A White Paper: T-shaped Learning for the New Technologist

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NEF
The Innovation Institute

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White Paper:

T-SHAPED LEARNING FOR THE NEW TECHNOLOGIST

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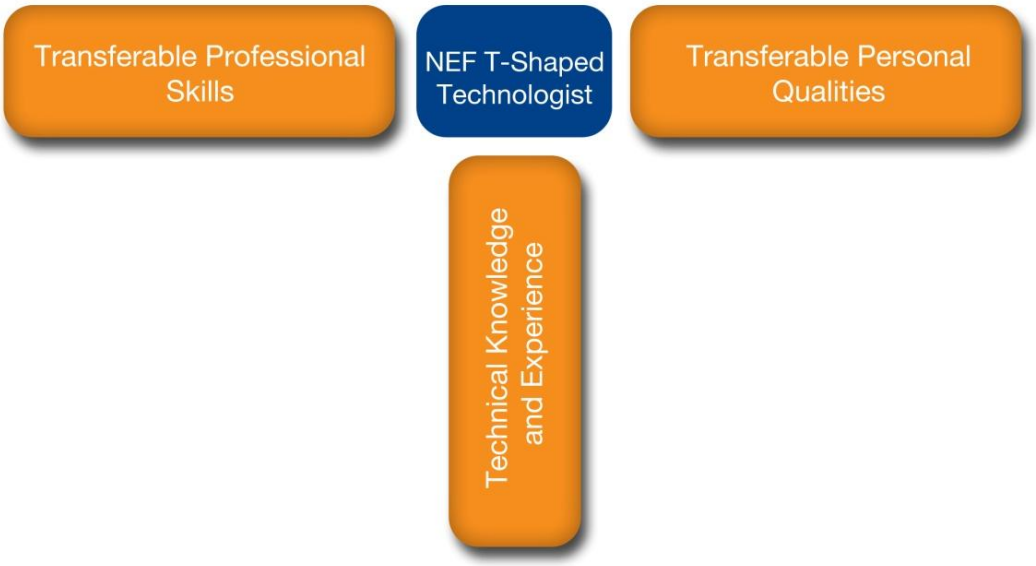
FOREWORD

This White Paper prepared by NEF: The Innovation Institute puts forward a radically new approach to the development of the knowledge, skills and behaviours required by individuals to perform well in a wide range of Science & Technology (SciTech) related industries and sectors.

We present here the new T-Shaped Technologist and with this, T-Shaped Learning, a model for education and skills which will cultivate and catalyse learners into productive, valued and responsive technologists for a new age of industry.



I hope this concept paper will stimulate debate and discussion. We welcome your views and participation in future events to develop the concepts outlined here.

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Chief Executive
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1. Background

The skills gap in SciTech skills is hampering the UK economy.

UK industry, particularly the SciTech related sectors, relies heavily on a trained workforce at several different levels of skills and knowledge ranging from operatives to design engineers.

There is absolutely no doubt that there is a shortage of SciTech skills at almost all levels and across all SciTech industries. The shortage of graduates in most engineering and science disciplines is most often highlighted by the media and by education; but it is the 'middle' levels, the technicians and technologists, where the gap is widest and which is having the most impact on UK industry by limiting growth, particularly in new and emerging technologies.

Aside from the fundamental issue of the longstanding weak SciTech base in the UK, there are several further reasons for this technical skills gap in the UK:

- **Perceptions:** The value and opportunities of technical roles are not always recognised by schools, colleges and parents/carers. These job roles are often perceived as non-aspirational;
- **Education:** Learning for work is often seen as inferior, and there is a lack of appreciation at all levels of education of the role of SciTech in the world outside education;
- **Workforce training**: Instruction can be very specific to a sector or company, so leading to inflexibility – the 'not-trained-here' syndrome – and on to reduced mobility to other sectors;
- **Lack of development:** Technician level staff are often not encouraged to develop skills beyond those required for their immediate job role. This impacts on innovation, enterprise and growth;
- **Barriers to progression:** The recognition of skills developed and expertise gained, beyond the immediate monetary reward an employer might make, is limited.

