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Technological literacy: Subject or Pedagogy. Implications for liberal education

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Introduction

At the 2010 meeting of the Technological Literacy Division Heywood argued that "a person who has no perception of the contribution that engineering can make to our understandings of behaviour and society is not liberally educated. At some stage (high school/university) they should experience the study of engineering literacy" [1]. In the 12 years that have followed much has happened in the world of engineering, and while it is possible to stand over the thesis that was then offered, much has changed, and what members of the public conceive to be technological literacy is somewhat different to what some of us thought it to be, even in that short period. Whereas Heywood could be fairly accused of using the terms technological and literacy and engineering literacy interchangeably, Krupczak and other members of the division made a sharp distinction between engineering and its technological products [2]. Thus, engineering was related to the process, and technology to the product. In both cases there is a more or less hidden attempt to distance the definitions from information technology. Unfortunately, the association of technology with information technology and the internet has become deeply embedded in the public mind, and particularly in the way that is related to the positive and negative impacts that it can have on individual behaviour. It is not about the technology of the technology.

It is argued here, that the Division has failed to keep up with these changes, and that for many of its members its purpose is about teaching engineering and technology to non-engineers and technologists, and not about the role of engineers and technologists in pursuit of a common good. Evidence supporting this view, is the oft reported difficulty that engineering educators have in finding time for the development of soft skills in the curriculum, which is seen primarily as engineering science divided for convenience into a number of appropriate divisions based on a high level of competence in mathematics. The principle objection to the inclusion of soft skills and knowledge in the curriculum is that the curriculum becomes overloaded.

At least two interrelated reasons may be advanced for this dilemma. The first, is the view that many academics including engineering educators have about the nature of knowledge and learning. The second, is the view of what academics consider engineering to be.

Engineering: a received curriculum and scientific discipline

In the United Kingdom John Eggleston [3] defined a "received curriculum" as one in which there is a fixed body of knowledge to be received which is non-negotiable, non-dialectic, and co-sensual. In the days when chalk boards were in use students would describe the method of teaching that this view of curriculum caused as "chalk and talk".

Something akin to the received curriculum was described by Michael Schiro [4] in the United States which he called the "Scholar-Academic Ideology". These models can be traced back to ancient Greece, which crudely interpreted, considered the mind to be *a tabula rasa* on which everything is written. Schiro sums it up thus "The mind […] is viewed as consisting of two facilities one is for storage and the other for performing mental operations on that which is stored. The former is often called 'memory' and the latter 'reason'. The former is capable of being filled, and the latter is capable of being shaped to conform to an academic discipline's ways of thinking" (p45).

In today's academic climate that is thought to be best achieved by the lecture method in which power points substitute for chalk-and-talk. It is sometimes called "teacher-centred" education and is accompanied by the assumption that if a person reasons on what they are told it will lead to appropriate behaviour, as for example, with sex education in schools.

The scholar-academic ideology is rooted in the disciplines and education is the initiation of a student into a (the) discipline(s). This ideology is widely supported by academics and prevails among politicians both of whom wilfully ignore research to the contrary, particularly in the area of learning, notwithstanding the debate about what it is that constitutes a discipline. It is in this context that the contentious attempt to define engineering education research as a discipline [5] needs to be viewed. It seems to be thought that researchers will gain both identity and respect if it is considered to be a discipline. From the perspective of the teacher of engineering it reinforces the view that engineering is applied science, and thus, a discipline that belongs with the other sciences, especially mathematics and physics.

Is technological literacy a discipline?

Many of the papers presented over the years seem to assume that technological literacy is a discipline in that it tries to make sense for the 'ordinary' person of some of the conceptual frameworks used in the teaching of engineering to persons wanting to become engineers. Recently, however, it has been argued that because solutions to the variety of personal and societal problems posed by technology require transdisciplinary knowledge, technological literacy is not a discipline *per se*, that is, a specific subject of the curriculum. But, if a distinction is made between a subject (defined as an area of knowledge) and a discipline, then there is evidence from the 1960s attempts to introduce information based soft skills and knowledge into the engineering curriculum which seem to have been successful [6]. Case studies show that some of this knowledge is of value in solving some of the problems that the technologically literate person may face. Unfortunately recent discussions in TELPhE [7] suggest that the division is by no means clear about what it is that a technologically literate person should be able to do. This is quite a different question to - what do we expect a technologically literate person to know?

