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Today's pupils, tomorrow's engineers! Pedagogy and policy: a UK perspective

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Abstract

Purpose – This paper aims to provide a critical analysis of UK Government policy in respect of recent moves to attract young people into engineering. Drawing together UK and EU policy literature, the paper considers why young people fail to look at engineering positively.

Design/methodology/approach – Drawing together UK policy, practitioner and academic-related literature the paper critically considers the various factors influencing young people's decision-making processes in respect of entering the engineering profession. A conceptual framework providing a diagrammatic representation of the "push" and "pull" factors impacting young people at pre-university level is given.

Findings – The discussion argues that higher education in general has a responsibility to assist young people overcome negative stereotypical views in respect of engineering education. Universities are in the business of building human capability ethically and sustainably. As such they hold a duty of care towards the next generation. From an engineering education perspective, the major challenge is to present a relevant and sustainable learning experience that will equip students with the necessary skills and competencies for a lifelong career in engineering. This may be achieved by promoting transferable skills and competencies or by the introduction of a capabilities-driven curriculum which brings together generic and engineering skills and abilities.

Social implications – In identifying the push/pull factors impacting young people's decisions to study engineering, this paper considers why, at a time of global recession, young people should select to study the required subjects of mathematics, science and technology necessary to study for a degree in engineering. The paper identifies the long-term social benefits of increasing the number of young people studying engineering.

Originality/value – In bringing together pedagogy and policy within an engineering framework, the paper adds to current debates in engineering education providing a distinctive look at what seems to be a recurring problem – the failure to attract young people into engineering.

Keywords Engineering education, Pedagogy, Educational policy, Generation Y, Youth

Paper type Research paper

Background: engineering today and tomorrow

Described in a recent UK Government Report as "where science meets society and where scientific advances impact on the health, wealth and wellbeing of individuals" (DIUS, 2008), it may be argued that from a UK public policy perspective, engineering represents a bridge between science and society, linking theory and practice, academia and real life. Despite this, engineering is frequently misrepresented as "outdated or old fashioned" (IMechE, 2009, p. 1). Indeed misconceptions regarding exactly what engineering is about constitute a real barrier to understanding the profession – both in terms of public

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awareness and the recruitment of young engineers (NAE, 1998). Yet, within this somewhat complex environment, engineers are frequently called upon to deal with some of societies' biggest challenges – including those associated with environmental, energy and security-related matters (RAEng, 2008). Indeed it may be argued that if humanity is to begin to address such challenges, both now and in the future, innovative and sustainable solutions need to be found. Building on this argument, it is only logical to suggest that in the future, engineers will have a major role to play in ensuring the prosperity and sustainability of our society. A point emphasized in a recent UK Report about climate change which argued:

> [. . .] the engineering profession is an important stakeholder in enabling the world to adapt to climate change [. . .] engineers themselves need to be provided with the opportunities to respond to the challenges (IMechE, 2009, p. 25).

In sum, there can be little argument that global society faces a challenging future – a future that will require innovative and practical engineering solutions.

From an educational perspective, in order to meet future challenges, it is vital that universities are able to provide a steady supply of engineering talent able to turn its collective mind to the matter in hand. One only has to consider the impact that recent human-made disasters and natural events, such as the oil spillage in the Gulf of Mexico and the volcanic eruption in Iceland, have on global society to realise the integral and vital role engineers have to play in sustaining current and future lifestyles. Indeed, it is increasingly evident that graduates entering the profession need to be equipped with a wide range of generic skills in addition to core engineering competencies. Such skills include critical thinking, analytical abilities, creativity, a practical aptitude and an awareness of global social context (for more details, see *Engineer of 2020 Study*, NAE, 2003). Yet at a time when demands for engineers able to provide innovative solutions to contemporary problems are possibly at its highest, in the UK and elsewhere the profession is plagued by shortages and an inability to attract young people (Mitchell and Quirk, 2005; DIUS, 2008; RAEng, 2008; NSF, 2009). Whilst the solution to such shortages seems, on the surface, to be relatively simple, that is to train more young engineers, the issue is not that simple. In the USA, the problem seems to be more that engineering graduates are choosing alternative, higher paying careers – rather than entering the engineering profession upon graduation (Lowell *et al.*, 2009). Whereas in the UK, universities are increasingly struggling to attract suitably qualified young people onto undergraduate engineering programmes (RAEng, 2007a).

