Attractiveness in Engineering Education – Culture and Challenges

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INTRODUCTION

How does the attractiveness of a specific profession affect the attractiveness of education? When they choose an area to study or not do potential students calculate the price of education, the time spent and the effort needed to graduate? If yes, what is the value of each of these parts? What makes students appreciate a university and a study program it offers? Is it an international ranking list? Is it - well known professors or teachers, location, famous alumni, one of many other reasons? What is the role of fees? Some countries offer free access to higher education - others collect just a small fee - some a fee that covers the costs and some at a price that generates a surplus. What influence do these have on attractiveness? Do students have greater appreciation for a more expensive education and is the expensive education able to attract better teachers? What is the payback time of education and do potential students calculating that? What is the role of education in one's lifelong earnings?

What criteria do school levers apply when they are choosing their future; short education or university - and if university what area of studies - and finally which country, which university and which programme? What is the role of finance, reputation, ease of study, social activities for example a partner's interest or parent's expectations and willingness of pay? Can tuition fees raise attractiveness by motivating teachers or by improving facilities for teaching? Or as is the case in the UK the fee income is there to compensate a reduction in state support? How does this influence attractiveness for students from other countries - and how does the student diversity affect the attractiveness seen by the local students?

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These and other engineering education attractiveness issues are discussed bringing the perspective of two very different European countries: Finland (free education - low diversity of students) and Great Brittan (high fees and high diversity of students).

1 PROFESSIONAL STATUS OF ENGINEERS AND ATTRACTIVENESS

1.1 How engineers are viewed in society

The status of engineers within different European countries varies widely. In some countries – Finland for example – the engineering profession is one of the most appreciated. Engineers are often working in well paid positions - as managing directors, directors of development, etc., and an engineering education is considered to give competences for wide range of jobs. The same is true in Germany and France. However, in some other countries, the experience is very different. In the UK for example, the public at large seems incapable of distinguishing between the technician who services their automobiles and the team developing the next generation of cars. The word engineer is applied liberally! In addition there are few legislators who have any level of professional engineering qualification. In the East, for example in China and Japan the professional status is high, as in Finland and Germany, but the US shows a much more similar situation to the UK

One problem is that of image and familiarity. Whereas, and for whatever reason, it is highly likely that an individual in society will have encountered a medical practitioner, a dentist or a lawyer. Recovering from an illness, easing a tooth pain or buying a house are but three examples, where such encounters with one of these professional groups might occur. But encounters with professional engineers are more unlikely. A construction or extension to a house might involve a civil engineer or perhaps a mechanical engineer, but these more likely may only be at the technical level. (In the UK frequently for many people there is a confusion between a professional and a technical engineer. An inability to distinguish between the individual who diagnoses and repairs a car fault and the one who is evaluating new car designed for drag.)

Thus we have a situation where so many of the benefits that accrue from the work of engineers, are not readily visible to those that benefit from them, and the many profiles of engineers are far less well understood than the diversity of roles in other professions.

Perhaps another facet to this problem is how engineers themselves view their own role in society. Frequently it is one where the move into management positions is seen more as a burden than as an opportunity, a move that takes them away from the security and arriving a technical solutions to problems, however challenging these may be, to the territory of budgets, staffing issues, negotiation and compromise – all the pillars on which the business world is supported.

The world of politics, national or local, is even one stage further removed, with probably a lower remuneration than senior management positions might offer, but with comparable hassle. It can be quite easily argued that the training and orientation of engineering makes the individual ill equipped for the apparent superficiality of politicians towards engineering. (This might be compared with a background in law, which can be extremely valuable, even essential when drafting legislation.)

Interestingly in the UK, involvement in government e.g. from a lack of politicians with science/engineering qualifications, is being approached in one slightly different way.

In many of the key ministries, where there is a need for a scientific understanding, there is now embedded within the UK Civil Service support, a chief scientist, who might be seconded for a period and a small support team. These are ministries such as defence, environment, and energy. This kind of strengthening and widening of technological understanding in the preparation of state policies of education, taxation, industrial regulations etc., would be very beneficial also for Finland.