Building the case for Technologists' education and careers

The lack of investment in SciTech skills is:

1. Limiting productivity and growth
2. Restricting mobility between and across sectors
3. Preventing knowledge transfer as a catalyst for innovation
4. Stunting progression and enterprise

Examples of what industry wants…

Development Technologist
Salary: £30,000+
Employer: Lonza Biologics
Location: Slough
Contract Type: Full Time

To perform routine computerised goods manufacturing processes stability testing for therapeutic products

Key responsibilities and accountabilities

1. Perform routine stability testing using analytical techniques
2. Capture data and testing as per internal systems
3. Perform data evaluation
4. Maintain key assigned laboratory equipment
5. Troubleshoot assays as required
6. Attend specialised training and to develop relevant knowledge and skills

Qualifications and attributes

- HNC/ knowledge/ experience of performing protein analysis
- Effective organisational skills to ensure completion of work to challenging deadlines whilst maintaining accuracy and attention to detail
- Professional attitude with competent verbal and written communication skills to present data both internally and externally
- Good team worker – works with managers and other team members to ensure team and department operates efficiently
- Proactive – anticipates problems and shows initiative for problem-solving and generating new ideas

Technologists
Salary: Up to £30,000
Employer: Hilton Meats Retail Ltd
Location: Huntingdon
Contract Type: Full Time

This role is to assist in the development of new products. You will be liaising with our customers, suppliers and internal departments to ensure the efficient launch of new products and on-going review of existing products. You will also be responsible for researching current and potential trends within the business.

The successful candidate will ideally have fresh meat experience and knowledge of production processes and a food industry qualification or experience would be advantageous. Excellent computer skills – Word, Excel and PowerPoint are essential, as are good analytical skills and an attention to detail. Duties include working with our technical team to create product specifications, conducting factory trials, assisting with presentation of new products and producing appropriate data and reports.

"The demand for new technologists is growing. Indeed Recruitment's website recently had 1,366 vacancies for New Product Development Technologists."

2. The T-Shaped Technologist

Adopt and adapt the term 'Technologist' to change perceptions and drive innovation.

A technologist is a senior technical employee, highly trained and experienced, often with a supervisory role leading teams of technicians. Typically they carry out specialist functions including:

- Planning and design;
- Delivery and operations;
- Maintenance and diagnostics;
- Evaluating and reviewing;
- Leading, managing and supervising.

Such individuals are in high demand from UK industry.

An opportunity for Policy and Further Education
The opportunity is to embrace the T-Shaped Technologist model for technical vocational education and training to support innovation, productivity and growth.

Adopting the term 'Technologist' creates an opportunity to change perceptions...

- It is a broad, inherently multidisciplinary term, with no legacies or baggage
- It is a natural, futuristic and approachable term - chiming well with aspirations of younger learners
- It supports the notions of *broadening* and *deepening*, both educationally and professionally
- It works well as a role postfix such as clinical technologist, product technologist and design technologist
- It offers a 'cachet' which attaches a sense of value, career progression and personal rewards such as development and salary

For most SciTech sectors, technologists will hold qualifications at a minimum of Level 3, but will often have attained up to Level 6.

Depending on the sector, they may hold professional qualifications, such as Engineering Technician or Incorporated Engineer (EngTech, IEng).

In all SciTech sectors, there is huge amount of investment to turn a school- or college-leaver, or even graduate into a technologist. This indicates the wide gap between the output from education and the expected attributes of a technologist.

The **T-Shaped Technologist** combines technical knowledge & experience with professional skills, and personal behaviours & qualities which will include leadership, enterprise, and a drive for innovation. These individuals will fulfil the demand for technologists from industry and will also create and drive new business from agriculture to platform games, from hairdressing to new interactive web based business, from creative industries to traditional manufacturing.

3. T-Shaped Learning

The new Technologist will require a new model for learning.

NEF is championing T-Shaped Learning as a means to create the new T-Shaped Technologist by:

- Identifying the attributes in technicians, applied scientists, technical engineers and so on that are of value to industry and enable economic growth and innovation in the UK;
- Embedding these attributes within a new proposed model for education with a wide application to business and enterprise;

The T-Shaped Learning model meets the demand for the T-Shaped Technologist by integrating three core stands of learning into a cross-cutting curriculum (and potentially co-curricular) framework covering:

1. ***Technical knowledge and experience*** – largely discipline specific and defined by the sector; and including "know-how", those good, practical skills, but importantly also "know-why", a sound understanding of the STEM theory behind practice;
2. ***Transferable professional skills*** - including business acumen, and the skills related to knowledge transfer and innovation;
3. ***Transferable personal qualities*** - including enterprise and initiative, behaviours and attitudes – some of which are seemingly nebulous characteristics.