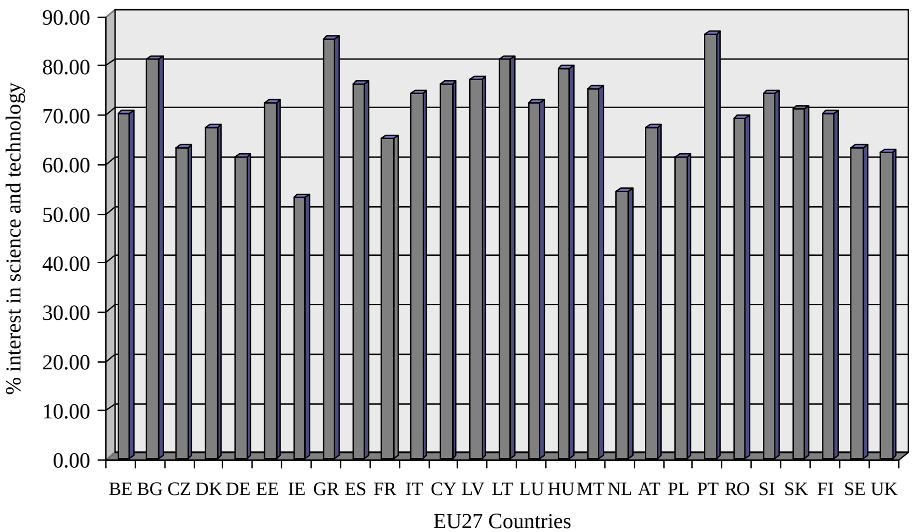
Although the current situation appears critical, potential future shortages of engineers mean that, unless action is taken urgently, matters will get worse during the next 20-30 years. From an educational perspective, predicted deficits in the numbers of young people expected to enrol in undergraduate engineering programmes over the next ten to 20 years in the developed world, will represent a serious challenge to future governments' ability to ensure and maintain a sustainable infrastructure and global community (Norden, 2008; RAEng, 2008; Schneiderman, 2010).

One of the reasons for such dire predictions is that engineering is not a preferred subject of study for the current generation of students (Gallup, 2008). Although globally engineering programmes have adapted to meet the changing needs of engineering students (Miller *et al.*, 2005; Machika, 2007), a recent study focusing on whether young people living in the European Union (EU) would consider studying engineering in order to get a job, indicated 71 per cent answered no (Gallup, 2008). This differs markedly from interest in science and technology – both areas young people are far more likely to consider as a viable career option. Figure 1 shows the variability in interest in science and technology across the 27 countries of the EU.

Taking into account the figures given in the graph, and comparing engineering to science and technology, the fact that 71 per cent of young Europeans would not consider a career in engineering, whereas across Europe over 50 per cent would consider a career in science and technology (in Greece and Portugal, the figure is over 80 per cent) is a matter of serious concern that represents a significant challenge for the engineering profession. Indeed, for governments, policy makers and engineering educators alike, the predicament is how to change young people's perceptions of engineering in such a manner that it is seen as a worthwhile and rewarding career. This paper considers this matter, looking in detail at why young people fail to view engineering positively. It suggests that in order to promote engineering as a profession that young people want to enter, both pedagogic- and policy-grounded solutions need to be found. In bringing together pedagogy and policy within an engineering framework, the paper adds to current debates in engineering education providing a distinctive look at what seems to be a recurring problem.

The lack of previous empirical research in this area has required the clarification of the key conceptual, theoretical and practical phenomena. In order to provide clarity, the literature has been used to develop a conceptual framework, upon which the research process necessary to explore the subject of engaging children in engineering can be built.

