Public understanding of engineering: consequences and solutions

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ABSTRACT: Engineering specialists contribute significantly to the economic success and the overall quality of life in any country. Research data show that the percentage of engineering and technology graduates throughout the last decade is either flat or is decreasing worldwide, except in China and India. This is happening in spite of the increasing infrastructure demands and the growing need for engineering and technology specialists to develop and support it. It has been suggested that part of the solution to this problem lies in improving the public image of the engineering and technology profession. It is argued in this paper that it will only be possible to achieve this goal through significant changes to engineering and technology curricula, so that specialists are better able to reach out to the wider community. Engineers themselves should be the first line of communication concerning their profession, its achievements, contributions and future projects that are intended to improve the quality of peoples' lives. Professional engineering societies should also contribute adequately to the improvement of the public understanding of engineering.

INTRODUCTION

There is a conceptual difference between how engineers think about themselves and their profession, and how they are perceived by society. The public image of engineers is not very favourable and is rather vague. This may be the reason why there has been no substantial increase in the popularity of engineering and technology education. This is in spite of the growing demand for engineering specialists that is likely to increase even more as the world slowly comes out of the recent global financial crisis.

There is an urgent need to change the public understanding of engineering, promote technical literacy, stimulate interest in mathematics and science at all educational levels and implement changes in engineering and technology curricula at a tertiary level in order to prepare engineering graduates for a better interaction with the public. By improving the public image of engineering and enhancing the engineering and technology curricula, it should be possible to attract more talented people to the profession thus enhancing countries' capacities for innovations and economic development.

ENGINEERS ABOUT THEMSELVES

Engineers see themselves as a special breed of people who are able to turn ideas into reality. It has been asserted that scientists' goal is to uncover new information about how the world works, while engineers take this knowledge and solve real problems [1].

Engineers believe that they shape the world with their intelligence and ingenuity. When talking about the significance of the engineering profession, Florman affirmed the following:

> *…once common man was released from drudgery, he would inevitably become educated, cultured and ennobled, and this improvement in the race would also be to the credit of the engineering profession* [2].

It is even argued that engineers may be displacing or greatly interfering with the biological processes of evolution. Carroll has stated the following:

> *When the next Ice Age moves down, for instance, instead of growing more fur,* homo sapiens *may step up the production of air-conditioning units* [3].

Engineers believe that they form a valuable segment of society. They are well-educated, creative, professional and ethical. Moreover, they can contribute well to research, development, innovations, economic and social well-being, etc.

However, there is also an understanding that the cost of engineering mistakes can be really high. An engineer and former United States president Herbert Hoover emphasised that:

> *Engineering elevates standards of living and adds to the comforts of lives, which is the engineer's high privilege. The great liability of the engineer compared to men of other professions is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air or blame the judge like the lawyers. He cannot, like architects, cover his failure with trees and vines. He cannot, like the politician, screen his shortcomings by blaming his opponents and hope that the people will forget. The engineer simply cannot deny that he did it. If his works do not work, he is damned forever* [4].

Petroski returns time and again to the theme of engineering failures and argues that this is an undesirable but natural part of the creation process. He states that *engineering is a human endeavour and this is subject to error* [5]. Petroski also emphasises that some engineering mistakes are merely annoying while others may seem humanly unforgivable but it is crucial for the engineering profession, as well as the public image of engineers, to learn from these failures in order not to repeat them again [5].

Failures occur mainly due to the inefficiency in the organisational structure of engineering work and the inability of engineers to function as one team when dealing with different parts of the same project. Kunda has identified that:

> *…the organisation of work in engineering is often described by insiders as vague, decentralised, chaotic, ambiguous - a controlled anarchy* [6].

Engineering work is very complicated and involves thorough mapping of a complex network of activities combined with the distribution of responsibilities and tasks, which have to be accomplished within a certain time frame. Hence, it is important that task groups and divisions tune their activities through effective communication and work collaboration. This is where communication skills and the ability to work as part of a team come forward. These are the elements of the livelihood of any engineering project.