Developed together these three elements enable an individual to perform well in their chosen career/industry and to work across discipline/expertise boundaries.

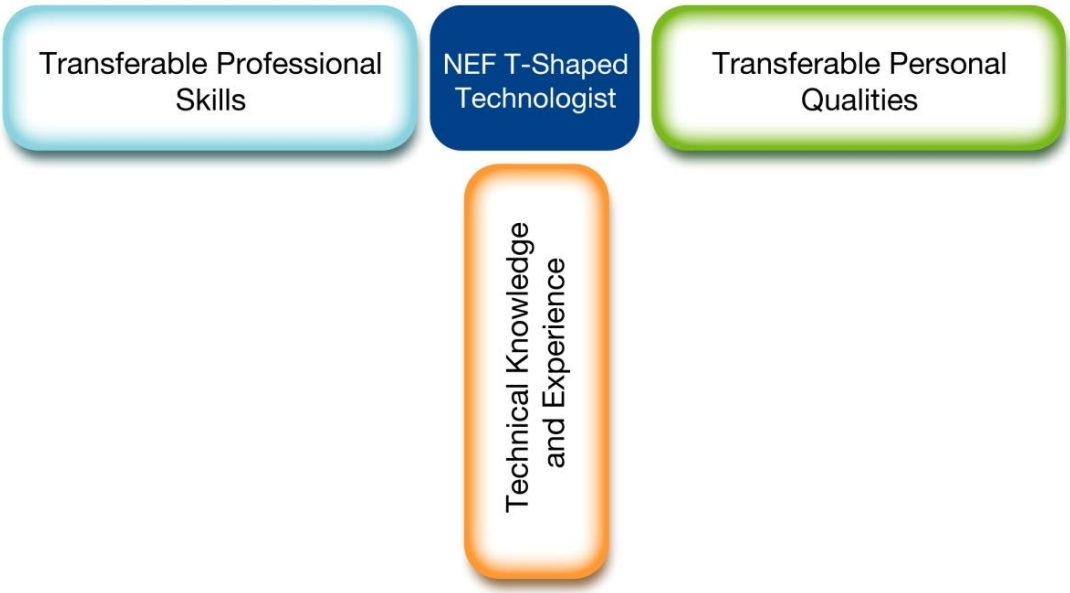

Figure 1 - The T Shaped Technologist

The likely knowledge, skills and behavioural outcomes related to each of the three strands of learning are briefly described below. The expected outcomes will be defined fully according to level- and job role dependent. The model for learning will make explicit how, where and when each attribute will be fostered or developed, as part of formal learning, or through other means.

Technical Knowledge and Experience	Transferable Professional Skills	Transferable Personal Qualities
Scientific and technical knowledge • Demonstrate in depth understanding of a specialist, technical field • Express broad knowledge and understanding of scientific and technical principles across their sector and the wider field of science and technology	Sector and industry understanding • Understand the relevance of their technical specialism within the wider sector and in relation to other specialisms • Identify potential career routes available and the relevant professional development paths	Critical thinking and communication • Use critical thinking to synthesise information, communicate & evaluate opinions and demonstrate understanding of issues from differing perspectives • Use speech, writing, technology & behaviour effectively to present and exchange opinions, ideas & information
Scientific and technical practical knowledge and experience • Apply knowledge in core STEM areas to practical situations • Understand and use of diagnostics and problem solving to generate ideas & solutions and the need to monitor the development of ideas	Cross sector technologies and innovation • Understand and use core technologies within specialist discipline, across the wider sector and as a driver for innovation • Recognise the impact of technology on markets and emerging sector trends	Personal enterprise and initiative • Identify and respond to opportunities and initiate change to support continuous improvement • Identify, control and make effective use of human and physical resources to initiate, review and sustain activities
Scientific and technical discourse • Understand and use of technical language to explain and convey technical subject information orally and in writing • Accurately manipulate, interpret and present numerical and technical data in relevant context	Core business and professional skills • Understand the global nature of business strategy & operation and the process of establishing, operating & resourcing a business or project • Define the role and impact of stakeholders on a business and the need to follow correct procedures and comply with relevant legal obligations	Self-awareness and active leadership • Define personal values, qualities and skills within the context of their career aspirations and using this to plan professional development • Lead teams effectively, making best use of available knowledge & skills, setting direction and taking responsibility for actions

Table 1 - The three core strands of T-Shaped Learning explained

4. A new model for curriculum design and delivery

The old approaches to curriculum design and delivery just won't work. A new model for curriculum delivery is needed.