Described as "the basis of analysis", Strauss and Corbin (1998, p. 202) argue that concepts represent the "building blocks of analysis". A conceptual framework brings together the building blocks, articulating and clarifying relationships between them. In this way, the framework provides a coherent foundation upon which subsequent empirical investigation may be conducted. This perspective was also discussed



Note: See Appendix for list of EU countries
Source: Data from Gallup (2008)

Figure 1. Young people's interest in science and technology across the EU27 countries

by Dewey (1938, p. 263) who drew attention to the importance of conceptualism arguing that "The conceptual dimension is held to be logically an objective necessary condition in all determination of knowledge".

Young people and engineering education: a matter of balance?

Research conducted for the IET which draws upon a literature review critiquing just under 300 papers and articles, reiterates evidence from the 1960s that suggested school pupils' perceptions of science are framed by the time they reach 12 years of age (IET, 2008). Five "switch-off" factors which may result in students losing interest in studying science, technology, engineering and mathematics (STEM) subjects are identified (IET, 2008). These factors are: negative perceptions about future career opportunities, concerns regarding teaching, the perceived degree of difficulty, the transition from elementary to high school and the gender imbalance. Each of these factors is now addressed in-turn.

The first "switch-off" factor, negative perceptions about future career opportunities, is especially significant given the current global recession. At a time when the value of knowledge within business is of utmost importance (Chen and Mohamed, 2008) and when the engineering job market is still buoyant, the key question is what motivates a young person, aged 14-18 years, to choose to study the required subjects of mathematics, science and technology necessary to study for an engineering degree at undergraduate level? Questions arising from the EU Commission data indicating that engineering is not viewed positively by the younger generation (Gallup, 2008) suggest that engineering educators have much work to do in making engineering a viable career prospect for future generations. Moreover, when considering the perspectives of young people, it is evident that engineering is not alone amongst the STEM subjects in experiencing a negative public standing. Whilst many young people may show an interest in science and technology (Gallup, 2008), a recent study found that two-thirds of Generation Y students (that is, the current generation of teenagers and young adults, aged between 11 and 25 years; Astahana, 2008) fail to select to study STEM subjects out of a belief that to do so would limit their future career options (Science Council, 2008). Many select not to study STEM subjects as they perceive them to be overly challenging or lacking in enjoyment (Science Council, 2008). Such negative stereotypical images can mean that young people fail to appreciate the breadth of career opportunities STEM education may offer.

Concerns about the second "switch-off" factor, relating to teaching content, standards and quality, are discussed at length in the literature and represent a significant pedagogical challenge to those charged with teaching in higher education in general (McKimm, 2009; Hounsell, 2009), and with teaching engineering in particular (Booth, 2004; Maillardet, 2004). Engineering schools across the developed world are taking steps to address such concerns and in doing so are introducing new and innovative learning and teaching approaches (Baillie and Moore, 2004; Renée *et al.*, 2008). Such approaches are beginning to change the face of engineering education; however, questions remain regarding how to communicate innovation in the engineering curriculum to future students in a manner that will increase the numbers attracted onto undergraduate engineering programmes.

Likewise, the third "switch-off" factor, issues around the perceived level of difficulty in studying at a higher level have long been the subject of discussion in areas such as mathematics and science (for further discussion, see LMS, 1995; Jones *et al.*, 2000). It may be argued that such perceptions reflect changes in the secondary school examination system – particularly in the UK where, year upon year, the popular press argues that standards are dropping and examinations are becoming easier (du Sautoy, 2008; Garner, 2010). It should, however, be noted that whilst such arguments may include discussions about the prerequisite subjects necessary to study engineering, such as mathematics, physics and chemistry, they do not consider engineering education at a pre-university level *per se*. Furthermore, although much previous research has been conducted into school children's perceptions of studying at university level (Crozier *et al.*, 2008; Christie, 2009), little attention has been paid to young people's perceptions of engineering as a subject worthy of study at degree level. The reason for this is likely to be reflective of the fact that school children simply do not know what engineering entails and, thus, have no perceptions or expectations for researchers to investigate.