2 PRE-UNIVERSITY EXPERIENCES

2.1 Role models

The initial years of life can be very formative in the interests and values that a person acquires. Inputs come from home, the local community, school, broadcast media etc. Today there is probably an excess of unstructured influences arriving via broadcast media, the www, etc., which makes it even more challenging for young people. Some professions, through none of their own efforts, make suitable subjects for media drama, examples are detectives, lawyers, doctors and other healthcare workers. Other occupations by their intrinsic appeal to young people can immediately attract those with appropriate talents, classic examples might be of boys wanting to become professional football players or girls to be vets or fashion models, but there are others of these, pilots, racing drivers, etc.

The scientist does sometimes enter into films, but frequently he, because it is usually a man, is portrayed as a somewhat ‘quirky’ individual, intelligent for sure, but a little strange – the ‘mad’ professor. The very nature of the profession does not make it a natural topic for the media. Engineering is even less visible in the media, with perhaps the occasional docu/drama. The recent film success of ‘The Imitation Game’ about World War II code-breaking is an example of the type of film where there is technical background, but the focus has to be elsewhere. However this low level of media visibility is not a criticism of media counter bias, but more a reflection of the nature of the profession. Unfortunately the result is a low level of exposure of the profession to young people.

Not clear to school students or sometimes their teaches just what it is that engineers do. Very few people with engineering qualification become teachers,

2.2 Additional challenges for girls – cultural issues, society

Gender stereo typing begins immediately after birth - the blue-pink syndrome – and regrettably persists extensively thereafter, making the problems of attracting female students into the engineering profession even more of a challenging than it is for male students. Engineering is seen as a male profession having a male culture, mathematically-based, for ‘techy-types’, devoid of human interaction and not one to be followed if your orientation is towards a ‘caring’ profession. While there may be some truth in this, it surely does not provide an accurate summary of the profession.

If there is a shortage of all teachers with experience of, knowledge about, and appreciation of engineering as a profession, this applies even more to female teachers than male. Hence the role model of a female teacher with an engineering background or familiarity is even rarer.

3 CHALLENGES OF SUBJECT

While not exclusive, mathematics is a key tool that underpins all sciences and engineering. It is the formalism through which the inspiration, ideas and data can be brought together to unable understanding to be reached and ultimately communicated. Without it our science and engineering would be primitive, yet mathematics is not seen by many, if not most, students as an easy subject. There are, some students who have natural abilities or inclinations in this direction and take to it easily, but for others this is far from the case. Unfortunately in the many stages of education, the subject may be being taught by those who are not really confident at the level in which they may be being asked to teach it. This can work against inspiring teaching. At the same time many parents are also unhappy with the seeming abstraction of the subject. Unfortunately it is also the case that there are many more career opportunities available outside of teaching for those with science or mathematics backgrounds.

As any practicing professional is aware, engineering requires skills in more areas than just mathematics and basic science, but those are important constituents. However, a culture where at any level there can be impediments either at home or in school to the development of these, either from the interest shown or the quality and enthusiasm of the teaching leads to students being 'turned-off the subject at far too early a stage.

Although the developments of the ubiquitous computer has brought benefits, with these have also come counter productive issues. The ability to access vast knowledge reservoirs via the www and search engines can also lead to 'lazy thinking'. Questioning facts and their integrity, assembling data in a way such as to produce information are skills that can so easily be overlooked, and yet are so vital.

4 CAREER OPPORTUNITIES

4.1 Content of work and Role models

In many cases the stereotypes of roles are dominating the thinking of people - in the case of engineering this means it is seen as a rough machine-orientated male profession - female should go towards humanities-based professions, where there is judged to be more emphasis on people and care.

Those thoughts have nothing to do with intelligence, skills in mathematical thinking or any other science based evidence.

Interestingly enough, it is many of these 'female' professions - like jobs with elderly people or patients, which are physically much more demanding than engineering professions; nurses might need to lift or turn very heavy patients - while engineers may just be computing.