Some companies, such as Toyota, speak proudly about developing the corporate culture, which helps to establish good communication and coordination for each step in the process within task groups, which also enables effective work to be built by the various teams and contributes to the overall success of the company. It has been described by Liker that:

> *…according to the Toyota Way, it's the people who bring the system to life: working, communicating, resolving issues, and growing together. Toyota Way means more dependence on people, not less. It is a culture, even more than a set of efficiency and improvement techniques. You depend upon the workers to reduce inventory, identify hidden problems, and fix them. The workers have a sense of urgency, purpose, and teamwork because if they don't fix it there will be an inventory outage. On a daily basis, engineers, skilled workers, quality specialist, vendors, team leaders, and - most importantly - operators are all involved in continuous problem solving and improvement...* [7].

There is a current tendency for companies to be organised structurally and run in such a way that a balance and a differentiation between individual work contributions and group work effectiveness is recognised and highly valued. Hence, the ability to communicate effectively, solve problems and contribute individually to the efficient work of the team are credentials that are as valuable as engineering and technical excellence. The development of these skills has to be part of engineering and technology education in order to prepare students for successful professional practice. Moreover, good communication skills will also allow engineering specialists to reach out to the public and change their unfavourable image for the better.

PUBLIC IMAGE OF ENGINEERING

Surprisingly, in spite of the fact that engineers have their main mission to serve society through engineering practice, the public image of engineers is not very favourable. An engineer is often perceived as:

> *…a soulless apparatchik, building ever taller, slicker, quicker, more coldly efficient devices that few want and that fewer can afford, which from time to time go hideously wrong* [8].

A senior mechanical engineer at the Adidas Innovation Team believes that the average person in the street would describe a mechanical engineer as *a person with a spanner and dirt under his fingernails* [9]. An image of a chemical engineer will most likely be seen as *a guy in the hard hat standing on the catwalk of a refinery surveying his world-scale plant* [10].

There are many rather unfavourable stereotypes and negative social images of the engineering profession, activities and mentality. In general, engineers are said:

> *…to possess big egos, addictive personalities, little if any social skills, not to mention graces, a bent for hard, obsessive work, and a penchant for* burnout, *the scars of which are carried and displayed almost as one would a purple heart* [6].

Often cited in Beder's publications is an article from the UK magazine *Professional Engineering*, which likens engineers to autistic children. According to the article:

> *Autistic children do not develop normal social relationships and they tend to wander off by themselves and play with mechanical things. ...engineers and autistic children shared various characteristics including strong visualisation skills, strong affinity with physical objects while being less interested in social activities and communication* [11].

There is no doubt that if a young person comes across this type of comparison, he/she would feel reluctant to choose engineering as his/her future career.

According to some research findings, engineers do lack communication skills. However, communication is a skill that can be learned. Communication skills are essential for engineers because while technological in nature, the engineering profession is highly communicative and increasingly international in practice. Hence, there should be a strong foundation in the engineering and technology curricula that should aim to develop foreign language and communication skills. This will foster not only the engineering work environment, but will also help to improve the public understanding of engineering and the overall engineering image.

Another reason, which adds negativity to the engineering public image, as noted by Vesilind and Gunn is:

> *...well-publicised engineering failures resulting in damage to human and environmental health that have encouraged many people to perceive engineers as the creators, not solvers, of problems* [12].

Journalists hunt for major sensations in order to increase the rating of the news agencies they work for. In the case of publicity and popularisation of engineering activities, it is not hard to agree with Petroski, who has observed that:

> *…engineers are, sometimes their worst enemies, at least so far as communicating their work to the general public* [13].

Public opinion that characterises engineers as very unsociable and hard-to-deal-with people is unreasonable in many cases. Therefore, something needs to be done in order to change the public perception of engineers and to achieve recognition of their professional involvement for the benefit of the society.

ACTIONS TO BE TAKEN

Action to change the low public profile of engineers is coming through both engineering professional activities and from the engineering education sector. According to the project called *Engineers 2020*, one of the main objectives is

> *...to consider changes in engineering education in the broader context of enhancing the status of the engineering profession and improving the public understanding of engineering* [14].

The recent campaign, called *Make it so*, run by *Engineers Australia*, is devoted to improving public awareness and changing what Australians think about engineering [15]. With the help of public relations, media and on-line activities, it is intended to involve the people in engineering. The organisers intend that:

> *...The campaign will become an engaging and memorable way to showcase how the profession solves problems with creativity, innovation and the application of science* [15].