The fourth "switch-off" factor, the transition between elementary and high schools, is widely acknowledged to be one of the most difficult periods of a child's educational journey (for further discussion, see Huggins and Knight, 1997; Henderson *et al.*, 2003) with social class, culture and gender identified as particularly relevant in terms of success in secondary education (Lucey and Reay, 2002; Breen *et al.*, 2009). Similar difficulties are experienced by young people moving into higher education, although research suggests students' lack of preparedness for university may be augmented by insufficient student support mechanisms at university level (Pitkethly and Prosser, 2001; Harvey *et al.*, 2006). Both periods of transition are particularly relevant when considering engineering education. In the UK in particular, but also elsewhere, the fact that engineering is generally absent from the school curriculum means that university is often the first time students have been exposed to engineering as a subject in its own right. One of the longer term implications of this is that their support needs with regard to the curriculum may be high.

The fifth "switch-off" factor, relating to the gender gap in engineering and engineering education has wide implications in terms of skills shortages within the profession and damage to the wider economy. Such problems are discussed at length in UK Government and professional body policy documents (Langlands, 2005; NSF, 2009; RAEng, 2009). Whilst higher education has a responsibility to address such inequities, the need to address gender in engineering education extends far beyond the remit of tertiary education. Schools need to encourage girls to consider engineering as a viable and attractive career option – and in doing so promote the prerequisite subjects of mathematics, science and technology (Chubin *et al.*, 2005). However, despite many years of effort and numerous initiatives in this area the gender gap remains.

To summarise, it may be argued that the "switch-off factors" identified by IET (2008) represent a real challenge to engineering education; a challenge that is reinforced by stereotypical views of engineering education as a difficult, exclusive and somewhat forbidding area to engage with (Science Council, 2008). The "stereotypical view" identified in the Science Council (2008) Report suggests that many young people simply fail to understand exactly what an engineer is and what engineering is about. Whilst within contemporary society there is much talk about science, it is rare to see a focus on engineering. Indeed, the public generally have a limited view of engineering (RAEng, 2007b), often perceiving engineers to be car mechanics, technicians or train drivers. This situation is made worse by the fact that many people confuse engineering and science – failing to distinguish the differences between the two disciplines (NAE, 1998; RAEng, 2007b).

On a more positive note, and in contrast to the IET (2008) Report, earlier research by the RAEng (2007b) examined the "drivers" that influence individual decisions to become engaged with engineering. Five distinctive drivers were identified: the "wow" factor, simplicity, social responsibility, the potential for large-scale change, relevance to one's own interests and concerns. These are now discussed in detail.

The "wow" factor, which is possibly best conceptualized as a "light-bulb" moment, can be viewed as a catalytic experience in which a sudden awareness of new ideas and thinking results in a search for understanding and knowledge about engineering solutions. When considering engineering solutions, the "wow" factor reflects the uniqueness and excitement of engineering as a force for positive change. The greater the "wow" factor, the greater the public's interest and engagement. The second "driver" identified by the RAEng (2007b) Report was the apparent simplicity of some engineering solutions. The seemingly straightforward nature of some engineering discoveries and the way they can be presented does much to spark public interest and promote engagement. The third "driver", the concept of social responsibility within engineering, was also viewed in a positive light. Given the current global socio-political and economic emphasis on the "green agenda" and the wider notion of sustainability, it is not surprising that social responsibility should be a significant factor influencing young people's decisions to engage in engineering; particularly when engineering solutions can be seen to be of direct benefit to wider society.

Building upon the concept of social responsibility, and linked with young people's individual interests and concerns, is the fourth "driver", the idea that engineering can potentially bring about large-scale change to the world in a positive way (RAEng, 2007b, pp. 30-5). It is the potential to make a difference on a global scale that most attracts young people and which therefore needs to be built upon. This fits in with the fifth "driver", individual interest in engineering. There can be little disputing the argument that young people have the ability and motivation to engage fully with complex and complicated subjects – provided such subjects capture their imaginations. The challenge for engineering educators is to make the subject of engineering sufficiently exciting and socially relevant so that it captures young people's attention and in doing so sparks their engineering imaginations (McCarty, 2009).