What this "know-how" might be has been demonstrated in case studies which have shown how solutions to problems that affect the public, either personally or as taxpayers, often depend on the utilisation of knowledge from a variety of disciplines. In this case it may be argued that technological literacy is not a discipline, but a mechanism or technique that enables a a problem solver to better define the problem and draw on the knowledges and techniques required for solving that socio-technical problem. It is transdisciplinary in this sense, in that it searches the unity of knowledge for the components it requires to solve the problem. It is a skill required for working in contingent situations of varying complexity, and differing knowledge requirements. Its purpose is not knowledge acquisition but knowledge in action, for "action is the determination of the future" [8, p182]. As such a technologically literate person is a doer not a thinker for decision making is action irrespective of whether or not the decision is to do nothing. Moreover, the situations with which it has to deal are contingent in one category or another.

In sum the task of technological literacy is two-fold. On the one hand, it is to provide opportunities for the exploration of the unity of knowledge, and on the other hand, skill in the utilisation of components of that knowledge in action. To borrow from Samuel Goldman's philosophy of engineering it is concerned with "wilfulness, particularity, probability, concreteness and practice" [9]. It requires a different way of thinking to that which is intended by the scholar-academic ideology. It is learner centred, and it depends as much on a pedagogy of the contingent, as it does on a pedagogy of necessity, as well as a capacity for independent learning the tools of which are over-arching and key concepts [10]. It is aligned with the everyday and the messiness that surrounds it, particularly in respect of career expectations and prospects, and for which it has a particular mission. Put in another way it enables a person "to use, manage, evaluate, and understand technology in one's day-to-day activities or one's life" [11]. It is necessarily problem-based.

The future of work, technological literacy and liberal education

A major pressure on higher education arises from the structure of work, this impacts on how a curriculum in technological literacy might be developed. There are counter scenarios about changes in the workforce. The first, assumes that developments will continue as they do now; that is, as many people that are put out of work by technology will be replaced by technology. It is in contrast with that view of the future which argues that very large numbers of people will be put out of work, and jobs will not be replaced. We should, therefore, plan for a life of leisure [12]. Whichever view is taken there is a third perspective which is, that most of us will experience redundancy, and not be able to obtain cognate work. It follows that if non-cognate work is available, how do individuals prepare themselves to compete in a new market? It is in this sense, that technological literacy as defined here, may be the key to the conundrum.

One way of expressing the goal of technological literacy is to say that it is preparing an individual to deal with contingent situations. By their nature these situations are likely to require mixes of cognate and non-cognate thinking. One of these situations is redundancy where the only alternative occupations available are non-cognate. While it is relatively easy to adapt to new or developing dimensions of a cognate area, an activity sometimes called the "transfer" of learning, it is much more difficult to make transfer in a non-cognate situation. A strong argument for programmes of liberal education is that they condition individuals, not merely to different knowledges and different ways of looking at individuals and the universe but with different ways of thinking. It is accommodating these different ways of thinking that is the primary difficulty in making non-cognate transfer. Technological literacy is a pedagogy of the contingent and necessarily, therefore, of the cognate to the non-cognate. As such, even if the argument is rejected it is a necessary component of liberal education, it requires liberal education as a constituent which it supplies to some extent.

Practically this justifies a broad education since it exposes (or should expose) an individual to several modes of thinking in which the learner is an explorer. Heywood [13] has discussed how Albert North Whitehead [14] captured this idea in his understanding of mental growth that derived from the view that "life is essentially periodic" (p 27), and related it specifically to engineering and technological literacy. Whitehead argued that educator's pay too little attention to the rhythm and character of mental growth. "It is a main source of the wooden

futility of education". He thought that Hegel's view that there were three stages in progress, and he applied them to education, but with different names and explanation.

Whitehead's stages of rhythm in learning

The three stages are romance, precision and generalisation. It is very easy to observe in young children who when learning independently are oblivious of systematic procedure. "The subject-matter has vividness of novelty; it holds within it unexplored connexions with possibilities half-disclosed by glimpses and half-concealed by the wealth of material" (p 28).

