

Progression through STEM

The challenges, issues and opportunities

Teaching and Learning

LSIS LEARNING
AND SKILLS
IMPROVEMENT
SERVICE



Including
'Talking STEM'
activity cards

Progression through STEM

I am delighted to be able to introduce this innovative and stimulating report: *Progression through STEM* and the linked pilot activity cards, *Talking STEM: an introduction for managers*, developed by the Learning and Skills Improvement Service (LSIS) as part of the Teaching and Learning Programme.

This Programme aims to support providers to improve the quality of teaching and learning by linking organisational strategies for quality improvement, continuing professional development (CPD) and the Subject Learning Coach model. The emphasis is on helping the sector help itself, knowledge transfer and building on what is already there.

Teachers, tutors and trainers in the learning and skills sector work with a wide range of learners – work-based learning organisations, in adult learning, in colleges, in prisons, in voluntary and community organisations and in the workplace. This resource has been developed in consultation with them and their learners as well as other subject and national experts. The resource has also been designed to support the aims of the Institute for Learning (IfL) and the requirements for Professional. As the professional body for teachers, trainers and assessors across the learning and skills sector, IfL’s key priority is to support individual teachers’ and trainers’ learning so that they can maintain their high professional status and have long-term CPD interests as career teachers.

I hope you find this resource and the approaches of real benefit to you and your organisation. I am certain you will find it provides an excellent opportunity for your teachers, tutors, trainers and managers to improve their professional development and support LSIS’s mission of excellence for the learning and skills sector as a whole.

Markos Tiris Programme Director Teaching and Learning

Why STEM?

STEM brings together Science, Technology, Engineering and Mathematics, and all the subjects that draw on these areas, to create a vital strand that can deliver benefits to further education providers, teachers, learners and the wider UK economy. As Lord Sainsbury put it: “The UK is well placed to take advantage of the new markets opened up by globalisation. We have an extraordinary record of scientific discovery and a rapidly growing share of high-technology manufacturing and knowledge-intensive services in the UK’s GDP.” (Lord Sainsbury Review of Science and Innovation, 2007). Therefore, supporting learners in developing their skills across STEM can help raise achievement, broaden career opportunities and offer greater potential in innovation to business and industry.

The learning and skills sector has an essential role to play in improving STEM education, supporting learners across further education, adult learning, work-based learning and prison education. The LSIS STEM Programme aims to support providers across the sector to enhance STEM teaching and learning, offering both subject-specific support and encouraging collaboration across all the STEM-based subjects to ensure that learners are supported effectively however they engage with STEM. The programme offers free, targeted support that is of real, practical value to teachers and managers including training, networking, resources and funding.

To find out more about the LSIS STEM Programme visit www.excellencegateway.org.uk/STEM or email info@lsisstem.org.uk to be put in touch with the STEM Programme manager in your region.

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STEM in further education: the big picture