Typically a learner is asked to choose a pathway that leads to a restricted menu of disparate qualifications, made up of disparate modules, and if the desired attributes – professional, determined, tenacious, collaborator, creative, innovative – are developed, it is through serendipity and not design.

Assessment becomes a *tick box* process: has the learner achieved the right number of modules with the right score? And this may lead to a weak, incoherent and irrelevant (see Figure 2) process of education.

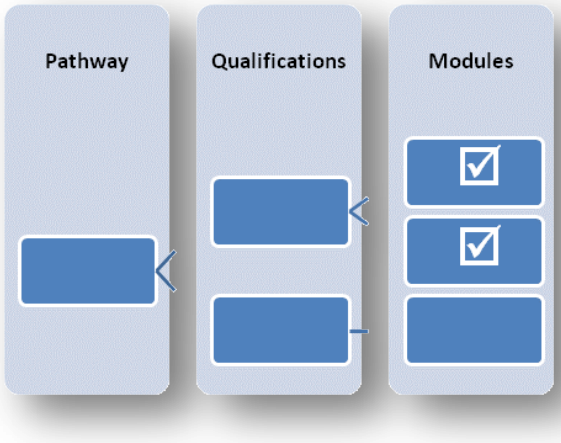

Figure 2 - A *tick box* model for education: an incoherent process

A new model of education is therefore required; one where the world of work is inextricably from education, where learning for all desired attributes is deliberate, where the curriculum and assessment is well integrated. A model that sets a context; conformity, uniformity and the repression of creativity in the pursuit of league-table position is no good.

The new model needs to comprise:

- An atmosphere in which learners (of all ages) can think and create;
- An ambition to stretch the capabilities of all and which responds to all types of intelligence, understanding how deep learning happens;
- A teaching and learning strategy that encourages ingenuity and sees classes as 'theatres of opportunity' and utilises new technologies effectively;
- A curriculum that is based on delivering technical skills, attributes and capacity to apply knowledge and linked closely to work and industry;
- An assessment regime that records these things through accreditation and demonstrations of knowledge, skills and behaviours;
- A self assessment approach to quality and relevance, driving innovation.

The T-Shaped Learning framework would therefore offer a means by which to:

- Implement a new approach to vocational learning underpinned by a robust framework focused on the development of T-Shaped Technologists;
- Realise a cross-cutting curriculum – the imaginative and the logical, the technical and the creative, with enterprise at the core;
- Focus on technological and engineering knowledge and skills;
- Emphasise a true understanding of the fundamentals of science and mathematics;
- Develop personal and professional transferable skills and behaviours in a robust way as an integral part of the learning experience;
- Ensure the learning intensifies with 'level' as part of an integrated curriculum framework of accredited modules, with core modules clearly identified;
- Adopt new and innovative approaches to assessment, as well as recognise (and accredit) co-curricular learning and development as an integral element of the students' experience;
- Provide learning pathways mapped with routes of progression, as part of a clear and integrated learning and teaching strategy;
- Integrate employer engagement and knowledge exchange, with the support of dynamic, highly capable and industry-experienced lecturers;
- Support institutional self evaluation, driving continuous improvement and innovation.

The new T-Shaped Learning model may be built upon the best of the current model, but needs to make explicit the need for *3-dimensionality* of curriculum and of assessment, linking assessment and curriculum across to the attributes represented by the horizontal bar of the T-shape. But more than this, we need a better approach to assessment.

