E4E submission to Education Committee inquiry on the purpose and quality of education in England

Education for Engineering (E4E) is the body through which the engineering profession offers coordinated advice on education and skills policy to UK Government and the devolved Assemblies. It deals with all aspects of learning that underpin engineering.

It is hosted by The Royal Academy of Engineering with membership drawn from the professional engineering community including all 35 Professional Engineering Institutions, Engineering Council and EngineeringUK.

1. What the purpose of education for children of all ages in England should be

We have attempted to speak generally about education for all students pre-16. However, at each Key Stage, the way in which each of the following 'purposes' is achieved will be different. In summary, education should:

- Inspire lifelong learning
- Combine theory with application
- Prepare students to be active citizens
- Identify and help address weaknesses, not just encourage strengths
- Foster creativity and innovation
- Nurture resilience, character and integrity
- Promote engineering habits of mind
- Increase aspiration, ability, and access

Inspire lifelong learning

Representing the engineering profession means that E4E is highly supportive of a 'lifelong learning' approach to skills and education. We understand, better than most, the need to keep knowledge and competence current. We also understand that lifelong learning, while it may be funded and encouraged through Government and/or employers, requires an intrinsic and innate desire on the part of the individual to keep learning.

This desire can be embedded in a child's earliest years, by making learning enjoyable and rewarding, and helping them understand how valuable it will be to them This does not mean that they should never 'fail', because that is not a suitable preparation for real life. Rather, experiencing failure, and understanding how further knowledge and practice will reduce failures in the future, helps young people build the kind of character which is not afraid to learn and try new things.

The engineering profession, with its high levels of professional standards, and network of professional engineering institutions designed specifically to support career progression, is highly attuned to the factors which necessitate lifelong learning, such as:

- The speed of technological change
- The multi-disciplinary nature of the profession, requiring new combinations of skills across engineering, science, technology, and social science
- The constant forming and re-forming of teams, which means individuals fill changing roles over their careers

These factors are experienced, to a greater or lesser extent, across all professions, and the education system must prepare young people to embrace and manage these factors.

Combine theory with application

Engineering combines knowledge of the fundamental building blocks of theory with its practical application. It is not enough to know 'about' the subject, neither is it sufficient to learn 'how' without knowing 'why'. This is what makes it such a challenging and rewarding career choice.

Any engineering role will fall somewhere on the spectrum of practical application/theoretical knowledge, but almost none lack elements of both.

We would suggest that all young people, from the most academically-minded, to the most practically adept, require an education which combines knowledge and practice. To send the message that academic high achievers don't need to learn vocational skills, or that practically-minded students can 'get away' with low levels of academic application, is misguided and wrong. We all need to be comfortable with different ways of acquiring knowledge and skills.

Prepare students to be active citizens

Engineers operate in a complex world. From the initial inspiration to actually delivering the outcome, there are a host of potential external influences and considerations. If engineering can be defined as *making 'things' that work and making 'things' work better*[1], that carries with it a great number of provisos and dependencies. At the core of this is an ability in the individual to look beyond the immediate and consider the wider implications of their actions. To do this, they must engage outside their particular sphere of expertise and influence, to work for the wider benefit.

Identify and help address weaknesses, not just encouraging strengths

As a nation, we have identified the lack of certain skills as a real barrier to progress. Employer bodies across all sectors repeatedly express their concern about the science, technology, engineering, and maths (STEM) skills of young people. This is compounded by a belief in some quarters that engineers are 'born, not made'. Given the shortages of STEM skills reported, this is simply an argument which does not hold. We need to 'make' many more engineers and technicians in the future, and we need the education system to help us.

We strongly believe that capability for engineering exists in many children, particularly at a young age. Unfortunately, the current education system is not successful in nurturing this talent and inclination beyond primary age. We need young people to 'add' other interests to their engineering, not replace engineering with others.

This means young people being encouraged to improve their STEM understanding and skills, and to apply this to their aspirations and natural inclinations. Whether a student is drawn to creativity, nurturing/caring, or financial reward, STEM will help them achieve their goals. We must stop young people putting themselves in boxes which they think removes the need for STEM study and competence.

Just as we do not want to see young people divided and narrowed by their preferred learning environment (the academic/vocational divide), we can describe any career along a continuum where STEM application is essential in some form.