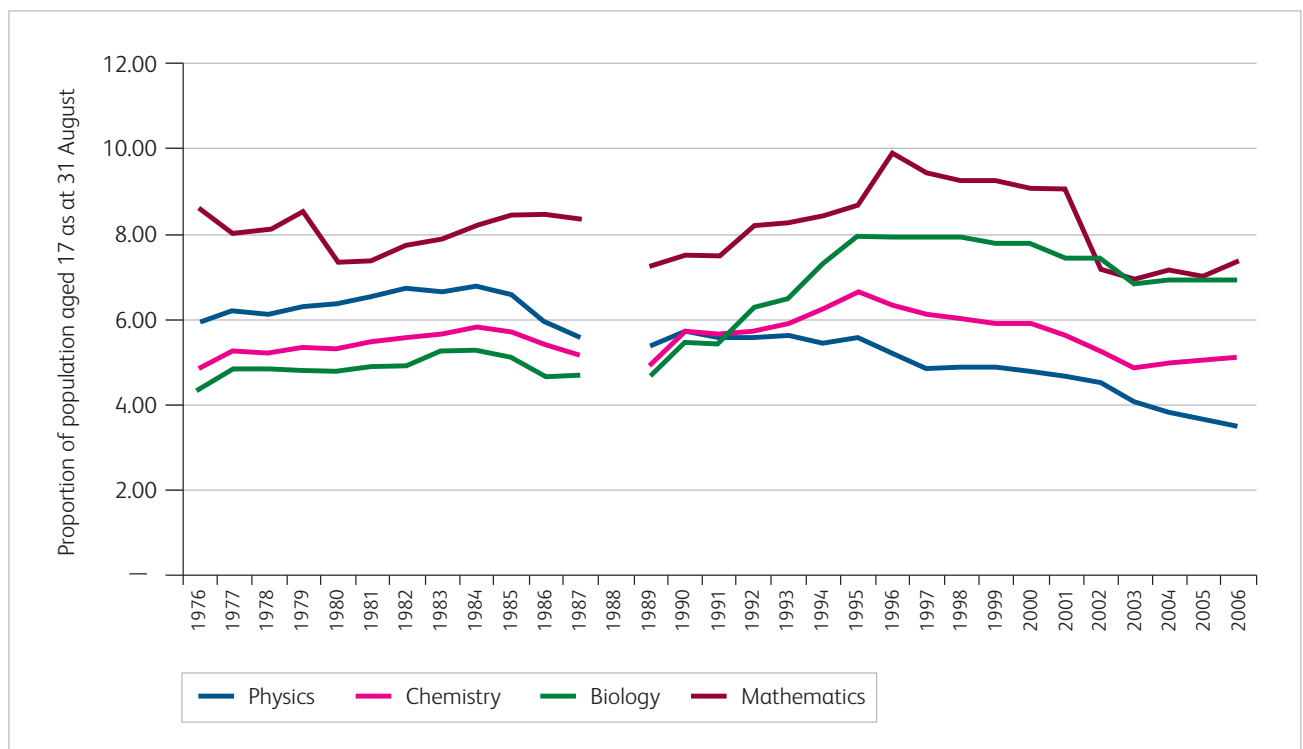
The further education (FE) sector has a key role to play in taking forward the STEM agenda. This booklet sets out the importance of the agenda and offers possible ways in which FE might play its part.

In January 2009, the Council for Industry and Higher Education (CIHE) rang alarm bells: *We cannot stress too forcibly our concern at the critical shortage of graduates and post-graduates with STEM capabilities. This is a burning platform that has to be addressed or the UK will not remain competitive.*

Though the Sainsbury Review called for a major campaign to enhance the teaching of and increase the numbers of young people studying Science and Technology, a steady drift away from STEM subjects continues. This graph¹ shows the proportion of the population of 17-year-olds taking Biology, Chemistry, Mathematics and Physics at A Level over 30 years. Compared to competitors, Britain appears to be in crisis.

This skills gap spans all levels. Look at the *Ambition 2020: World Class Skills and Jobs for the UK* report by the UK Commission for Employment and Skills (UKCES). It concludes: *The UK's relative international position on skills is unlikely to improve by 2020, let alone become World Class. In 2020 we are likely to be ranked 23rd on low level skills (compared to 17th now); 21st on intermediate level skills (compared to 18th now); and 10th on high level skills (compared to 12th now). We will, therefore, not be in the top eight countries of the world at any skill level.*

In 2008, the CBI found a quarter of employers had difficulty recruiting to technician-level posts, a finding borne out by the Sector Skills Council for Science, Engineering and Manufacturing Technologies (SEMTE) in the UK, who find that the lack of practical and technical skills at Level 3 worries employers most.



¹ Source, Professor John Holman

The brute fact is: not enough people choose STEM either in school or further education. Professor Adrian Smith, Director General of Science and Research at the Department for Business, Innovation and Skills, calls the route into STEM a “fragile pipeline”. At each academic level, the flow dramatically lessens.

