Supporting the T and the E in STEM: 2004-2010

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Abstract
Engineering, the 'E' in STEM, is seldom taught as a distinct curriculum subject in English and Welsh schools to pupils under the age of 14 years. This contrasts with design and technology (D&T), taken in this paper to represent the largest contributor to the 'T' in STEM (the remainder being taken to be the computing and digital communications aspects of ICT), which is currently taught to all pupils up to the age of 14 and remains a very popular option thereafter.

The UK Government STEM programme (with sister projects: the LSIS 16+ STEM programme, the London Engineering Project and the 14-19 Diploma in Engineering) has provided large-scale action-research opportunities to better understand the nature of the T and E in STEM.

This paper describes how the T and E in STEM have been found to be subjects in their own right and also to provide practical context for other STEM subjects. Some effective-practice guidelines have been established as a result, and these are discussed, but the paper concludes there is still much to do to fully establish the identity and character of the T and the E in STEM. Ideas for how this might develop are offered.

Key words
STEM, engineering, vocational education, CPD

1. Introduction
There was a determined and well-funded public policy focus on STEM (Science, Technology, Engineering and Mathematics) subjects in the UK during the period 2004-2010. The origins are in the UK Government Science and Innovation Investment Framework 2004-2014 (HM Treasury, 2004, pp159)

> "Science, technology, engineering and maths have a core role in the future health of sustainable higher value added activity in the UK. As such, the DfES (Department for Education and Skills) will play a more strategic role in the coming years towards monitoring the quality and quantity of outputs from the education system, at all levels, in STEM subjects, and acting decisively to redress emerging mismatches between supply and demand for skills."

The first use of the abbreviation *STEM* in UK public policy seems to coincide with the 2004-2014 investment framework. Two years previously, the Roberts Report (Roberts, 2002) had used *SET* when describing the same set of subjects and taking the long view the terms *Scientific Instruction and Technical Instruction* were used by successive UK Governments as far back as the mid 19th Century (Wolf, 2002, pp 62-66). Whatever the abbreviation chosen the meaning is the same. These are subjects, taught in schools, colleges and universities that aid the development of the UK economy, particularly through productive industries that provide high added-value products for export.

Productive industries are important to the UK. The UK is the seventh largest manufacturing nation in the world (ERA Foundation, 2010) slipping recently from sixth position (UNCTAD, 2008) behind the USA, China, Japan, Germany Italy and France.

2.6 million people were employed in UK manufacturing in 2009. According to data from the UK Office of National Statistics this represented 10% of all employees. Manufacturing's contribution to GDP is a little higher at around 12%. It is interesting to note that whilst the proportion of GPD due to manufacturing has fallen by two thirds since 1970 (when it stood at more than 30%) the *output* of the manufacturing sector has actually grown by 25% in that time. It is only because the economy has grown faster than manufacturing output that manufacturing has fallen as a share of GDP (Willman, 2010).

Despite UK Government's interest in promoting productive industry, engineering is seldom taught as a distinct curriculum subject in English and Welsh schools to pupils under the age of 14 years. This contrasts with design and technology (D&T), taken here to represent the largest contributor to the 'T' in STEM (the remainder being taken to be the computing and digital communications aspects of ICT), which is taught to all pupils up to the age of 14 and remains a very popular option thereafter. In fact recent data from the Joint Council for Qualifications (JCQ) shows that it is the most popular option at GCSE amongst non-mandatory subjects, with 287,701 taking a GCSE in D&T in England and Wales in 2009/2010 (JCQ, 2010).

Unlike D&T, engineering is a minority subject at Key Stage 4 (pupils aged 14-16 years) in England and Wales. Whilst the results for the popular GCSE qualifications in subjects such as English, Mathematics, Science or History are discussed in the media each summer, the number of engineering qualifications awarded in the schools sector is not routinely published. What evidence is available in the public domain suggests that around 15,000 GCSE and other 'Level 2' engineering qualifications were awarded in the English school system in 2009/2010 whereas there were 5.375M GCSE entries overall (JCQ, 2010). As these engineering qualifications will have been taken by separate individuals, and assuming a cohort size of 750,000, this represents an estimated 2% of the eligible school population taking engineering qualifications aged 14-16 years. D&T is taken by more than 1/3 of the eligible school population.