Foster creativity and innovation

E4E is also responding to the DfE consultation on implementation of the EBacc, and foremost among the engineering profession's concerns is the EBacc's potential to restrict access to creative subjects such as Design & Technology. The EBacc argument has drawn out strong examples of the value of creativity in both the technical side of engineering, and in developing leadership skills. It holds true for education from the earliest age, not just at 14-16. We must nurture creativity in young people at all ages, so they have the chance to explore these skills. Engineering needs people who have leadership qualities as well as technical competence. We have found that leadership is linked to creativity – one must be creative to bring-about positive change. We believe that the UK is good at Engineering (and other things) partly because of a culture of creativity. UK Engineering is characterised by great leadership.

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[1] This is at the heart of the Royal Academy of Engineering's publication *Thinking Like An Engineer: Implications for the education system*, which was published in 2014. http://www.raeng.org.uk/news/news-releases/2014/may/do-you-think-like-an-engineer

Nurture resilience, character and integrity

Just as education should encourage young people to learn in different ways, and explore the whole range of subjects, it must give young people the tools to 'succeed' by a whole range of measures. This means they must understand the nature of failure, how it can be defined in many different ways, and how to deal with it. This means:

- Accepting when failure occurs, being able to identify it
- Admitting to failure, and identifying their part in it
- Understanding the causes
- Engaging in action to address it

This is particularly important in the education of future engineers. Taking responsibility for one's actions while understanding the nature of risk is central to successful engineering. Understanding risk, and having integrity, form the cornerstones of the role engineering will play in health, the environment, and all the other concerns which it can materially improve in the future.

Promote engineering habits of mind

The research into 'Thinking Like An Engineer' mentioned previously took a close look at how the education system can help young people develop those 'habits of mind' which engineers need. While the focus was on those mindsets which are most commonly found in engineers, in practice, they are valuable in any profession:

- Systems thinking: seeing whole systems and parts and how they connect, pattern-sniffing, recognising interdependencies, synthesising
- Problem-finding: clarifying needs, checking existing solutions, investigating contexts, verifying.
- Visualising: being able to move from abstract to concrete, manipulating materials, mental rehearsal of physical space and of practical design solutions.
- Improving: relentlessly trying to make things better by experimenting, designing, sketching, guessing, conjecturing, thought-experimenting, prototyping
- Creative problem-solving: applying techniques from different traditions, generating ideas and solutions with others, generous but rigorous critiquing, seeing engineering as a 'team sport'
- Adapting: testing, analysing, reflecting, rethinking, changing both in a physical sense and in mentally

The report suggests many ways in which education can introduce, nurture, and grow these habits of mind in young people.

Increase aspiration, ability, and access

In many ways, this is the most difficult aspect of the educational process – helping young people develop in ways which is inspiring and also attainable. In the process of 'professional formation' of engineers, the individual must have the following:

- The ambition to become an engineer
- The intellectual capability to do so
- Access to the subjects and teaching which will provide the basis of an engineering career
- The job opportunities to enable them to work as an engineer

The first three can all be nurtured in education, from an early age.

2. What measures should be used to evaluate the quality of education against this purpose

The 'purposes' listed above are quite difficult to measure in quantitative terms. However, we would suggest that the following could be used:

- Progression measures: more and better progression measures, which provided longitudinal data on choices, attainment, etc. This would show more of 'what works well' than reflecting the performance of individual education institutions and establishments
- Numbers studying STEM subjects post 14, 16, 18, etc.
- Inspection regimes which recognise and reward institutions which properly prepare their students for the next stage.

3. How well the current education system performs against these measures

Progression measures are not currently well-used in the current system. Lack of continuation post-16 is rarely addressed in the individual's pre-16 institution, yet it is usually due to the advice given, and options available pre-16 which determine post-16 success.

As for the numbers studying STEM subjects at 14, 16 and 18, numbers are improving but not at fast enough rate and not in all areas (eg girls doing physics A level remain a stubbornly low percentage). Government has specifically targeted action in this area (such as the Your Life campaign) but educational institutions are not held accountable.

The inspection regime is not yet reflecting the breadth of the purposes of education which we list above.