Between 2009 and 2019, a sharp fall in the number of 16-19 year olds will pose a demographic challenge to the nation’s social and economic wellbeing. The situation is serious.

In 2008, the Learning and Skills Improvement Service (LSIS) established the LSIS STEM Programme in recognition of the need for specific support in this area. LSIS also commissioned this report on post-16 progression within STEM subjects in further education.

This report shows a number of ways in which providers across further education are addressing these challenges head on.

We look at four main challenges: recruitment, retention, achievement and progression from further education. Included with this booklet is the pilot version of a discussion activity for senior managers to raise awareness of STEM and develop strategies to strengthen progression through STEM across their organisation.

The research that supported this report revealed some key success factors among providers who succeed in addressing these challenges.

Providers who succeed:

- focus on widening participation
- nurture learners
- enhance the quality of teaching while resourcing teacher training
- build effective curriculum links with higher education and industry.

We know that:

- Engineering UK praises the achievement of engineering apprenticeships: 70,000 achieving Level 3 in 2008
- a huge study of learning in the South East shows that studying STEM subjects is linked to better academic achievement
- improving ICT and Mathematics skills are key to further success
- continuing professional development (CPD) that is collaborative and inventive inspires teachers and learners
- colleges which link to industry motivate learners most.

Now is the time for the further education sector to increase the appeal of STEM subjects to women, older people and learners from black and ethnic minorities, groups traditionally reluctant to participate in STEM programme areas.

As the Sainsbury Review, the *Innovation Nation* and the *Demand for Science, Engineering and Mathematics Skills* reports all make clear, the UK’s future depends on a healthy knowledge-intensive economy, driven by STEM subjects and our capacity to innovate and be creative. further education has a huge role to play in this future; the further education sector can optimise how it recruits, enrolls, advises, teaches and enables learners.



Recruitment: challenges and successes

Report after report² describes declining or static take-up of STEM subjects, although the population of post-16 learners has been increasing. As the Higher Education Funding Council of England (HEFCE) said in 2005, STEM subjects are “both strategically important and vulnerable”: there are simply not enough STEM students.

A DIUS report³, points to the two-thirds of young people gaining no A Levels at all as the greatest “leakage” from the system; most of these gain no later qualification either. Only 10% of young people have at least one pass in an A Level STEM subject, and 40% of these do not pursue STEM in any form in higher education (HE), which leaves very few STEM graduates.

Further education is ideally placed to catch those ‘leaking’ from the education system. But is it doing so? Throughout the text we trace a few success stories. These offer inspiring examples and we invite you to share successes that you are having in promoting progression in STEM subjects.

To share your experiences please log-on to www.subjectlearningcoach.net and contribute to the online discussions sharing successful practice and issues.

Of course, there are challenges specific to further education. Post-16 learners make choices dictated by personal circumstance as well as career. Often, they may change direction or lose heart even before starting the course. They may also be confused by the multiplicity of STEM courses on offer: the Learning and Skills Council (LSC) identified more than 500 courses in Science, Technology, Engineering and Mathematics.

Of the students who do sign up, some groups are underrepresented, notably females, white working-class boys, and learners from black and minority ethnic backgrounds.

A study by the East Midlands Centre for Excellence in Teacher Training (EMCETT) confirmed what many further education managers know: young women shy away from Mathematics and Engineering. However, they did find that advances in ICT and e-learning widen participation, as does actively developing the curriculum, embracing new technologies, increasing the level of interactivity and of collaborative learning.

So what can help to attract learners? “It’s not rocket science” says Jim Mutton, principal of Loughborough College – although in some cases that is exactly it! Effective recruitment can include:

- rockets and explosions on big science events
- events targeted at key groups such as young women or ethnic communities
- providing courses focused on jobs
- running supplementary skills tuition.