Professional societies concerned with the quality assurance of engineering and technology education also raise the awareness of engineers of their need to develop and apply the skills, which are outside the boundaries of technical excellence. It is widely recognised that engineering and technology education has to be enriched with non-engineering subjects in order to develop the so-called *soft skills*, which will enable future engineers to function successfully in an ever globalising social and economic environment. This is a demand of the time, because life in the epoch where intellect and information are the best values is characterised by an increase of mobility, transfusion of cultures and the need for intellectual, cultural and social compatibility. These processes lead to inevitable evolutionary changes in engineering education and pedagogy.

A quick glance at some of the changes in engineering and technology education in different countries, even within this decade, reveals the obvious shift in the educational paradigm. On the one hand, educational institutions fight to preserve their identity; on the other hand, programmes, syllabi, methods and techniques of teaching, learning strategies, implementation of new technologies and even the educational structure of institutions are undergoing serious

adjustments in order to meet world standards in their effort to gain global recognition. Engineers should learn how to communicate, as well as use a foreign language when working in international teams.

In 1998, Tomsk Polytechnic University, Tomsk, Russia, which holds the third place in the official ranking of the Russian Ministry of Higher Education,

> *developed and started implementing an innovative Multi-Level Intensive Foreign Language Programme based on learner-centred and differential approaches with respect to learners' needs, aims, requirements and job-related specialisations. The programme embraced undergraduates, graduates and academics with different levels of English level proficiency* [16].

Zhurakovsky, et al, have also stated that the main objective in the reformation of Russian engineering education was the formation of

> *...a new generation of engineers who would meet the demands of the post-industrial society, educational and scientific-technical potential of higher educational institutions in Russia, who could solve problems concerning the quality of education in the area of high technologies, and who could use Russian and foreign educational experience. The important factor of engineering education is* [English] *language training, which is regarded as a means of intercultural communication* [17].

Countries that were a part of the former Soviet Union are going through similar processes of reforming their higher education systems in order to adjust the quality of their technical education to world standards. It was stated, for example, that:

> *Lithuania is not rich enough in natural resources to equally compete with most technically and technologically advanced countries of the world. One of the few resources that it possesses is its people and their intellect. Since the time when Lithuania regained independence in 1991, higher education schools have been searching for new approaches to education … At present 40 European countries* [including Lithuania] *are working to meet the requirement of the European Higher Education Area. The EU mobility target of at least 20% of all students by 2010 is based on common learning language (usually English), and freedom of movement of students and teaching staff across the national borders of the EU* [18].

The TEMPUS PHARE Joint European Project defined as one of the Project's main objectives to *promote the learning of English as the main tool within engineering education and research* [19]. This project was carried out from 1997 to 2001 by Kaunas University of Technology, Kaunas, Lithuania; Vilnius Gediminas Technical University, Vilnius, Lithuania; Technical University of Denmark, Copenhagen, Denmark; City University, London, England, UK; and the University of Karlsruhe, Karlsruhe, Germany.

It is very popular and, indeed, quite effective to engage joint intellectual, technical and financial potential to solve the problems of engineering and technology education in the globalisation era. In 1999, King Mongkut's University of Technology Thonburi in Bangkok, Thailand, and the University of Tasmania in Hobart, Australia, created the so-called *twinning programme*, under the Thailand-Australia Science and Engineering Assistance Project, which listed among its objectives the following:

- To promote international calibre civil engineering graduates;
- To enhance strong cooperation in engineering education with world standard universities;
- To produce graduates with a strong proficiency in English [20].

For historical reasons, speaking and writing in English is quite well developed in some countries, such as Hong Kong, Singapore, India, Zimbabwe, etc, although the language barrier and a lack of communication skills still remain a great problem when it concerns engineering and technology education and professional practice.

It has been observed that the graduates of engineering and technology courses in the Indian State of Maharashtra, which has always been at the forefront of education, technology and industrial development, encounter employability problems because of *poor English language proficiency, lack of oral and written communication skills and lack of proper representation techniques* [21]. It was concluded that *the curriculum of the communication skills subject … can be considered as being the most important and essential course in this changing environment of globalisation and the internationalisation of technical education* [21].

As has been correctly noticed, *engineering practice today is increasingly international, with cross-border practice of the profession becoming pervasive* [22]. Hence, in order to prepare engineering and technology graduates for international practice, engineering and technology education has to meet new requirements among which are foreign language proficiency and cultural background development; in other words, awareness of cultural differences that engineers may face in the world regions where they may work [22].