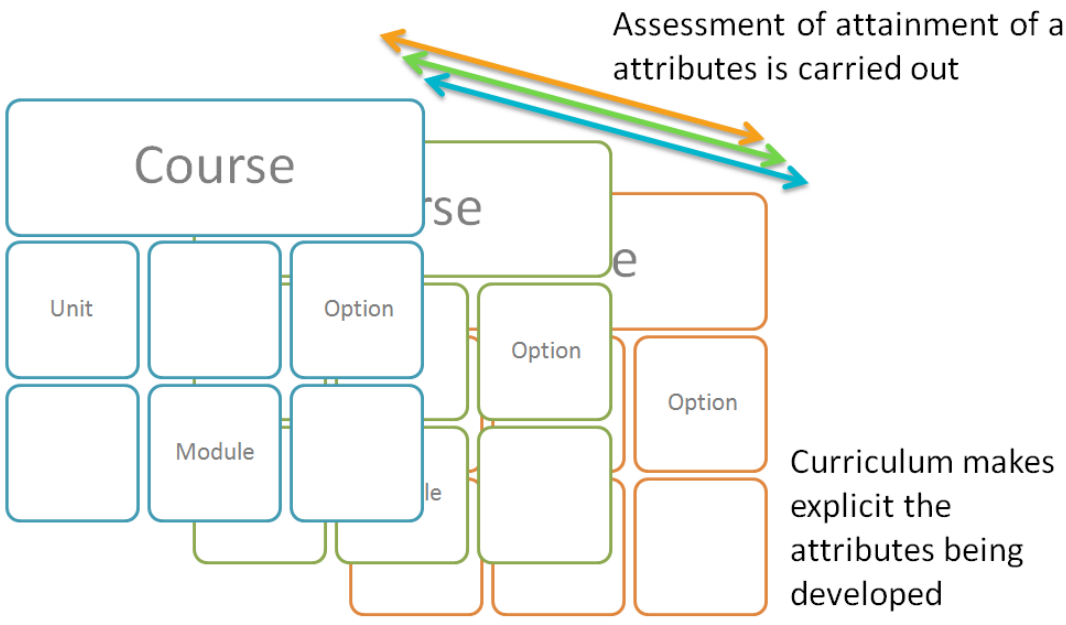

Figure 3 –The T-Shaped Learning framework: A *new* 3-D model for education

5. A new approach to assessment

Current measures of success and attainment for learners are not always relevant for the real working world.

We need success measures that relate well to what the economy and society need and what the student has learned. Students want qualifications to mean just that – they are qualified to do something, something that their learning has given them and is added-value and will be accepted as such. We do not need a proliferation of certificates that simply tell someone and their employer what they already could do.

The aim should be measuring success in terms of 'economic value', 'personal gain' and 'potential future value'. This could include measures of success that, via qualifications combined in programmes:

- Capture the enterprise and innovation capacity of students, by continually assessing them;
- Endorse expertise and skills in terms of the knowledge students acquire and their capability in applying it;
- Are based on the demonstration of knowledge and skills, technical, professional and personal;
- Are graded and based on 'limitless ceilings' not 'solid floors'.

We propose **five core principles** to underpin development of new framework for learning and assessment:

- **Success has to be based on real measures of the attributes students develop through the educational process**. This will tell what people can offer, they will encourage the full range of intelligence and they will be about what people can do, not what they can't. The T-Shaped Technologist model identifies the technical skills and competencies, the attributes and behaviours that are valued and that provide learners with real opportunities, and the means to demonstrate these capacities;
- **Outcomes-defined** that get us off the hook of 'outputs' and into a better understanding of the impacts of colleges have on their communities. This should be achieved through **better qualifications and assessments** that help fulfil the needs but which do not lead to a narrow 'route one' approach to the goal of success in education;
- Teaching moves towards new practice to support **'deep' learning**, where lecturers are facilitators and coaches, with a good understanding of STEM, industry and new technologies, and versed in the art of understanding the young, taking a leaf out of the approach to training demonstrated by BRUSH Electrical Machinery (the Loughborough based manufacturers of turbo-generators) and Rolls-Royce[1];

[1] BRUSH and Roll-Royce are featured, with other examples from industry, in NEF's research report Open Innovation in STEM Learning, published December 2012.

- Skills demonstrated in **different and work-based settings**, as a means to ensure that new skills have been acquired and can be practised by the student;
- **Applying knowledge to new situations** is the ultimate form of effective assessment of learning.

The T-Shaped Learning for the new Technologist – taking inspiration from the best implementations of apprenticeship frameworks – would be supported by a range of robust assessments and vocational qualifications. It will:

- Encourage **enterprise and innovation** via teaching, learning and assessment;
- Assess **all desirable attributes** representing expertise, technical skills and creative capacities...
- ...in a way that does not risk either an 'easy pass' system, or a just the latest version of 'tick-box target hitting'.