Bringing together the literature pertaining to both the "switch-off" factors and "drivers", it may therefore be postulated that Generation Y are subjected to a number of "push" and "pull" factors, encouraging or discouraging them from considering engineering as a career choice. Figure 2 shows the authors' representation of these factors in a diagrammatic format that constitutes a conceptual framework on which further research can be developed.

In taking account of the "push" and "pull" factors on Generation Y in respect of interest in engineering, the need for the profession as a whole to balance such considerations is of paramount importance. Moreover, it would seem that at present the negative "pull" factors far outweigh the positive "push" factors in terms of general awareness and public perceptions. Indeed, having looked at the barriers and incentives to studying engineering, it would appear, on balance, that from the perspective of Generation Y there are far more barriers than incentives. The need for engineering to promote itself as a worthwhile, relevant and forward-thinking profession is evident. Engagement with the media would be a valuable step to take in doing this. Tertiary-level engineering education provides students with the fundamentals of engineering science.

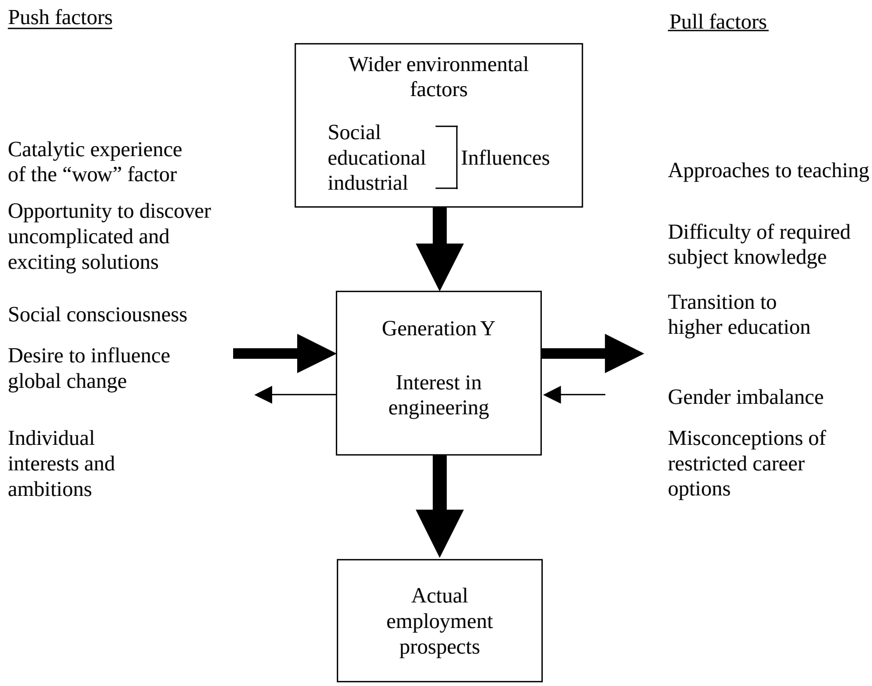


Figure 2. Attracting Generation Y into engineering: push and pull factors

However, one clear problem is that students learn little about the current methods used in industry to apply these principles to real engineering challenges. In order to address this issue, engineering education needs to be closely aligned with industry – with the curricula arranged in such a manner that enables students to explore real life industrial and social challenges. Approaches to engineering education such as problem-based learning (UNESCO, 2008; CDIO, 2009) go some way to helping address this requirement. However, one difficulty with such an applied approach is that it requires a commitment to develop and can be costly in terms of both time and money. The opportunity is to use the available resources within a university's environment to create the best "real life" model possible. In the UK, with the introduction of the engineering diploma, 14 to 19 year olds will have the opportunity to experience an application-focused curriculum that promotes engineering understanding (Lewis and Drabble, 2007; DCSF, 2010). This is a positive step yet it should not preclude efforts to engage young people in engineering ideas from the earliest stage of their educational journey.