2. Technology intertwined with Engineering

The T and the E in STEM get intertwined in the English and Welsh education systems. For example, they are classed together by the Higher Education Statistics Agency (HESA) and in the National STEM Programme (Department for Children, Schools and Families, 2006). A useful definition of T and E is provided by Malpas (Malpas, 2000):

Technology is an *enabling package* of knowledge, devices, systems, processes and other technologies, created for a specific purpose. The word technology is used colloquially to describe either a complete system, a capability, or a specific device. ***Engineering*** *is the knowledge required, and the process applied, to conceive,* ***design, make, build,*** *operate, sustain, recycle or retire, something of significant technical content* ***for a specified purpose; – a concept, a model, a product, a device, a process, a system, a technology.***

Another vision of engineering is provided by the National Academy of Engineering in the United States (National Academy of Engineering, 2008)

"No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to ***improve our lives by creating bold new solutions that connect science to life*** *in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their imaginations to help us meet the needs of the 21st century."*

and in the UK (Engineering Council, 2010)

"Chartered Engineers are characterised by their ability to ***develop appropriate solutions to engineering problems, using new or existing technologies, through innovation, creativity and change.*** *They might develop and apply new technologies, promote advanced designs and design methods, introduce new and more efficient production techniques, marketing and construction concepts, or pioneer new engineering services and management methods. Chartered Engineers are variously engaged in technical and commercial leadership and possess effective interpersonal skills".*

The 'Importance Statement for Design and Technology' as a curriculum subject (Department for Education and Skills, 2004) offers a perspective on D&T:

The importance of design and technology

Design and technology prepares pupils to ***participate in tomorrow's rapidly changing technologies****. They learn to think and* ***intervene creatively to improve quality of life.*** *The subject calls for pupils to become autonomous and* ***creative problem solvers****, as individuals and members of a team. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems. They combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices. As they do so, they reflect on and evaluate present and past design and technology, its uses and effects. Through design and technology, all pupils can become discriminating and informed users of products, and become innovators.*

The highlighted sections of text demonstrate the close alignment between visions for engineering and for D&T. However, the two visions are different just as the two subjects are different. There is much in the importance statement for D&T that does not receive the same degree of focus in the visions for engineering. The primary differences lie in the emphasis given to design and realisation processes in D&T.

There are further similarities and differences worthy of discussion. These revolve around the interesting question (with helpful definitions provided by Lucas et al., 2010):

Do the T and E in STEM provide academic, practical, technical or vocational education?

First the similarities. Engineering is taught as an academic subject in Higher Education and is a blend of mathematics, engineering science and engineering practice. As with any other subject there is clear evidence of scholarship with emphasis placed on research, on the pursuit of excellence and on publication. D&T is not so frequently taught as a subject in Higher Education, although close cousins such as product design are, and the same blending of science and professional practice are evident along with the scholarship noted for engineering. As well as being academic subjects, both engineering and D&T/product design are practical subjects, where the taught course includes regular timetabled practical activities, laboratory sessions, workshop sessions and so on. Because both provide learners with technical skills it seems fair to describe both as technical subjects.

Now to the differences. Unlike D&T, where the specifications for qualifications have 'Key Subject Aims' (Edexcel, 2009), engineering does not appear as an academic 'subject' in the 14-19 qualifications system in England and Wales. The three most popular 14-19 engineering qualifications in England are the BTEC First Certificate/Diploma in Engineering, the GCSE in Engineering and 14-19 Diploma in Engineering. Specifications for the first two (Exexcel, 2008 and 2002), clearly state their links to National Occupational Standards which are designed *'to raise standards in business and industry'* (Skills for Business, 2010). This makes these qualifications vocational rather than academic. The 14-19 Diploma in Engineering is somewhat different, not claiming links to National Occupational standards but stating aims that are linked to the acquisition of knowledge and skills relating to chosen occupational sectors (Edexcel, 2010) which suggests at an employment-related approach which, whilst it might be delivered in a practical way, won't form part of a general academic education in the way that D&T does.

Making such distinctions between the academic and the vocational would seem unnecessary as long as learners enjoy their studies and gain something positive from them. For example, the Tomlinson Report (Tomlinson, 2004) stated:

> 'There is no absolute distinction between vocational and general (or academic) learning. Good vocational provision develops skills, knowledge and attributes that are desirable in adult life generally, and not only in the workplace; conversely, much of what is learnt in general or academic learning is relevant to employment.'