Julie Raine, Director of Basic Education, City of Sunderland College says:

Sunderland is a hot spot for those Not currently engaged in Employment, Education or Training (NEET) – and not just up to age 19. The Leitch report tells us we need to reach Entry 3 numeracy but we also need to be ‘world-class skilled’. We need provision for those who are not anywhere near test ready – who even may be non-readers, though they may be functioning well in society.

At City of Sunderland College, our programme ‘Test the City’ brings in more than 2,500 learners each year. Our marketing has successfully dispelled any embarrassment. We assess their literacy and numeracy and tell them, ‘Come to us and we’ll give you the background for the qualifications you need.’ We run a set of courses for a year or term as a pre-requisite for progression onto vocational and other courses including STEM subjects, with subjects like Test the City as well as Maths for Plumbers and Maths for Engineers.

It works brilliantly. Of those drawn in with numeracy skills at or above E3 level, 250-300 will then go on and do a Level 2 in one of Construction, Motor vehicle, Engineering or Hair and beauty.

² Institute of Physics 2001; Roberts 2002; Stagg 2003; Royal Society 2007; Nuffield Review 2006

³ Call for evidence: Analysis on Demand for STEM skills Department for Innovation, Universities and Skills (January 2009)

Ian Harvey, Head of Biology, Hills Road Sixth Form College, Cambridge, says:

Our recruitment in STEM has doubled over the last 10 years, while nationally figures have declined. We currently have 700 doing A Level Biology, 600 Chemistry; 400 Physics and 1,000 Mathematics, with more than 100 taking Further maths, out of a total student body of 1,800.

No doubt some of this is down to the 'Cambridge effect' of motivated, middle-class students, but much is due to our outreach with schools. We constantly liaise with our local schools. Several take some complementary AS subjects in Year 11, like Science or Human biology, so that they come in to take traditional Physics, Chemistry or Biology fired up about Level 3 learning. We've set up local teachers' groups in all three sciences who meet regularly: it joins up the levels and keeps the interest up in schools.

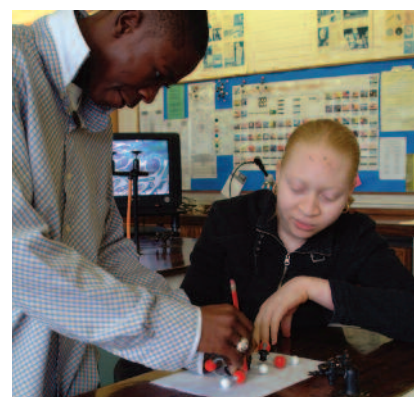
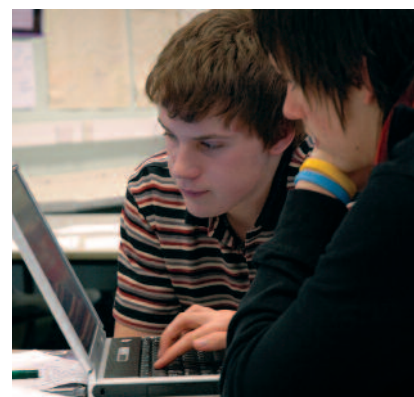
Fay Best, Senior Tutor in Engineering at Leeds College of Technology says:

Working with the UK Resource Centre for Women in Science, Engineering and Technology (UKRC) since 1998, the Engineering department has boosted numbers of female students year on year: from 32 in 2006, for instance, to 51 in 2009. We've developed the curriculum and trained staff to create a learning environment conducive to women learning. Marketing includes women-friendly images, women-only taster courses offering one-to-one encouragement to enquirers and gender-awareness training through UKRC for marketing staff.

But Jim Mutton cautions against gearing the curriculum too far towards 'flavour of the month' qualifications. Familiar science subjects are still winners if you sell them right: which is where 'whizzbang' rockets and explosions come in.

Research on effective recruitment to STEM courses, undertaken by the government's National Strategies for schools, confirms that developing students' interest in, and enjoyment of, science can make a big difference. Science departments everywhere need to blow their own trumpets. And, say the National Strategies, STEM staff also need solid backing from their senior management team, so that Science, Technology, Engineering and Mathematics are widely celebrated, inside the institution and out. It may be corny to summon the press to your awards day but, says Cerian Ayres of North Devon College, 'It does work, building a high profile.'

