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Technological Literacy, Engineering Literacy, Engineers, Public Officials and the Public

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Abstract

In 2017 The Technological and Engineering Literacy and Philosophy Division of the American Society for Engineering Education initiated a debate on "for whom" and "what" are studies in technological and engineering literacy for. This study presents a case for technological and engineering literacy for all. This is achieved by analysis of currently available documentation and in particular to the ASH report and BBC "Newsnight" documentaries on the on-going case of the Grenfell Fire tragedy of the 14th June 2017. On the data currently available this study reveals an apparent lack of engineering expertise in the planning, implementation and approval of the substantial refurbishment of the building.

While the study demonstrates the validity of Krupczak *et als* distinction between technological and engineering literacy, it also suggests that the attention given to science and technology to the exclusion of engineering by the media may prevent the public from asking key questions about the role of engineering in such developments. It is argued that a major purpose of a curriculum in engineering and technological literacy is to better enable the public to ask and better understand the answers to questions that such disasters cause.

Following Bucciarelli it is noted that the different *elites* involved understanding the engineering and social problems from different perspectives or object worlds that are governed by the different *language*s they use. In this case fire safety engineers are one of those *elites*. It is argued that the public as defined by the residents of the tower and associated housing including tower blocks in the vicinity are an *elite*. They provide the justification for teaching engineering literacy let alone technological literacy. The challenge for engineering literacy is to develop a "bridging" language so as they may better communicate with the other *elites* including those representing the law.

Following a brief introduction, the Grenfell Tower Block is described, the overall purposes of its refurbishment outlined, and the management organisation described. The purposes, and function of the ASH report are outlined. The primary and secondary causes of the fire as currently understood are summarised. The implications for professional engineering are considered and questions the public should seek answers to are listed. From the perspectives of technological literacy two issues are considered, namely fake news, and the role of prejudice in public perceptions of what happened.

It is concluded that a radically different approach to the design of the curriculum will be required if the public are to become engaged in engineering and technological literacy.

Introduction

In 2017 the TELPHE division of ASEE published the fourth edition in its series of handbooks in which the authors responded to a paper by Heywood in which he discussed the problems facing those who would establish a community of scholarship in technological and engineering literacy [1]. This commentary may be regarded as a continuation of that

discussion. Its specific purpose is to consider the need or otherwise of the general public for an understanding of technological and engineering literacy. It is assumed that public discussion is better fostered if they are able to think critically about the important issues that face the public which by default the public generally passes over. Our approach is to illustrate these tenets by means of a case study. We will not labour the advantages and disadvantages of case studies which have a long history of use in the liberal education of engineers. Perhaps the best known are case studies related to the Challenger disaster.

The event we have chosen is that of the Grenfell Tower fire that took place in London on Tuesday 14th June 2017 with the loss of 72 lives, and the cause of at least 70 injuries.

The Grenfell Tower Block

A tower block is a marvel of modern engineering solutions and which exhibits increasingly more innovative technologies and utilities. Conceptually, it remains a simple multi-storey residential building with repeating configurations on each storey with simple shared access and egress provisions. Grenfell Tower is a high rise apartment block that has 24 concrete floors. It was built in 1974 and is nearly 70 metres high. The floors were accessed by two lifts (elevators) in the centre of the block. There is a single escape (and access) staircase alongside the lifts accessed off the lift lobby. Vertical risers provided the services. The structure included projecting concrete columns on the perimeter of the exterior of the building. Each floor had four two bedroom and two 1 bedroom flats, making a total of 200 bedrooms. Communal facilities included a nursery on the first floor (or mezzanine level) and the Dale Youth Amateur Boxing Club, which moved into the ground floor of Grenfell Tower in 2000.

The refurbishment of Grenfell Tower

As part of its refurbishment in 2016, both nursery and boxing club were relocated respectively to the ground and third floor (or walkway level), and an additional six 4-bedroom and one 3 bedroom flats added ion the first and fourth floors. This brought the total number of flats in Grenfell Tower up to 127, and the number of bedrooms to 227. The original 1970s building was built without cladding and was upgraded for heat insulation in 2016 with a rain cladding system added to the exterior, and the new windows located outside the plane of the original concrete wall panels. The over-cladding created vertical voids over the projecting structural columns. There was no sprinkler system for firefighting, the stairwell was not pressurized and the strategic advice to occupants was based on a Stay-In-Place advisory, due to the non-combustible construction and the presumption of adequate fire brigade intervention.