Addressing the balance: perceptions, policy and practice

According to Dessler (2009), Generation Y may have different work-related values than their predecessors. Indeed, whilst newly qualified graduates undoubtedly bring with them the usual challenges and strengths reflective of their qualifications and abilities, they may well be the most high-maintenance workforce in history (for further discussion, see Hira, 2007; Zaslow, 2007). Moreover, as economic challenges continue to impact on business and the job market, the perceived negative characteristics of Generation Y graduates (as being fickle, demanding, inexperienced and lacking loyalty) mean that across all sectors, it is 18 to 25 year olds who are experiencing the highest unemployment levels (Tahmincioglu, 2009). Higher education in general has a responsibility to assist young people to overcome such negative stereotypical views and to promote the employability and talents of students and graduates. From an engineering perspective, this may be achieved by promoting transferable skills and competencies or by the introduction of a capabilities-driven curriculum which brings together generic and engineering skills and abilities (Bowden, 2004). Industry consultation will better ensure a supply of employable graduates but it should be in conjunction with academic considerations.

Within the UK, the opportunities for young people to experience engineering are limited in what may be described as a "resource heavy initiative culture". Such initiatives are often reliant on an individual champion within a school and based around a competition model. Evidence of this may be found in the government response to concerns about the study of STEM subjects at a secondary level with the publication of *The Shape the Future Directory* (STEM Directories, 2008). This publication details around 80 engineering-focused initiatives for school children from elementary school age through to 16 plus. Whilst this publication provides detailed information regarding the characteristics and availability of engineering initiatives, it does little in itself to boost young people's enthusiasm for, or knowledge about, engineering, and is, instead, aimed at teachers. It is the initiatives themselves which are aimed at influencing young people and they will only take place if a teacher sees a need or is driven by a personal interest. One example, the UK's largest initiative, is the LEP (2009). Funded by the government, this pilot programme runs in five of the poorer London boroughs with the purpose of developing engineering talent for the future. The ultimate aim is to increase participation in engineering at a university level (RAEng, 2008). Whilst the long-term success of this programme (which is running in 50 primary and secondary schools) has yet to be empirically proven, emerging evidence suggests that in the short term, the project is showing signs of success and that children are being enthused by the engineering challenges presented (HEFCE, 2009). This would suggest that early exposure can engage children's interest and enthusiasm for engineering and that the need to embed engineering education in the curriculum is evident. However, on a cautionary note, where engineering is currently included within the elementary school curriculum, the challenge of how to build on children's enthusiasm and carry it through to university level has yet to be addressed. Indeed, there is no coherent attempt to develop a sustainable path for children in order that early interventions can be built upon in a manner that develops and encourages the next generation of engineering talent. The UK National STEM Education Programme launched in 2009 and the follow up to the LEP may address this as the programme detail is agreed upon (HE STEM, 2010).

The "hands-on" approach offered by the engineering-focused initiatives is supported by a less direct approach in the format of a plethora of engineering and science-related materials available on the World Wide Web aimed directly at young people themselves. Examples of such materials can be found in the *Engineering – Go For It!* publication and web site produced by the ASEE (2009) and *Flipside* from the IET (2009) in the UK. Such materials bring engineering to life by highlighting contemporary and exciting examples of science, mathematics and technology in a way that is intended to appeal to young people. Whilst these publications are undoubtedly worthwhile, concerns remain that the amount of electronic material available to young people with regard to engineering, whilst creative, lacks coherence and fails to address the underpinning issues discussed earlier. For a subject already perceived as difficult, such incoherence may, at best, result in disengagement (Pinnell *et al.*, 2008) or, at worst, be damaging to the profession as a whole. Moreover, the extent to which this publicity actually reaches its intended audience is unknown.