The second stage is that of precision. "It is the stage of exactness of formulation. It is the stage of grammar" (p 29. It is a "way of analysing facts, bit by bit", and adding facts to them as they fit the analysis. Education tends to be occupied with precision and not to recognise the rhythm in learning. The final stage is that of generalisation; that is, "romanticism with added advantage of classified ideas and relevant technique" (p 30). In current systems of higher education this may be brought about by a substantial project or dissertation or their equivalent.

In contrast with primary education where romance is just that, romance; with age the learner will be skilled enough to take the exploration into precision, and perhaps some generalisation. But, the purpose remains the same, the understanding of different ways of thinking, and the recognition of the contribution they have to make to solving problems created by technology in our lives. More generally, it is clear that in the future individuals will be required to become independent learners, and that the provision of lifelong-long-learning will have to be in response to the learner's perception of those needs. Given that higher education may be regarded as a preparation for life-long-learning, and given a congruency with technological literacy a framework for the curriculum begins to emerge.

Toward a framework for the curriculum

Given that technological literacy is a pedagogy for learning in contingent situations that enable a person to use, manage, evaluate, and understand technology in one's day-to-to day activities, its primary outcomes are the ability to define and solve problems, and all that that entails, in particular the ability to learn on one's own. Therefore, the central focus of the course should be on a wide range of problem-based and project-based and other appropriate non-contiguous activities designed to place the learner in a variety of contingent situations that range from the immediate to the executive [15]. Such activities might be designed by focusing them on key concepts relevant to the goal such as Risk, Uncertainty, Evidence, Control, Perception, Design etc.

Design in this context arises from Perkin's [16] view of knowledge as design. He argued that structures such as governments, theorems, experiments and short stories are designs thus broadening the whole concept of what we perceive to be design. It is a way of thinking and theory of knowledge that everyone, including young children, can comprehend. More specifically, in relation to technological literacy, there are problems related to engineering design and its role in profit taking. For example the location of batteries in smart phones that make them difficult to change and force users to purchase a new instrument every two years or so. As such technological literacy as defined here, embraces engineering literacy.

While it is easy to demonstrate that design for profit of this kind can be harmful of the environment, and it is often done, the difficulties that this creates for the economy are seldom discussed. If artefacts are made to last twice as long, fewer of them will be required, profits may be reduced, and fewer people will be required to produce them. Arguments about what should be done are the essence of moral philosophy, and create situations in which learners are required to reflect on their values.

Clearly, the practice of IT is something that has to be pursued throughout the programme and will continued to be pursued subsequently. That is the way it is. Similarly, there is a basis for a design and make approach to engineering literacy that takes into account skills not normally associated with higher education both to be conducted in the presence of the development of an active personal philosophy

Since the course is about independent learning (decision making), it follows that it should begin with a comprehensive and practical induction to learning. Given that most of the problems a person is likely to have to solve will require knowledge from many areas of knowledge, exposure to where a learner might also turn for information, can be accommodated through a stage of romance in which the learner can explore the "basics" of a range of areas of knowledge. Such studies should be designed so that learners also understand that there are other ways of thinking that will have to be accommodated in the solution of problems, thus preparing the way for development in a non-cognate area.

The learner should choose from a non-cognate area from which they can design, implement and evaluate an independent programme of in-depth study.

There will be no one way of achieving the general aims of such programmes, neither will there be one ideology that supports them..

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He argues that currently we view work as an exercise in need-fulfilment. Work he suggests is the new opium, and we tend to believe this of everyone even the person who empties our wheely bins. But, as Goldthorpe found long ago we are willing to put up with awful work in order to achieve other objectives, some of which were about finding leisure. Clearly, there are important philosophic discussions about the meaning of work and leisure that, as Susskind points out, need to be had. They are central to a liberal education, and if technological literacy is a component of liberal education, then such discussions are very much the matter of technological literacy. As such, the idea of technological literacy as a framework for a programme of liberal education is far from nonsense, but at sight it would seem to be a formidable task.

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