In normal circumstances, it would be expected that a fire could be contained within the flat enclosure and that it would not spread to the stairwell enclosure at all. The building was built with that purpose in mind. The fire in Grenfell catastrophically spread to the stairwell and the public enquiry must ask the questions as to the causes, what was missing and the circumstances which lead to that spread, despite the refurbishment works.

The architect of the Tower said of its original construction that it could have lasted 100 years.

The ownership and management of the Tower.

The Tower was built as social housing by the Royal Borough of Kensington and Chelsea. It is the richest borough in London but has extremes of wealth and poverty within its boundaries. Greater London is divided into electoral areas called boroughs. Each has its own

elected council which is responsible for building control and housing. In 1996, the Borough placed its housing stock in a separate organisation called the Kensington and Chelsea Tenant Management Organisation (KCTMO). It managed approximately 6,900 tenancies and 2,500 leasehold properties bringing it an income of £44 million in rent and £10 million in service charges. Profits arising from its activities are not taxable. The housing stock was owned by the Council, and of significance to this study it was exempt from the Freedom of Information Act.

The management company for the tower would not appear to have had any role in reviewing standards of safety compliance for the building. The public enquiry should ask as to whether there should be an obligation for the management company to source a standard review of the building under its care be it annually or bi-annually or every five years.

The ASH (Architects for Social Housing) Report

Given the considerable literature on the event in the media we assume that case studies are already being developed. In the absence of an engineer's report this study is based on "The Truth about Grenfell Tower. A Report by Architects for Social Housing", and the information in the above paragraphs is taken from that report [2].

Architects for Social Housing (ASH) was established "to respond architecturally to London's housing crisis. We are a collective of architects, urban designers, engineers, planners, building industry consultants, academics, theatre directors, photographers, writers and housing activists".

"ASH offers support, advice and expertise to residents who feel their interests are not being represented by landlords, housing associations or local councils during the redevelopment process". As a result of the fire ASH held an open meeting in the Residents Centre of Cotton Gardens Estate in Lambeth which is located on the opposite side of the River Thames to where the Grenfell fire took place. In judging their report it is important to note their objective. "We wanted to use this meeting, therefore, to counter the misperceptions and misinformation being propagated in the media, not only about the Grenfell Tower fire but about the council estate it belongs to, and to begin to organise opposition to the use of the disaster and the lives it has claimed to further promote the already widespread programme of estate regeneration that threatens the homes of hundreds of thousands of Londoners".

It should be noted that there is a socio-political dimension to their report which necessarily leads to questions about the report's validity. ASH says that it has tried to be as objective as possible in compiling its report. They dedicated their work to the community directly affected by the fire "in the hope that it will aid them in their struggle for some form of justice". This is also one of the purposes of case studies in engineering and technological literacy for the general public and the political community.

The design of the refurbishment

For the purposes of this paper the salient upgrading work included the provision of a rain screen cladding system. The cladding consisted of the fixing of 150mm of thermal insulation (Polyisocyanuranate:PIR) [Colotex RS5000] to the face of the original concrete exterior wall panels which was overcladded by an Aluminium Composite Material (ACM) rainscreen. It used an aluminium framed fixing system suspending aluminium sheeted cassette panels which were suspended 50mm from the outer face of the insulation. These 7mm thick cassette panels

consisted of a 6 mm core laminated on either face with 0.5mm aluminium sheeting. The core of the screen as fitted used Reynbond PE (polyethylene).