However, vocational education has always suffered from an image problem in the UK, going back over generations (Evans, 2008). This causes a significant difference in how 14-19 qualifications in engineering and in D&T are currently perceived with engineering being a vocational option for a minority and D&T being a general, academic option for a majority. Because of this, the engineering profession relies on D&T to provide the majority of young learners with an exposure to design, realisation, the acquisition of practical and technical skills and an overall experience of making things that work. This experience is vital if young people are to develop self-efficacy (Bandura, 1997) as people who can engineer *(i.e. conceive, design, make, build, operate, sustain, recycle or retire, something of significant technical content for a specified purpose).* However, self efficacy requires authentic practices relevant to the domain of activity. If the intended activity is engineering, then only some of the D&T curriculum applies. And then, only if it is realised in such a way to produce engineered products (something of significant technical content for a specified purpose) and not craft products.

Those in the D&T community who wish to encourage their learners to create engineered products are keen to invite engineering and engineers as 'guests in the D&T curriculum' (this was a theme of a meeting of the STEM Forum in London, 2009). Engineers are keen to accept the invitation in order to expose a significant proportion of young people to, what will be for most of them, the closest they will get to engineering within the school curriculum. This exposure is vital to them exploring an 'engineering identity' for themselves, thought to be a pre-requisite to choosing engineering as a next progression step. The London Engineering Project, which brought hands-on engineering activities to young Londoners, described this process as "positioning engineering as a viable career choice in the minds of young people" (Harrison, 2009). The importance of identity in choosing an engineering career seems to be replicated for the case of careers in science (Archer et al., 2010).

Producing engineered products within D&T has not halted declines in the formation of graduate engineers in the UK. In 2007-2008 there were 1.052M full-time equivalent (FTE) undergraduate students in England (Higher Education Funding Council for England, 2009). The number of engineering and technology undergraduates was a little over 71,000. This represented 6.8% of the higher education provision in England at the time. The number of undergraduate student FTEs grew overall by 18% between 1999-2000 and 2007-2008. The number of Engineering and Technology FTEs dropped by 4% in that time. The 4% fall overall masks some growth (in Civil and in Chemical Engineering for example up 9% and 30% respectively) and some sharp declines (in Computer Science/IT down 21% and Electrical/Electronic Engineering down 13%).

Falls in participation in Engineering and Technology Higher Education mirror antipathy towards becoming engineers more generally. Only 37% of 12-16 year olds and 31% of 17-19 year olds in the UK see engineering as a desirable career (Engineering UK, 2010). This varies with gender as another survey found (Becker, 2010) that in the UK 18% of young women and 50% of young men are willing to become engineers. This does not seem to be linked to the prevalence of manufacturing in the economy. In Germany, the largest manufacturing economy in Europe, the figures are almost identical.

3. T and E in the UK STEM Programme

The UK Government funded explicit support for STEM subjects between 2006 and 2010 under a 'STEM Programme' (HM Treasury, 2006).

The STEM Programme adopted a 'STEM Framework' (National Science Learning Centre, 2008) with 11 so-called 'Action Programmes' led by different organisations. Two of these related to Technology and Engineering and were led by The Royal Academy of Engineering:

Action Programme 4: Improving teaching and learning by engaging teachers with engineering and technology

Action Programme 6: Enhancing and enriching the teaching of engineering and technology across the curriculum

It is worth noting that Action Programme 4 does not state 'improving the teaching and learning of *engineering and technology* and that Action Programme 6 talks of engineering and technology *across the curriculum*. Neither statement suggests explicit support for either engineering or D&T as curriculum subjects. Rather, the two statements place the T and the E (reversed at E & T in Action Programmes 4 and 6) as a context for STEM. The pair of statements, over time, have has taken on a range of meanings in discourse amongst the community of STEM practitioners:

- T and E as the components of D&T which are 'STEM-like'. This became the components of D&T that were 'engineering-like' being predominantly digital: electronics, systems and control, computer aided design, computer aided manufacture.
- T and E as real world contexts for enriching and enhancing the study of STEM subjects.
- T and E as the components of ICT which are STEM-like (although this meaning was never fully explored).
- The T and the E in science (explored through the application of scientific principals to practical engineering or technological ends).
- The T and E in mathematics (although this meaning was never fully explored).
- T and E as career opportunities that are available to learners who progress with STEM subjects.