In addition to a lack of exposure to engineering, one of the main barriers in encouraging Generation Y to consider engineering as a choice for undergraduate study relates to perceptions of the career options an engineering qualification may offer. Key influencers such as career advisors and parents are ill informed about the opportunities available, hence young people simply do not know or may be somewhat confused about what is on offer. Despite the recession, the prospects for engineering graduates are somewhat better than those of other disciplines. Indeed, the *2009 Graduate Recruitment Survey* suggests that of all of the professions, engineering has the brightest prospects for the coming year with a predicted 8.3 per cent rise in jobs. In terms of graduates' first destination for the UK, data for 2007 reveal good prospects for graduating engineers with 72 per cent entering employment and 14 per cent going on to some form of further study. Whilst such high numbers give an indication of the demand for qualified engineering graduates, concerns exist regarding a lack of suitably qualified graduates to fill those vacancies (AGR, 2009). It is up to engineering educators to address such concerns, and to make sure those graduating from engineering programmes are not only qualified to take up vacancies – but are also enthused by engineering and looking forward to a career in the field.

Evidence suggests that interest in engineering is often higher in the developing world than it is in developed countries (Wu, 2009). This is reflected in increased public perceptions of the status of engineering in the developing world. Testament to this argument is the considerable growth in the number of engineering graduates in China over the past few years where engineering is viewed as a positive and socially responsible career choice (Wu, 2009).

Using data from the Gallup (2008) Report, a correlation analysis was performed considering GDP, interest in STEM and the number of STEM graduates. It was found that there is no correlation between GDP and the number of graduates. Moreover, there is a low negative correlation of 0.35 between GDP and interest in STEM, similarly for the number of graduates and interest. Whilst this data need further investigation, it appears that the relationship between interest in STEM and more measurable factors such as GDP and the number of graduates is multifaceted and complex in nature. The suggestion is that low interest in STEM is more prevalent in developed countries where the status of engineering as a worthwhile and fulfilling profession is less acknowledged.

Whilst the rising status of engineering is matched by increased numbers of engineering graduates in the developing world, a recent report by the Deutsche Bank (2008) argues that the actual number of STEM graduates has also risen since 1999 across much of the industrialized world including the EU, Japan and the USA. However, on a cautionary note, this rise does not reflect an increase in the overall percentage of young people studying STEM across the curriculum as a whole. Indeed, the rise in the number of STEM graduates has been insufficient to maintain the disciplines' overall share of the graduate labour market; when compared to other subjects, the overall percentage of the graduate labour market in 2005 fell for the STEM subjects from 24.8 per cent in 1999 to 22.7 per cent (Deutsche Bank, 2008, p. 5).

Moreover, across the EU 27 since 1999, of those opting to study STEM subjects, the vast majority have selected to study computer science. Whilst young people's preferences towards computer science are undoubtedly reflective of the current digital age, it is not unreasonable to suggest that many of those currently opting to study computing do so to the detriment of engineering and other STEM subjects (Deutsche Bank, 2008). The question of how to attract more young people into engineering across the developed world remains one that needs urgently addressing.

Discussion and concluding remarks

Whilst the notion that interest in engineering may be negatively impacted by a rise in interest in computer science provides a worthwhile focus for discussion, the need to make STEM subjects in general, and engineering in particular more attractive for young people remains of pivotal importance. One important factor when considering how to promote engineering to Generation Y is the expectation that engineering schools should provide graduates able to meet the ever-changing needs of industry (Bowden, 2004). The idea of aligning curricula and learning and teaching with the needs of a specific area of industry has the potential to present a number of problems – most notably when considering how to equip students with the appropriate skills and competencies for effective employment and mobility in an ever-changing global profession. Indeed, it may be argued that building the curriculum around the need to cater for current economic and industrial needs in terms of addressing current job shortages may well be a strategic mistake in the longer term. Although an awareness of market needs in respect of addressing "windows of opportunity" is necessary to meet short-term economic needs (Katila and Mang, 2003; Huang and Ritter, 2004), the danger is that such an approach is strategically unsound. From the perspective of higher education, whilst consultation represents a necessary part of future curriculum development, it is evident that engineering educators need to capture the needs and perspectives of a wide range of stakeholders including senior professionals, policy makers and alumni groups. However, unlike product design, there is no room for trial and error. Universities are in the business of building human capability through ethical and sustainable development, as such they hold a duty of care towards the next generation. From an engineering education perspective, the major challenge is to present a relevant and sustainable learning experience that will first attract students and then equip them with the necessary skills and competencies for a life-long career in engineering.