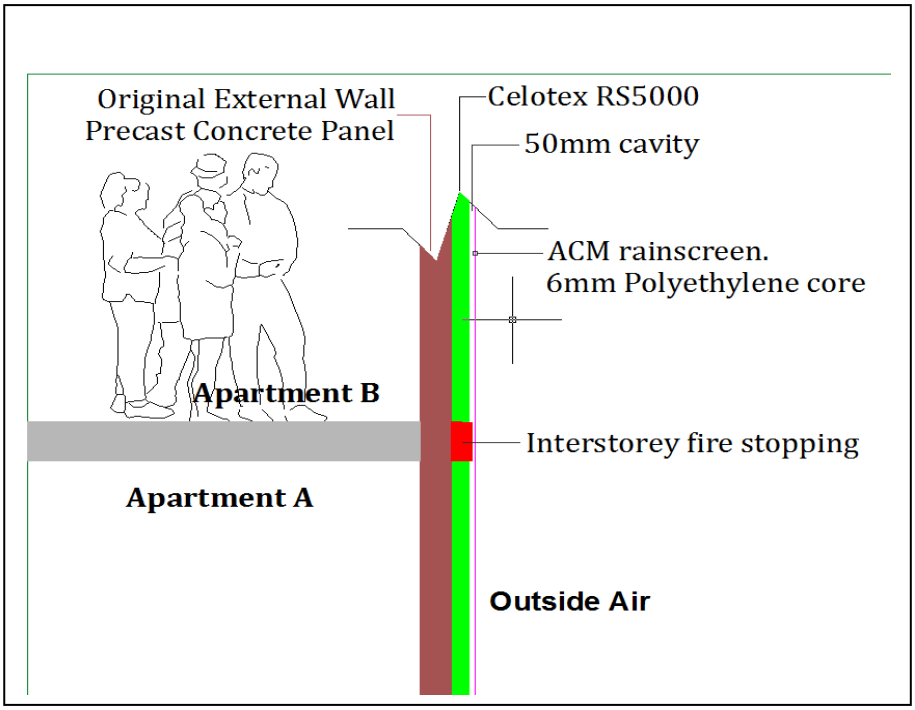

Figure 1. Build-up of external wall during 2016 refurbishment.

From a singularly scientific perspective the 2016 works to Grenfell Tower were excellent. The tower had been a pre-ecological building and was upgraded to meet energy efficient standards, using materials scientifically tested and approved to various standards - albeit now appearing to be inadequate from an engineering perspective. The span of science involved was broad in terms of the performance of materials, the location of windows, the ventilation related to the cladding, and the suspension systems of the cladding materials. However, it would seem that there was an insufficiently broad engineering evaluation of the building as a system. This raises the question "What engineering knowledge do the evaluators, including now the public, need to make critical judgements about what is reported?" The problem of how people gain this knowledge is, as yet, unresolved.

An engineering literate public would likely ask the question, "Was a professional engineer with fire safety expertise involved in the refurbishment of the tower block?

The fire at Grenfell Tower

(i) Primary cause

The fire originated in a fourth floor storey flat, understood now to have originated in an electrical compliance., The fire spread externally to the facade and travelled upwards to the top storey externally. The fire continued to spread laterally until nearly all of the exterior had burned by the time the fire was brought under control.