The key will be to inject rigour into the assessment process; to describe outcomes rather than content and to design a new overall framework– T-Shaped Learning for the new Technologist – which delivers the following features:

- **Outcomes-led**: examination boards need to prescribe less and describe more. That is, they need to describe the required outcomes (expertise, enterprise, skills, applying knowledge) with precision – and leave the rest to colleges to devise the best means to achieve the outcomes based on the possibilities of collaboration with employers and industry;
- **Creative intelligence rewarded**: the new framework needs to create plenty of opportunity for creative intelligence to thrive – partly by liberating the learning process to enable students to drive it; partly by encouraging a learning model more suited to the technology of the day and the future; and partly though the means of assessment requiring the use of creative intelligence;
- **Technical expertise:** across the whole range of education, this is important. From the manipulation of formulae to the construction of a wall, students will need to demonstrate they can do what is necessary to demonstrate expertise at a particular level;
- **T-Shaped Technologist:** is the citizen for the future; equipped with a broader range of expertise across the art / design / technology / engineering/ science needs that the economy of the future has for high-grade technical experts. A possibility is to define new qualifications in the terms of 'Technologist'.

6. Moving the concept forward

We have an opportunity to act now and make T-Shaped Learning happen.

The key factors in ensuring success in creating T-Shaped Learning for the new Technologist are:

Extrinsic	Intrinsic
• Freedom to design the curriculum; • Outcomes-led assessments; • Funding and accountability that align the policy need with college action and intended impacts; • Engaged industry and employers to shape the learning.	• Progress towards the Intelligent College model; • Horizon-scanning and knowledge transfer capacity and capability; • Realising the assets of colleges for prototyping, patent realisation; • The golden thread of innovation demonstrated through customer focus, employer engagement and ingenuity.

Given this we advocate building on recent innovations in Further Education and creating a new model for STEM learning. NEF can support with this by:

- Shaping further the concept and identifying the attributes of the T-Shaped Technologist directly with industry and colleges;
- Devising the new T-Shaped Learning model with industry and colleges that will develop these attributes deliberately rather than by osmosis - an informed and enriched work-based experience;
- Guiding FE colleges, through the **STEM in Development** programme, to create the new T-shaped Technologist as part of their offer;
- Supporting FE colleges, through **Innovation Hubs**, to develop internal and external ingenuity and connect to industry;
- Enabling curriculum development informed by horizon-scanning information through **STEM Foresight**, that exploits employer and industry engagement, assets and capability;
- Assuring colleges that offer to all their learners coherent, fit-for-purpose STEM provision that is informed by industry requirements, through **STEM Assured**, and supporting or accrediting a student award for the T-Shaped Technologist.

Acknowledgements

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We are also grateful for the support of the NEF Advisory Panel; in particular those individuals who took part in a Think Tank at the Royal Society of Chemistry:

Think Tank 18 October 2012

We thank the following for providing us with their views on the T-Shaped Technologist concept, the attributes and the model for education, during this facilitated workshop event.

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Terry Killer	Microsoft
Dr Terry Butland	Middlesex University
Mandy Crawford-Lee	National Apprenticeship Service
Jo Tipa	National Skills Academy - Nuclear
Graham Schuhmacher	Rolls-Royce Plc
Rowan Joachim	Transport for London

YOUR VIEWS

We welcome views and opinions on the concepts represented in this paper , and we invite expressions of interest to take part in future consultations on the T-Shaped Technologist and a new model for STEM learning.

To respond to this paper or request to take part in future discussions on the T-Shaped Technologist, please contact sarah.peers@thenef.org.uk.

Professor Sa'ad Medhat, CEO
Dr Sarah Peers, Director of Programmes

A FINAL WORD...

We have all read about the "skills gap" that has emerged in the UK: students are not being trained enough in science and technology, engineering and maths to support our commercial and industrial ambitions. This is a particular worry for **New Scientist**, where we believe that using the processes given to us by STEM subjects are the best ways not only to find out about nature, but also to manipulate it for our benefit. There is no doubt we need to fill that skills gap urgently if the UK is to play a part in our increasingly technological future.

But while technical skills are necessary, they are not always sufficient for innovation, enterprise and growth. Ideas only become worthwhile innovations if they can be put into practice. And to achieve that usually needs much wider understanding: the aims and limitations of commerce, how to convince colleagues to try something new, the value of a smile when talking to a customer.

It would be wonderful if students emerging from our colleges, especially from vocational training, had both technical know-how and a good appreciation of the business skills and personal behaviours needed to be successful. To achieve this ideal will almost certainly mean that some colleges will need to rethink what and how they teach.

This White Paper has put forward a model that describes this ideal that will, perhaps, drive the type of STEM education that will help reduce the skills gap and support innovation and enterprise for UK industry. And it is now over to you, colleges and employers, to take part in future conversations to shape new teaching and learning that will drive innovation and growth in science and technology.

Jeremy Webb
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