Individual providers have made striking progress in recruiting students. In inner-city Islington and in leafy Cambridge, colleges have bucked the trend and refused to accept the old excuses that 'STEM subjects are just too difficult' or 'our students can't cope with maths'. Outreach to schools, science fairs, visiting scientists, talks from industry leaders and special events and workshops not only publicise STEM for young people, they also defuse its daunting reputation.



Russell Potepa, Head of Science and Mathematics at Pendleton Sixth Form College, Salford, Greater Manchester says:

The key thing was a huge group of kids who were interested in Science but who felt unqualified for A Levels. Previously, all they had been offered elsewhere was Forensic science, which limits further options. So we went for a 'bog-standard' BTEC applied science and instead of the 10 to 15 we expected, we got 37 and had to run two groups. It's been the same this year.

Each year, the department runs Science Extravaganza open days with Starchaser Industries, a local company specialising in space-related products. All the local feeder schools come to enjoy building and launching rockets and investigating rocket propulsion – even if the fire alarms do go off now and then. At the same time, they can discuss options from A Level physics to BTEC. Between 100 and 150 students attend; even if they don't choose to come to the college, the day builds the reputation of an exciting learning centre.

Young people who do choose STEM subjects are actually quite proud of their reputation for difficulty. "It's not a doss," they told researchers. They relish the importance of what they do, are attracted by good facilities and clear links to real career options. As long as they are encouraged by teachers and mentors to persist and achieve, they are not daunted by difficulty. So an important element in successful recruitment is sustained support for students, some of whom may have modest GCSE qualifications.

What strategies could you use to improve recruitment? See the discussion card activity included with this booklet to explore this, and other recruitment issues, further.

Learners say:

Teri, prospective student Engineering, Nelson and Colne College:

The Starchaser day was just: Wow! brilliant!

Kate, A Level Mathematics, Chesterfield College:

I chose to study at Chesterfield College as it is very modern and well equipped; I chose to study A Levels as they offer a broader range of choices for your future. I want to go to university to study a degree I enjoy.

Pablo, AS Mathematics, Tresham College:

I chose Maths because it is a good subject to choose as it is used in everything, giving me more options in the future.

Retention: challenges and successes

Academic pathways are not always linear, as further education managers know only too well. Across the year, the decisions of learners cause flux and churn: one study found 50% of their sample was not studying in September what they had chosen the previous May. These findings underline how hard it is to count learners in further education and the difficulty in developing policies and programmes for progression which incorporate how further education learners actually behave. Yet such policies need to be developed. The Ofsted report *Identifying good practice: a survey of post-16 science in colleges and schools* highlights how limited Level 1 and Level 2 provision limits progression in STEM subjects.

The National Strategies found that a key part of supporting effective progression was: “Support for students’ learning; knowing the students academically and personally, keeping good records and tracking systems and hence being able to provide appropriate support and stimuli to engage, motivate and develop students; using observations and challenging tasks to keep them at the frontiers of what they know, understand and can do”. As Jim Mutton puts it, “We are committed to our learners as individuals.”

Supporting Learners to Succeed (SLTS) provides guidance and tools which will help all providers in the learning and skills sector review and develop their pastoral provision. The guidance understands pastoral provision to comprise two interconnected components: *support for learners and personal, social, health and economic learning*.

This resource can be found in the Teaching and Learning Section of the Excellence Gateway (www.excellencegateway.org.uk/teachingandlearning).

Research suggests that learners of STEM subjects are in general less likely to progress to the second year of their course; those on Computer sciences, Mechanical or Electronic engineering are even less likely to progress than other STEM learners. To overcome loss of motivation the National Strategies have looked at how best to encourage students with Bs at GCSE to study science post-16. They found that, “They seem easier to influence and are more open-minded about the nature of Science education. First/second generation immigrants and young women may have benefited from policies of inclusion and emancipation but the situation may not be secure and approaches to nurturing such students must look to long-term as well as short-term measures.”

