it ought to contain something that was more positive.

There was, it seemed, no one in either of the BEIS or No 10 press teams who understood what the role of *Nature* was in the scientific community or who could distinguish a political item from an opinion piece for what some regard as the most important scientific journal.

A similar response was given to a proposed article in the *Lancet* with the title *"The UK Government's Task Force: strategy for protecting the UK and World*". It was held up or weeks. We are not told why; but, after it was published the Cabinet Office was delighted when it found that in the twenty-four hours after publication 384 articles in 38 countries had referred to it (p 270-1).

One of the most important proposals of the VTF was to establish a National Health |Service Vaccines Registry which would recruit hundreds of thousands of persons willing to participate in vaccine trials. Since it would require a public campaign on a massive scale of which Kate Bingham had no experience, she found through consultation that the National Institute of Health Research (NIHR) had hired Admiral Associates to provide specialist communications. She considered that they understood clinical trials and were trusted by NIHR. Her Director General agreed and set in motion the civil service legal, procurement and contracting processes.

Clearly the registry was of considerable importance and required the support of the Governments Advisors so she was surprised to find that the Chief Medical Officer for England would not give "*a quote to endorse the NHS Registry*" (p264). Upon investigation it was found that civil servant(s) considered that clinical trials was not of sufficient importance to inform the Chief Medical Officer. He, upon learning what had happened, warmly endorsed the press release (p264).

This raises the question of what knowledge and understanding did the official(s) have of the significance of the Registry that enabled them to judge that it was irrelevant to the work of the Chief Medical Officer. This brings us to the essence of Bingham's complaint that there are too few persons within Whitehall that had the knowledge necessary to pursue the vaccination programme with speed.