The varying strengths of these meanings, whilst never articulated in print, were evidenced by the Government funding support offered to the E and T in STEM. This was limited in scale and limited in focus to the first two items on the list. Nevertheless, some useful progress was made in understanding the nature of E and T in the context of STEM in schools as a result of this support and further progress provided through other action-research opportunities.

3.1. Action Programme 4: Improving teaching and learning by engaging teachers with engineering and technology

Under Action Programme 4, The Royal Academy of Engineering has worked since 2008 in partnership with the National STEM Centre, the Science Learning Centres and the Design and Technology Association to develop and deliver a programme of CPD for D&T teachers in England. This was co-funded by the Academy and UK Government. The project was split into three parts:

- Providing better quality CPD for teachers of D&T at the National Science Learning Centre.
- Providing better national co-ordination of CPD for teachers of D&T.
- Increasing provision of CPD for D&T teachers through the network of Science Learning Centres and partners.

CPD courses for D&T teachers were developed to help them reflect modern technology in their teaching. Key features of the courses were their emphasis on modern technology, engaging with employers and post course support via the Digital Design and Technology Support Centres and regional Science Learning Centres (RSLCs). The first two courses to be completed were *'Let's make it work'* and *'Let's make it move'* in 2009/10 (figure 1).

Both courses were under evaluation at the time of writing and the impact of the CPD on the long term classroom practice of delegates will not emerge for some while. Notwithstanding this, teachers involved in the CPD sessions report positive increase in both their confidence and competence in the STEM-like aspect of D&T covered by the courses.

In addition to developing teacher CPD under Action Programme 4 of the STEM Programme, The Royal Academy of Engineering also led the engineering

Let's Make It Work ... a course for D&T teachers

Summary
Presented by the Design and Technology Association in association with the National STEM Centre and the Royal Academy of Engineering. This course has been developed to support D&T teachers and their essential contribution to the STEM agenda at KS3. It is aimed at teachers and schools who currently do not teach the use of micro controller applications.

Overview
This course focuses on the essential elements of systems and control technology to enable pupils to embed control technology into products that they design and make through the use of Peripheral Interface Controllers (PICs). Teachers will learn how to build small products using feedback systems incorporating sense and control devices. These can be replicated by their pupils enabling them to use the knowledge in the design of their own individual products.

Outcomes
Participants will:
- gain knowledge and skills to develop the use of Peripheral Interface Controllers (PICs) at Key Stage 3;
- work through systems and control activities using hardware and software resources to be taken back into school for use with pupils;
- develop understanding of STEM and contexts associated with the use of microprocessor control;
- gain information to develop their learning further using on line resources, support available through the D&T Association Digital D&T Support Centres and the STEM Ambassador scheme.

Follow-up support
Following the course, further support will be available via the Digital D&T Support Centres. In addition, there is a vast amount of online information available to course delegates from the Electronics in Schools Strategy website (Electronics in Schools, 2010).

Let's Make It Move ... a course for D&T teachers

Summary
Presented by the Design and Technology Association in association with the National STEM Centre and the Royal Academy of Engineering. This course has been developed to support D&T teachers and their essential contribution to the STEM agenda at KS3. It is aimed at teachers and schools who currently have limited knowledge and experience of systems and control.

Overview
This course is designed for D&T teachers who need ideas for developing the mechanical control aspects of their schemes of work. It provides the opportunity to work with low cost resources that can be used at both KS3 and 4 by pupils designing and making products that require mechanical devices embedded within them. The associated science relating to their use is explored enabling cross curricular approaches to learning.

Outcomes
Participants will:
- gain knowledge, skills and understanding in the use of actuators that can be incorporated into KS3 pupils' designing and making and develop teachers' understanding of the associated scientific and mathematical knowledge;
- work through examples of practical activities that can be undertaken in school and work with resources for developing pupils' skills and knowledge when designing and making;
- develop understanding of STEM subjects and contexts associated with the use of microprocessor control;
- gain information to develop their learning further using on line resources, support available through the D&T Association Digital D&T Support Centres and the STEM Ambassador scheme.