In order to increase the popularity of engineering education, it is also necessary to promote mathematics and science in schools from the lower primary years onwards. Moreover, it is believed that science and engineering in junior fiction are highly stereotyped. Holbrook et al, have conducted an examination of 4,800 junior fiction titles in one region in New South Wales, Australia, and identified only 71 titles that addressed themes related to engineering and science [23]. It was also found that:

> *...crazy, nerdy, scientific stereotype exists in these stories, mostly in humorous vein* [however] *fictional characters were split between the nerdy, eccentric, and the more serious and professional types who were depicted as more popular* [23].

It was also discovered that the emphasis was placed on male characters and there were limited details that could be associated with engineering as all the activities were primarily connected to vehicles, mostly cars. Moreover, it was concluded by this research that *young people, particularly girls, were unlikely to gain accurate or compelling images about engineering as an occupation...* [from junior fiction]*... at present* [23].

These stereotypes are likely to play their negative role when the time comes for those children to choose their future professions. Hence, there should be initiatives, policies and campaigns coordinated by the engineering community and educators in order to encourage consistent and effective transmission of a positive image of engineering to the variety of audiences.

CONCLUSIONS

Higher education is a key element in the social and economic development of any country, especially if it rests upon the pillars of high quality research and innovation. Unfortunately, tertiary education institutions are not always transparent in their operations. Therefore, it is quite difficult, if not impossible, to ensure that a certain university guarantees the provision of high quality educational services, as well as the development of knowledge and skills for successful employability and, hence, a good quality of life after graduation. There is a growing concern about the quality of engineering and technology education, which enables various initiative groups to advocate for the reformation and improvement of engineering education in order to adjust it to emerging global requirements.

It is a widely recognised fact that being a part of the global economy, many changes are being brought to the social and professional environments, as well as many challenges evoked within the education system in order to keep the momentum and provide high quality education. It should also be understood that foreign languages and communication skills, although not primarily engineering skills, should not be neglected in engineering and technology curricula.

This is especially important when taking into account that linguistics develop other skills such as risk taking, thinking flexibility, dealing with the unexpected and working across communication boundaries. Moreover, the motivation of students to learn foreign languages could be enhanced when demonstrating to them the statistics from recruitment agencies, which state that salaries for those using foreign languages at work can be higher by between 8% and 20%, when compared with those without such skills, depending on how central languages are to the role [24].

Notably, only the Conceive-Design-Implement-Operate (CDIO) Initiative recognises and points out the necessity to develop foreign language proficiency as part of the engineering and technology curriculum. When analysing the curricula of the universities that are members of the CDIO Initiative, it was found that foreign language courses are mostly offered as electives and include courses of German, Spanish, Chinese, Hindu and other languages of the countries undergoing rapid economic development. However, there is an understanding about the necessity of developing foreign language and communication skills of engineering and technology students in order to enrich their professional credentials.

It was found that there are many international initiatives and programmes with an objective to contribute to the changing paradigm of engineering and technology education. The principles and undertaken efforts may differ in some aspects but the main objectives are similar. Most of the initiatives endeavour to develop universal curricula through which proficiency standards can be raised in order to allow engineering graduates to gain the requisite knowledge, skills and attitudes progressively as their careers advance.

The organisational structure of engineering work should be based on effective communication within internal groups and a variety of external audiences. There should be adequate changes in engineering and technology curricula that will focus on developing communication and foreign language skills. This will also allow for the improvement of organisational structures and the functionality of engineering teams. Better communication skills will also help to change the rather unfavourable image of engineers within society. It is believed that the enhancement of communication skills may help solve this problem.

Perhaps some elective courses such as science, engineering and technology journalism might also help to improve the public image of engineering. Specialists in such specific branches of public relations should be able to provide society with a balanced assessment of problematic issues and innovative developments in science, engineering and technology in a way that would be understandable for the general public.

It is important to recognise that improving the public image of engineering by providing insights into the role, importance and career potentials of engineers, can help to increase the popularity of this education, which is also necessary for the well-being of the society. Breaking the unfavourable stereotypes of engineering is necessary because it will help to achieve the following:

- Increase nations' capacity to sustain technological innovations;
- Improve technological literacy;
- Attract more students to take this career path;
- Popularise engineering among women;
- Improve the engineering working environment.

It is believed that improving the public understanding of engineering and the engineering profession in general can be achieved through adequate changes in engineering and technology curricula, by stimulating interest in engineering right back to school and, constant involvement of professional engineering societies in reaching out to the public.

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