In trying to make sense of some of the challenges faced by the engineering community in attracting more young people into engineering, this paper has only started to scratch the surface. For school children today, the distinction between science and engineering is difficult, if not impossible, to distinguish. For many young people in the developed world, the observation that their knowledge of engineering tends to be limited or non-existent remains a major pedagogical challenge for universities. Indeed, this paper has shown that even those selecting to study engineering at a university level generally have little idea exactly what it is they have chosen to study.

Thus, raising awareness of the fundamental principles underpinning engineering, as a profession needs to be a high priority. The arguments in this paper suggest that this needs to be achieved in a coherent and targeted manner, backed up by adequate resources and supported by realistic policies. Engineering educators need to take steps to place "engineering" at the heart of public debate, raising public awareness whilst addressing fears and misconceptions. There is a strong case to suggest that governments need to be persuaded to make engineering a core subject, differentiated from science, in the educational curriculum. With perceptions framed by age 12, some argue even earlier, a prime focus must be elementary school level but with a continuity of effort through to university entrance and enrolment on an industry-influenced programme of study.

With the embedding of engineering into the school curriculum will come the opportunity to capitalise on, and further develop, a range of creative learning and teaching resources and interventions that bring all STEM subjects alive through the discipline of engineering. This creativity must not stop at the school level; it must become part of the engineering education culture in universities across the globe. Creativity must not negate the need for quality, so along with developing resources engineering educators must ensure that the curriculum is delivered in a professional and aligned manner. Engineering has the benefit of being a subject that crosses boundaries linking all subjects from mathematics to history, design and technology to languages in explaining real world issues.

No small challenge, but one we must meet if we want a future that is both rewarding and sustainable. In conclusion, perhaps the message the engineering profession needs to get across to today's teenagers may best be summarised by Von Karmen (2009) who stated "scientists discover the world that exists; engineers create the world that never was".

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Appendix. List of EU countries

AT Austria.

BE Belgium.

BG Bulgaria.

CZ Czech Republic.

DE Germany.

DK Denmark.

EE Estonia.

ES Spain.

FI Finland.

FR France.

GR Greece.

HU Hungary.

IE Ireland.

IT Italy.

LU Lithuania.

MT Malta.

NL The Netherlands.

PL Poland.

PT Portugal.

RO Romania.

SE Sweden.

SI Slovenia.

SK Slovakia.

UK United Kingdom.

About the author
Robin Clark is Head of Learning and Teaching Research at Aston University, Birmingham, UK. He has a degree and PhD in Mechanical Engineering from University College London and an MBA from Western Connecticut State University. He worked in the UK and the USA as both an engineer and manager during a 14-year career in industry. His area of technical expertise is non-destructive evaluation. Starting in the nuclear industry, he went on to work on technology development applications in the rail industry. On joining Aston University in 2003, he took a lead role in developing the School of Engineering and Applied Science MSc in Engineering Management (accredited by the Chartered Management Institute). Using experience gained in industry, Robin has developed a creative teaching practice that in 2007 resulted in the award of a National Teaching Fellowship. Although engaged in research in the engineering and management fields, most recently as a Co-director of Aston's Centre for Project Management Practice (ESRC supported), Robin is now focussing on learning and teaching and building a strong research capability at Aston. Areas of research interest are engineering education, school/university transition, employability and the student experience. Robin is a Fellow of the IMechE. Robin Clark can be contacted at: r.p.clark@aston.ac.uk