Follow-up support
Following the course, further support will be available via the Digital D&T Support Centres. In addition, there is a vast amount of online information available to course delegates from the Electronics in Schools Strategy website (Electronics in Schools, 2010)

Figure 1.

component of the Learning and Skills Improvement Service (LSIS) 16+ STEM Programme which had the simple aim of improving teaching and learning of Science, Mathematics and Engineering in the FE & Skills sector. This work built on very detailed support given by the Academy to schools and teachers (almost exclusively D&T teachers which is of note) preparing during the period 2006-2008 for first delivery of the 14-19 Diploma in Engineering (Harrison and Ota, 2008) and subsequent support for teachers of the Advanced (Level 3) Diploma in Engineering. The combined Diploma and LSIS CPD experience has led to the following set of effective-practice guidelines for E&T CPD (figure 2).

3.2. Action Programme 6: Enhancing and enriching the teaching of engineering and technology across the curriculum.

The Royal Academy of Engineering has long supported a number of engineering enrichment and enhancements activities in schools. As a result of mapping these and a wide range of others in two editions of a catalogue of enrichment and enhancement activities produced by the Royal Academy of Engineering, the UK Government extended the idea STEM-wide in the form of the *STEM Directories* (STEM Directories, 2010). This lead to guidance being issued on how STEM activities can be best evaluated (National STEM Centre, 2009) and a set of evaluation seminars for enrichment and enhancement practitioners funded by the Academy.

Guidelines for running successful Professional Learning Communities/CPD

Through its work in supporting engineering teachers and lecturers over many years, the Royal Academy of Engineering (RAEng) has developed the following guidelines for successful Engineering and Technology teacher CPD events:

- Don't feel you have to use a whole day. A half or quarter day, when planned and executed carefully can have as much or more impact.
- A series approach to CPD is powerful. Use the findings from one session to inform the planning of the next. Take 15 minutes towards the end of every session for verbal feedback, discussion and evaluation. Reflect on what you learnt from this and improve the next session as a result.
- Use the first session of a series to ask delegates to reflect on their priorities. Advertise subsequent sessions as being on topics prioritised by practitioners.
- Make sessions relevant to local or regional employment opportunities.
- Have at least one hands-on activity in every session. Engineers enjoy them!
- Re-use existing learning materials wherever possible. There is a wealth of good material available online for free. Other materials can be purchased at low or little cost. The RAEng or the National STEM Centre can advise you.
- There are organisations who would make a short contribution to a CPD event if invited. The RAEng is one such organisation and can link you to others.
- Keeping sessions subject-specific is popular with engineering lecturers. Make sure that there is CPD on new or emerging technologies/approaches/methods in every session.
- A focus on making teaching and learning more effective is a must. Sessions should be planned for delegates to leave knowing at least one thing they can apply in their teaching straight away.
- Providing a link to engineering science and mathematics is effective. Most topics can be brought to life with the addition of simple calculations, graphical presentation of results or mathematical modelling. The RAEng can help with this.
- Identify delegates' specialisms when planning Professional Learning Community network meetings/CPD. This will make sessions more relevant for those attending.
- Give delegates at least one opportunity to present successful learning strategies and resources to their peers (show and tell/sharing best practice). This should probably focus on how they responded to a learning-based challenge and the impact their intervention has had.

Figure 2..

The Academy has been able to establish guidance on effective practice in E&T enrichment and enhancement through the long-running *London Engineering Project* (London Engineering Project, 2010) (figure 3).

The London Engineering Project, like most E&T enrichment activities aims to inspire the next generation of engineers through hands-on engineering activities and the advocacy of engineering employers and engineering role-models. In the period 2004-2010, the London Engineering Project, led by The Royal Academy of Engineering and delivered by a partnership of more than 20 organisations, has worked in 50 London primary and secondary schools and provided hands-on engineering activities for more than 20,000 young people.

The London Engineering Project worked with more than 100 teachers. It is interesting to note that these were almost exclusively D&T teachers whilst the project had offered to work with teachers from any STEM discipline. It is also interesting to note that many of the D&T teachers involved have subsequently gone on to be teachers of the 14-19 Diploma in Engineering.