Another dominating role model of an engineer is that engineers want to work with 'real things' - not make policies or politics. This image has led at least in Finland to the situation where until recently in the Parliament of Finland only 3% of the members had engineering backgrounds yet in the government itself this fell to 0%! Resulting from recent elections (19th of April) the percentage of elected members of Parliament having a background in engineering has increased to 7% (14 out of 200). However, what makes the situation even worse is that in the ministries, where the

laws and statements and background papers are prepared there are hardly any officials having engineering background.

When the polices of the country, state budgets, decisions of education and industrial programmes of the future are prepared, surely a deeper understanding of engineering should be needed. Otherwise the solutions for huge global and national problems, such as climate change, energy production, equal and effective healthcare, ageing of the population, etc., will not be addressed with workable solutions.

4.2 Opportunities for Remuneration

Marketing of engineering profession could be much more effective if the responsibility and capability of solving problems would be highlighted much stronger way. Engineers are not the origin of the problems - but engineers are there to solve the problems others have created. Engineers are there to find solutions to make the world a better place to live in.

4.3 Assessing the Value

Every profession tends to have its high earners, obvious examples are premier division football players, high profile lawyers, investment bankers, major company directors, heads of universities etc. However, it would be a mistake to assume that this reflects the entirety of any specific profession. It is also the case – although here there are quite a lot of country differences – that the financial remuneration levels between the top of any profession or occupation and the bottom is progressively widening. This is a global trend, although it is far more apparent in some countries, e.g. the UK and the USA, than in others e.g. Finland, Sweden or Japan. Many, including the authors, view this as detrimental for society, but to some extent the genie is out of the bottle and it will be a very difficult trend to reverse.

The very nature of much engineering means that it is team effort and as such produces very few high profile individuals. Salaries for employed engineers in most countries are more likely to fall within the category of ‘acceptable’ rather than ‘outstanding’. By employed we mean working for a company or organisation. Those individuals in consultancy or with their own ‘start-up’ company may achieve significantly higher returns.

Using US census data from 2011, a report from Georgetown University [1] presented an account which 171 subject in 15 categories were analysed and earnings tracked by subject. Although obtaining a degree was seen to matter, what mattered more was the choice of subject. The results indicated how critical the choice of subject was to median earnings, with engineering performing well in this study. In another report [2], again from the USA the cost of obtaining a degree at several universities was quoted together with the financial benefit over 20 years compared with not attending. A huge range of outcomes was indicated. This data indicated that within an engineering context the results were beneficial. For example, it was indicated that an engineering graduate from the University of California, Berkeley could expect to be nearly $1.1m better off after 20 years than someone who not been to university. The least lucrative course generated a 20-year return of almost $500,000. In comparison an arts graduate from Murray State University in Kentucky could expect to make $147,000 less over 20 years than a high school graduate, after paying for education.

In 2013 the Finnish National News Company, YLE, published a comparison of the life-long earnings between different professions [3]. An engineer (B. Eng.) was working 32 years after graduation with total earnings of 1,250,000 € while a library advisor with a master's degree worked 27 years with a total earning of 900,000€. That to compare with a 3-shift worker in a paper mill have the total of 40 years of work with 1,670,000€ total income while a nurse also in 3-shift work earned only about 1,190,000€. This comparison shows that the professions in technology areas are better rewarded than the professions have a more humanities orientation. So while the level of education inside technical professions might not give added lifelong earning potential, but still gives more interesting and flexible work. Spending even more years in education while graduating with master's degree in technology or doctorate adds to the average (median) monthly income with about 20% (BEng 3900€/month and M.Sc Eng 4700€/month) [4, 5].

When students are choosing engineering education, tuition fees have started to play an important role. While in Europe some decades ago, most of education was offered free or almost free - since then in many of the countries the situation has changed. In England the turning point came in 1998 when the labour government introduced yearly tuition fees of 1,000£. That has now grown up to the level of 9,000£. In Finland all degree tuition is still free for everyone, but the debate about it is very active. How fees are affecting attractiveness is another question - is expensive education more appreciated, will it attract better teachers, will the employers appreciate more the graduates from expensive programmes? These questions were debated more fully last year in our conference paper [6].