Jim Mutton, Principal, Loughborough College says: *We’re good at retaining students – more than 95 per cent of our students in STEM subjects – because a lot of endeavour goes into making sure students are coping. We are committed to treating everyone as individuals; we emphasise that their course is as important to us as it is to them. Ofsted has commended our support for students through learning mentors, counselling and a lot of extension work at lunchtimes.*

Our learners engage in a wide-ranging and responsive enrichment programme, participate in student councils and an ambassador scheme and fundraising. Flexible and responsive work experience with partners, ranging from local schools to businesses and universities, pays off not only in jobs, but also in helping students get the most of out of their time here. For example, the college’s BTEC Engineering students have built their own gravity racing car with the support of David Ackroyd, a national leader in the field.

Russell Potepa, Head of Science and Mathematics at Pendleton Sixth Form Centre, Salford City College, Greater Manchester, says:

Our retention is great. We've only lost a very few on any courses. They stay, because they get the support they need.

We steer applicants onto the course that is right for them, vocational and academic. Good relationships are the bedrock on which the college is built, including learning mentors and counsellors who work with academic staff. Sometimes just offering a quiet place and time to do homework can be immensely valuable.

We run support sessions on and off-timetable. It's expected that they call and ask for help, that they can come for support and that staff will lay on sessions for anyone who needs it. Our Mathematics staff run daily lunchtime support: it's extremely popular and also raises the profile of the subject.

They stress the "importance of responding to student voice, nurturing relationships and developing good pastoral care systems. Links with parents, universities, the world of work and other partners are crucially important". The report noted that such links were also praised by Ofsted, who found a close connection between teamwork among staff, staff development, interest from parents and enjoyment by students.

The National Centre for Excellence in the Teaching of Mathematics (NCETM) agrees. They found that the best approach to retention is a combination of better diagnostics and tracking, linked to intervention programmes of pastoral and academic support. Perhaps surprisingly, they also found that students value very high expectations from their teachers; the DCSF STEM programme report in 2006 even found that less-qualified students value high expectations most.

Underlying retention is the importance of nurturing good relationships throughout the organisation. Relationships with teachers, often identified as a 'significant other' are important. Such relationships, as noted in the National Strategies report, can "build up through activities like coaching in sport and field trips, because the science teachers are also tutors, or because they provide careers advice specific to science, or simply because the students know they will 'go the extra mile for me'. Students particularly emphasised the importance of not being left behind and the patience of teachers which helped them keep going even if it meant staying after lessons."



Fay Best, Senior Tutor in Engineering at Leeds College of Technology says: *Our ambassador programme inspires new students but also helps retain existing ones by boosting self-esteem.*

We make sure that everyone is aware of equal opportunities policies at induction and at stages throughout the year. We focus on detail: providing quiet areas, social events at lunch and keeping college entrances free from standing/smoking students. We actively recruit women staff and make sure that they are highly visible as role models and mentors. Change has not been dramatic but steady. Staff say their workload has not increased but the environment has become much more positive and pleasant.

Another significant factor, as Ofsted surveys in 2008 identify, is teacher subject knowledge, closely linked to teacher enthusiasm. You have to have good teaching to keep students. Again and again, students cite such universals as orderly lessons, keeping the intellectual thread going, lively and meaningful practical work, lively dialogue and debate and the possibility of asking questions if things are not clear. They want teachers to be 'on our tail' and 'take no prisoners'. They want teachers who care if work is in on time, who check notes, who demonstrate that they care.

Subject specific support available as part of the LSIS Teaching and Learning Programme

- Peer support, collaboration and networks for teachers of Mathematics, Science and Engineering to meet together to share resources and approaches to improving teaching and learning across STEM
- Funding for action research projects
- Mathematics, Engineering and Science resources available to download from the Excellence Gateway (www.excellencegateway.org.uk).