4 Further steps in support of the T and E in STEM

The UK Government STEM Programme (with sister projects: the LSIS 16+ STEM programme, the London Engineering Project and the 14-19 Diploma in Engineering) has provided large scale, evaluated, action-research opportunities to better understand the nature of the T and E in STEM. These have been found to be subjects in their own right and also to provide practical context for other STEM subjects. Some

Key things learned about inspiring the next generation of engineers through the evaluation of the London Engineering Project

1. That young people from a wide range of backgrounds enjoy *doing* engineering and that engineering activities are welcomed in both advantaged and disadvantaged schools if they are well organised and planned well in advance. Over time, schools will even fund them themselves providing long term sustainability. This is particularly true for schools offering engineering qualifications such as the 14-19 Diploma in Engineering but also true in schools with no formal engineering curriculum offer.

2. At key Stage 2, careful planning of activities can ensure that 50% of participants are girls. At key Stages 3 and 4, even when activities are voluntary and extra-curricular, this proportion can be as high as 40%. This is in marked contrast to the 13% of engineering undergraduates who are women.

3. That young people can readily understand and appreciate the breadth and content of *real* engineering as long as they have it explained to them with honesty and authenticity. *Doing* authentic engineering activities helps as does the involvement of real engineers.

4. e-mentoring can be an effective tool when deployed well. Tracking e-mentoring conversations reveals that the youngest students (Key Stages 2 and 3) want to be enthused, excited and inspired by engineering; students approaching national tests (Key Stage 4) want advice on how to attain; students facing big decisions on what to do next (post 16) want honest facts on what engineering might offer them.

5. Whilst young people might enjoy *doing* engineering, they won't want to be *engineers* unless extra effort is made. Young people from south and east London can accept an image of themselves as an engineer seemingly irrespective of socio-economics, ethnicity or gender. However, this is often a fragile construct; except amongst those who have support networks that favour engineering. White working class boys are such a group.

6. Most forms of engineering activity show impact in terms of aspiration-raising, awareness-raising or informing on careers in engineering. However, the most effective combine an authentic engineering role model (an engineer or undergraduate student Ambassador) working on a relevant engineering activity alongside a young person reasonably disposed to engineering. When funding is limited, these types of activity should be prioritised.

7. Engineering employers are very willing to support and fund engineering activities in schools. They are also willing to deploy their staff as ambassadors and role models. However, they expect a high level of co-ordination and planning in return.

8. High levels of equality and inclusion can be achieved when working with schools, even when pupils volunteer for engineering activities. However, this has to be set as an absolute expectation by those leading an activity. Numerical targets should be set for diversity and payments to contracted deliverers withheld if they are not met.

Full evaluation reports can be found in (Harrison, 2009)

Figure 3.

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effective-practice guidelines have been established but there is still much to do to fully establish the identity and character of the T and the E in STEM.

A few ideas are presented here as possible next steps:

- The practical nature of the T and the E in STEM is enjoyed by pupils. Greater emphasis could be placed by curriculum developers on a more practical approach to STEM in order to augment and enrich the student learning experience. Those developers will need the support of the engineering community if the authentic and relevant engineering practices required to build engineering self-efficacy amongst learners are to be incorporated.
- The academic and the vocational characteristics of the T and E should be better defined than at present in order that those who choose curricula for schools can position them more effectively for learners. This definition will require the convening of both engineering and D&T communities and the agreement of a shared lexicon, defining *academic, technical, vocational* and *occupational* in the context of 14-19 education.
- It may prove possible to identify something of 'an engineering pedagogy'. This might in turn include: active learning, experiential learning, modeling, relating practice to theory (abstraction) and theory to practice (exemplification), mathematical modelling, 'designerly behaviour', business simulation/gaming and impact analysis (the triple bottom line: financial impact; environmental impact; social impact). This 'engineering pedagogy' (if it truly exists) could form a useful component in initial teacher education and ongoing teacher CPD in STEM subjects.
- The T and E in STEM are being explored in different ways in different schools/colleges/institutions, for example in University Technical Colleges, Specialist Engineering schools and so on. The role of the character of the institution on the development of curricula needs more research.
- There is significant international work, such as the TIMMS study (TIMMS, 2010) being undertaken on how young people relate to science as a subject and science as a career. The extent to which the findings can be related to engineering or technology is not clear. However, there seems to be opportunities for the different STEM communities to collaborate more.

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