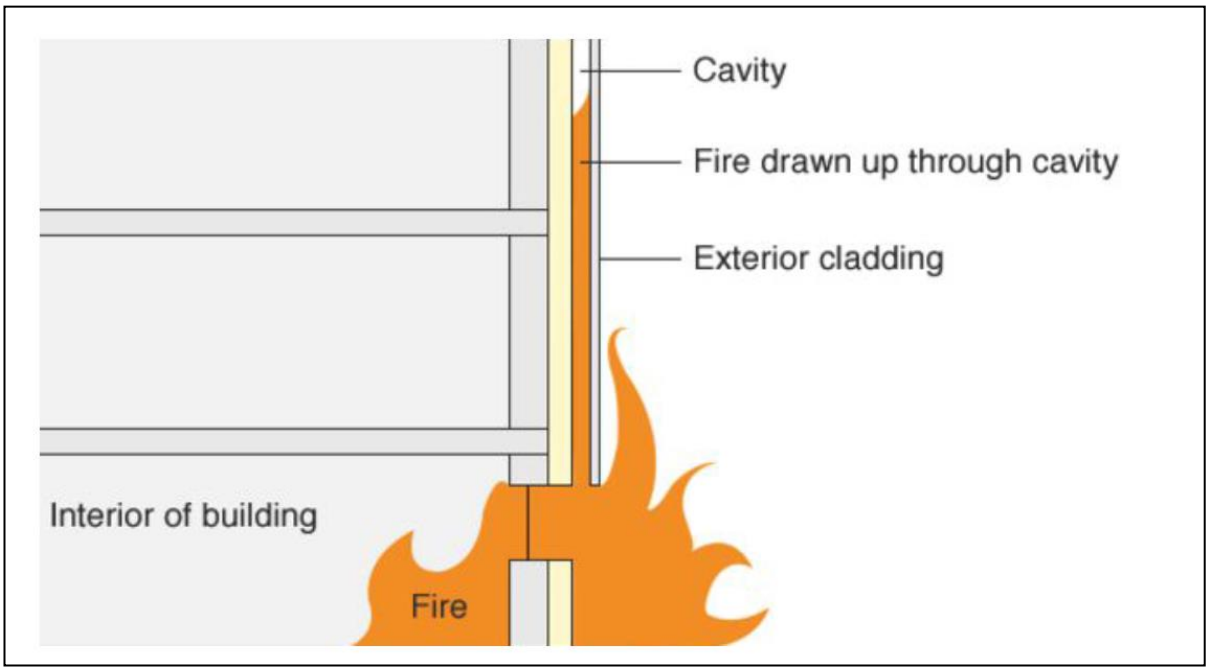

Figure 2 Exterior fire spread at Grenfell Tower.

Diagram taken from Page 7 of the ASH report.

(ii) Secondary (contributory) causes

The fire spread unchecked externally. The nature of the insulation appears to have contributed to the spread and the nature of the rainscreen core also appears to have contributed to the fire spread. The 50mm air gap does not appear to have been fire stopped at the location of the protruding pillars (columns) and a chimney effect manifested with rapid vertical spread from the fourth floor to the 23rd storey within 15 minutes of the fire being notified [i.e. approximately from 10m to 62m].

The current State actors have responded to the incident by launching inquiries into the regulatory framework, the technical guidance and the testing of materials for fire safety. The inquiries do not appear to have reviewed the role of professional advisors in the design team but it may arise as an indirect consequence of the questions asked regardless. The investigations are populated by various stakeholders in the construction industry and their various reports will emerge over time.

The report issued by ASH in July 2017 appears to hold up in terms of its veracity concerning the construction and evaluation of the incident. The findings in the ASH report are consistent with subsequent findings reported in the preliminary findings of the State-appointed Expert Group, various media, and in particular, the investigations of the British Broadcasting

Corporation's (BBC) "Newsnight" programme. This suggests that the technological analysis undertaken by ASH has criterion validity.

Implications for professional engineering

The incident occurred in 2017 and despite numerous details being publicly released it still remains to be shown that there was any professional fire safety engineering input into the fire safety design for the construction of the alterations or even to the scope of the package of works carried out prior to 2017. The system in the U.K involves professionals with varying architectural and building surveying knowledge but does not require a fire safety engineer to bring their professional engineering literacy to bear on the interpretation of the regulations in respect of the design and construction process. This is in contrast to Ireland, another European jurisdiction, where the refurbishment works to Grenfell would have had to obtain a fire safety certificate (a form of approval for design of fire safety for the building) in advance of the works. The certificate is only issued after a rigorous analysis by a publicly employed professional engineering official who is literate in fire safety engineering.

The absence of there being a fire safety engineer involved in the process raises the following questions which could inform the "public" in any of the enquiries currently being conducted.

(1) Where and who was the fire safety engineer in the design of the alterations?
(2) Where and who was the fire safety engineer on the execution of the alterations?
(3) Was the role of fire safety engineering recognised in the 2016 alterations package?
(4) Are the public or even the public representatives literate enough in engineering terms to ask the critical leading questions, to separate the chaff from the wheat?
(5) If a professional engineer with fire safety expertise was party to the design and construction team would their responsibilities to keeping to a Code of Ethics for Engineers {e.g. the Institution of Civil Engineers [3], or the Institution of Fire Engineers [4]) have made a difference to the nature of the specification of the materials used? Both codes would have required their member to show due regard for the safety of life and health of the public, and for any employee who may be affected by the work for which he/she is responsible. Such a member would not permit the use of a material of a lower specification than that required by the design regulations for a tall building.
(6) Would the involvement of an Engineer as Designer have ensured that the fire safety specification for the materials, and the details of fire stopping been clearer and more exacting for all of the contractors involved?
(7) Would the involvement of an Engineer as Regulator have ensured that the fire safety performance of the materials and the execution of the fire safety aspects of the 2016 works would have been clearer and more exacting for all of the contractors involved?