Learners say:

Jane Connolly, AS Mathematics and Science, Salford City:

The college encouraged me to participate in many extension activities such as co-funding my link course which was fantastic and made me realise I did want to be a vet. This has spurred me on to work really hard to achieve my goal. The encouragement to be more independent was also really positive.

Amin Abdul, BTEC National Diploma in Medical Science, GCSE mathematics and English, City and Islington College:

I have just completed the first year of my course and the teachers are supportive and provide really useful feedback. The environment is brilliant – I have access to the latest books and to high speed computers in the learning centre. The college was recommended to me and I would not hesitate in recommending it to anyone interested in studying Science. I've just won an award for outstanding achievement and commitment to studies. My father is disabled and I work in a restaurant to pay for my sister's school, but I've been able to keep going because my teachers are so encouraging and always have time for me.

Achievement: challenges and successes

The links between teacher subject knowledge and learner retention follow naturally into learner achievement. There is a clear relationship between the quality of teaching and the quality of learning.

In 2007 McKinsey published *How the world's best performing school systems come out on top*. They concluded, "Above all, the top performing systems demonstrate that the quality of an education system ultimately depends on the quality of its teachers."

The undoubted impact of enthusiastic, expert and well-organised and resourced teaching dominates a huge range of research. Reports from Ofsted, the National Centre for Excellence in the Teaching of Mathematics (NCETM), the Teaching and Learning Research Programme (TLRP) and the Secondary National Strategy emphasise the importance of:

- curriculum continuity and planning within a dedicated team
- lively, experiential and specialist teaching
- challenge and enrichment in teaching
- knowledge of learners, personalised learning and assessment
- connections with other subjects, careers and society
- whole organisation and senior management support
- integrated and consistent CPD for teachers
- increasing the impact of Subject Learning Coaches.

Government surveys by the DCSF underline the importance of specialist teaching, which in turn depends on regular updating through continuing professional development (CPD), particularly when it is collaborative. This in its turn depends on a supportive management willing to back teachers' needs for professional autonomy and collegiality. To go that extra mile, teachers need to feel valued.

Teachers who feel confident and valued are in turn willing to experiment with curriculum models, DCSF reported in 2007 and Ofsted confirmed in 2008. This is particularly important in Science, where enrichment activities like external speakers, visits, work experience in industry and field trips demand teacher commitment 'beyond the call of duty'. Willingness to experiment with unusual setting or stranding of STEM subjects, new syllabi and qualifications like the Diplomas and new workforce configurations also depends on teacher commitment.

Of course, there are other factors too. Learners are themselves a resource for teachers. "Success breeds success" was how three schools visited by the National Strategies described the influence of the achievements of previous students on choices made by new recruits. Although facilities and the learning environment alone may not directly affect post-16 take-up, a poor learning environment does detract. Students talk of the use of ICT to make lessons more visual and memorable, to illustrate difficult concepts, to scaffold their note-taking and to make the key points clear.

Joan Peagam, Head of Science, Mathematics and Engineering, Nelson and Colne College, says:

The biggest barrier to learning in engineering is maths. Too often, students enter FE without functional skills. We asked other providers and they said, "Yes, it's a problem, we can't get over it." But we decided that we would make it better.

We went to our five feeder schools and worked with the maths departments to look at the syllabus. We already go in and teach engineering and now we are doing GCSE extensions in years 10 and 11 for about 100 pupils. On top of that, we've got funding to teach functional maths along with our first Diploma and Foundation Diploma, so that we do percentages and ratios alongside tolerance levels in nuts and bolts. We're a pre-pilot for the national pilot. It is having such an impact – and it's only been six months!

Students are coming in with predicted pass in the diploma and getting merits and distinctions. For the first time, we've had two starred distinctions in maths units. Word gets out and recruitment is up 34 per cent in a falling roll situation. Success breeds success.