5 QUALITY RANKINGS AND ATRACTIVENESS

Students, their parents, teachers and other stakeholders are viewing different rankings - and in many cases they do not even try to find out what are the evaluation criteria on which the ranking lists are based. That gives huge power to the creator of the ranking lists and also to the bodies who are publishing and marketing them. On the other hand when the university - or its programme - is fulfilling the expectations and requirements of its own purpose it should manage well in all the appropriate evaluations and accreditations. Still a university might focus on the factors evaluated and get a "stamp" - although being very poor on some essential features.

In most countries there are national accreditation bodies that ensure the acceptable level of action of the university or programme and additionally give the permission for it to act as a university and grant degrees. Those national authorities usually appreciate the quality work that is done according to the guidelines of accreditation bodies having wider coverage. Such bodies exists in many shapes and forms like EUR-ACE (European Network for Accreditation of Engineering Education), ABET (Accreditation Board for Engineering and Technology, US) and Engineers Australia. However all of them have different accreditation systems using slightly different criteria and indicators. Additionally there are consortiums offering tools and networks for helping the practical work - an example from these is CDIO (Conceive- Design-Implement-Operate), which is well documented [7].

Benchmarking can help and challenge universities by directing and supporting a continuous development process to more effective and successful directions. A good

example encouraging benchmarking is the Erasmus project QAEMP, which is aiming to create a joint cross-sparring place for European university programs. The creation of such a “market place” will be based on wide research to cover all the important issues to be chosen into use by the universities and additionally the ways of finding beneficial partners for cross sparring. An essential part of piloting the system is to hold workshops with potential users during different conferences and meetings.

Reputation based on the different rankings has become increasingly important factor when attracting the best students from different parts of the world. Additionally the rankings are noticed by the employers hiring new graduates and professionals, who want to work in a university. Understanding the goal-orientated choice of the indicators that power the rankings is a quite frightening prospect for the development of a coherent and sound education for engineers.

If University education is following and responding to inappropriate drivers just to show excellent scores, that might not necessarily either improve the fundamentals of a good engineering education nor help the development of the subject to increase its attractiveness.

6 **WHAT ARE THE CHALLENGES FOR EDUCATORS**?

The educators in all levels have an enormous role and responsibility. Already in the pre-school level educators should be giving a positive interest of engineering - the existing toys and games do not just exist - they are built - and even a small child (independent of the sex) can build a new one in an elementary level. More simple solutions with guidance can be found by the kids themselves - the solutions can be made from very common things, wood, paper, kitchen materials etc., not to exclude the building blocks sold especially for these purposes (such as Lego).

Similar type of challenge continues throughout the whole compulsory school time; teachers are pedagogies - not engineers – unfortunately their own respect for and understanding of engineering as common solution building profession is most likely to be weak.

Later on in secondary high school the same challenge with educators continues - and many of the talented pupils might not be encouraged to study the necessary STEM subjects to build the appropriate background for understanding engineering.

Finally at university level the additional challenge for the educators is that not just of the technical skills, but also to develop it within the context of the responsibility of the society. It is not enough that engineers just solve a given problem - they need also to conceive that solution within the wider surroundings and the broader consequences of different possible solutions. Additionally engineers should learn to lead the science to create new solutions and avoid future problems.

For educators the diminishing resources create challenges - how to improve teaching with less investment. More co-operation and focusing is required - for instance producing MOOCs (Massive Open Online Courses) from one’s own area and using MOOCs from others areas of expertise.

SUMMARY

To save the world and make it a better place in which to live is a joint challenge for all professions. Engineering education is in key position to teach people to find solutions to advance that aim. The big issue for the profession and its educators is to make this fact better known and encourage talented students into such studies. Additionally much knowledge about the job opportunities and achievements should be marketed.

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