"Fake News". At the borders of technological literacy

The previous sections belong to engineering literacy but the study of Grenfell Tower also requires an understanding of technological literacy which in this case requires multi-dimensional knowledge. The first, embraces engineering literacy and what might loosely be

called social psychology. The second is historical and sociological. The first is derived from the media. The second is derived from the ASH report.

(1) "The baby that never was" [5]

On the morning after the fire several of the national newspapers reported that a baby had been thrown from the ninth or tenth floor and caught by someone on the ground. The information came from a named, on the record video interview with a woman, Ms. Samira Lamrani, who told the Press Association that she saw a woman throw a baby from the ninth or tenth floor and a man catch it. The woman subsequently told "Newsnight": "My memory of that night is fading… I don't want to talk about it". The story first appeared at 1.08pm on June 14, just hours after the terrible inferno began and while fire fighters were still battling the blaze. It appeared on the Twitter feed of a Ryan Hooper, a reporter for the Press Association, who posted a video interview with a woman who claimed to have seen the event. "Neighbour Samira Lamrani describes the moment a woman dropped her baby from a window in the burning tower to waiting public below," Mr Hooper tweeted.

Broadcaster and architect George Clarke also told BBC "Newsnight" on the day of the fire (June 14th 2017) that he saw a woman catch a "kid" thrown from the eighth floor. Subsequently, he also did not want to comment on the matter which he said was "so hurtful to so many people".

Indeed, almost all of the people that "Newsnight" was able to track down who had been reported as having seen the baby thrown from the building would not go on camera and repeat their previous claims; some said that they had been misquoted, and some who had been named in reports appeared not to have even existed in the first place. The closest that they came to uncovering the truth came from a local resident who had a novel theory about how the story came to be.

Jody Martin was on the scene as the first fire crews arrived at 1am. "There was an African-Caribbean lady with her baby and she was leaning out the window," he told "Newsnight". "It was more like a toddler. And there was smoke just billowing out behind her, so obviously she was just trying to get oxygen. So she was at the lowest point of the ledge, you know right down low, top half of her torso hanging out, but her infant at arm's length". Mr. Martin believed that when people saw the woman, who was rescued by fire fighters minutes later, it looked like she was throwing the baby, and that it was perhaps that which spawned the story.

The BBC interviewed two psychologists about this event and one explained it in terms of how such a perception is made, and in reference to the retained memory of the event to false memory syndrome.

The presenter also explained the physics of the event with the aid of the diagram. "Even if the child was dropped from five storeys or 15 metres an object would be travelling at 17m per second or 61.73 km per hour (38 mph). Double the height to 30 metres and the child would have been travelling at 87.3 km per hour or 54.2 mph). A consultant physician said that above one story the child would have likely experienced serious injury. He found it difficult to understand how the fall of a baby from that height would have had a benign result. To put it in another way, the child would probably have required hospital treatment. The BBC found that no hospital had reported treating an infant with such injuries.

The really astonishing part of the story is that the BBC was severely criticised in some quarters for spending time on debunking the false narrative. Irrespective of the evidence people continued (perhaps wanted) to believe the original storey.

(2). Public perceptions (prejudices)

While it is not the intention of this study to involve itself in the political debate about high rise social housing in general, and the Grenfell tower in particular, it is necessary to consider the prejudicial image of such towers that has been built up over a number of years. It would not be unreasonable to suggest that many middle class people would have had an image that the residents of such towers comprised drug addicts, unemployed persons, and criminals. Many people would have believed that the living conditions in them were poor, and in consequence they should be destroyed. Such views would have been reinforced in the media. Thus, in 2012 the think tank Policy Exchange wrote in a report that "the majority of social tenants are either totally or largely reliant on benefits"

The ASH report also cited Sir Simon Jenkins who wrote in *The Guardian* newspaper that "Residential towers are antisocial, high maintenance, disempowering, unnecessary, mostly ugly, and never truly safe".

A Labour politician David Lammy also wrote in *The Guardian* "For decades we have consigned people to live in overcrowded conditions that are not just unacceptable but that, in many cases, are certainly unsafe. Families live in hutches, not houses".

We suggest that such images are widely held among the middle classes and those concerned with political decision, and that image has been portrayed and reinforced though many items in the media over the years. One of us (JH) certainly believed such views and was shocked to find out very quickly after the fire that the residents did not believe they lived in hutches, that there were many self-supporting communities within the tower, that the accommodation was acceptable, and that the complaints some of which were very serious had not been dealt with by the management company. There were no drug addicts and there was no mention of criminals. Moreover some semi-professional and professional people (two architects who died in the fire) lived in the block. Moreover, those residents who were interviewed that lived on the top floors were quite happy living on the top floors although along with the other residents had expressed concerns about the safety of the building.

The political issue described in the ASH report is the view (with some evidential support) that councils are using the poor image of the blocks to have them destroyed so as to replace them with high value rather than social housing.

From the perspective of technological literacy there are two points to be made. First, there is a need to understand the importance of perception in all that we do and how it influences our behaviour. Second, relates to fake news, and that the national media is as likely (and perhaps deliberately) to convey false impressions which, by definition, are fake.

Engineering and technological literacy

In 2012 a working group of members of the TELPHE division of ASEE reported on the need to distinguish between engineering and technological literacy. Krupczak and his colleagues

offered a number of scenarios that distinguished between the two, and concluded that, "engineering literacy is directed more toward the process of creating or designing technological artefacts in systems. Technological literacy includes a wider ranging scope including the products or results of the engineering process as well as the relations between technology and society" [6].

However, it is clear that the definition of engineering literacy unintentionally hides important features of the process, more especially its management. In this case there is no legal requirement that engineers should be involved in its design or management. If they were, and their professional code of ethics was adequate and endorsed by the employer then the degree of risk should be minimised provided they act as engineers and not business people as was the case with the Challenger disaster [7].

As the discussion moves into the realm of regulatory requirements so it moves into the realm of technological literacy. It is clear from the ASH report and the Governments own expert group that the regulations were not fit for purpose. It also becomes clear that the failure of English society to protect the term "engineer" has contributed generally to the culture and consequent deficiencies in the whole of the development, planning and construction process.

Technological literacy embraces the public in a way that engineering literacy does not, and as Krupczak and his colleagues indicate is much wider ranging in its scope. In this case it extended to the political process and the perceptions that the local political class had of the occupancy of the building and its future use.

The need for the public to be literate in engineering is illustrated by the BBC's investigation into the widely published story of a baby being thrown from the ninth floor of the tower which showed that there was probably no such incident. The fact that abuse was heaped on the programme makers is a one matter of concern. Another is the failure of journalists and their editors to check the story against the science which the BBC did. Clearly "fake" news is as much of a problem for the news media as it is for the social media.

Conclusion

The TELPHE Division has initiated a debate about "for whom" and "what" are studies in technological and engineering literacy for [8]. At one end of the spectrum is a not very clear argument that it is for everyone (i.e. the public), while at the other end of the spectrum it is complained that engineers are not technologically literate. Generally, the curriculum for either group arises from the beliefs of those who wish to deliver the courses on behalf of the organizations and academies that support them. The concepts of technological and engineering literature are not part of the technological discourse in England. Should they be?

Bucciarelli [9] helps us to answer this question. He writes, "Participants in the object worlds (of the design process) function as *elites*. […] Object worlds divide the design tasks into different, but not independent, kinds of effort so one can say that there is a "division of linguistic labour" but the distinction is not that there is one group, an *elit*e, that knows the full meaning, has god's eye view of the object of design and another group with but less sophisticated common understanding of the design task. Rather there are multiple *elites*, each with their own proper *language*. It is in this sense that different participants within different object worlds with competencies, responsibilities and interests speak different *language*s. Crudely put one speaks structure, another electronics, another manufacturing processes, still

another marketing, etc" In this case fire safety engineers are an *elite*. It is our contention that in this context the "public" are also an *elite*. It is, therefore, a challenge for engineering literacy programmes to develop a "bridging" language.

The Grenfell Tower disaster does have a "public". It is its residents and residents of associated housing, including tower blocks, in the vicinity, and that extends to the residents of housing blocks wherever they are in the country. They provide the justification for engineering literacy let alone technological literacy. It is very clear from the media that the residents do not trust the various inquiries that have been established. They view the members of these inquiries as insiders and the terms of reference to be too restrictive. However, if they ask appropriate questions they should be able to get the answers they seek. We conclude that the purpose of engineering literacy is to enable persons to understand engineering problems and to be able to ask questions about them and interpret the views of engineers they seek to advise them. In this context a programme would lean rather more toward engineering design and management than engineering science.

Notes and references

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