Cerian Ayres CPD Leader, Learning Mentor Team Head, North Devon College says:

We use our purpose-built CPD centre to build communities of practice: schools, universities and employers. They all interact. We email 3,000 practitioners weekly to advise them of our CPD, be it bite-size 45 minutes, one-day or longer courses. Anyone can do any course and if we get big bookings we run the course again. We charge, but a fraction of what schools would pay to go up to a big city. And we get national experts coming to the region.

It's top-quality CPD and we are always innovating, thanks in part to our STEM co-ordinator. So we're running a reflective CPD blog, where teachers can reflect, plan and sum up what they've done and where they are going. Staff from schools and college work together on preparing for AS during GCSE years. Staff from college and universities and employers work together on 28 foundation degrees, all linked with industry.

It's win-win, because the whole purpose of CPD is inspiring teaching and learning. We've surveyed staff and students and analysed our 47 outstanding teachers for 'know, do value'. We use that to drive up standards: we've been named one of the top 10 colleges in the country for our A Levels, particularly Environmental science.

Above all, though, teachers do better when they work together in teams which are themselves learning. CPD, National Strategies confirm, is effective when it is integral to everyday teaching and long-term planning rather than a series of professionally run development events which only enable development of a few individual teachers. Collaborative CPD, run within schools, colleges or clusters, raises levels of collegiality so that teachers both challenge and help each other to provide the best they can.

STEM departments which work are strongly led and managed, all research suggests. They share a clear determination to 'put science on the map', perhaps even fired by some competitive pride against other departments. Fully staffed, they have clearly-established professional expectations of team members, a clear sense of purpose, enhanced by evidence from self-evaluation and student voice, good technical support and an orderly working environment. They work as a team, balanced between longer-serving members and enthusiastic more recent arrivals.

No surprise, then, that these characteristics align with Ofsted's description of what constitutes a good school and good teaching and learning. They also align with the principles underpinning the LSIS Teaching and Learning Programmes on effective practice and whole-organisation approaches. These are, too, the principles underpinning the growth of Subject Learning Coaches.



Ian Harvey, Head of Biology, Hills Road Sixth Form College, Cambridge, says:

Our A Level results are extremely good: we get 50 per cent A's in Biology, 75 to 80 per cent A/B's. Last year the college got 60 Oxbridge entrants. But it is not just able students. It's because all our staff are fully qualified specialists: everyone teaches their subject here.

And we add value all the time. For instance, I take 200 students each year on Biology field trips. We apply for Nuffield bursaries – a four-week funded experience in industry – and usually get several. We offer two OU biology modules under the national Young Applicants in Schools and Colleges Scheme (YASS) for 16 and 17-year-olds. They have to study independently but I run a programme of talks and visits with local science industries.

Senior management are excellent and appreciate our professionalism. You've got to give teachers what they need to produce attainment. We lose very few staff here. We're always looking to do something new. I've started annual conferences for schools and local PGCE students: 80 to 100 people come and spend a day sharing good practice in STEM teaching. After 34 years, I'm still enthusiastic.

As one provider told the National Strategies, "It's a small department that works well together as a team. We feel that this has a positive impact on post-16 uptake. Students always know where they are in science, they have continuity and are able to talk to staff. The team shares a lot, especially informally at the end of each day. The agenda of departmental meetings always has a 'bring and brag' session. Peer lesson-observation is well established and our 'Learner walk' initiative supports us in visiting lessons systematically to explore what is happening."

The LSIS STEM Programme aims to provide teachers and managers within the further education system with the resources and the opportunities to meet the challenge of improving their performance, unlocking their talent and the talent of those they teach. These resources and opportunities include

- Subject specific teaching and learning resources
- Tools for senior managers and STEM leaders
- Summer schools and network meetings for teachers of STEM subjects
- Funding for action research projects.

Learners say:

Gillian Williamson, basic skills in Mathematics, Sunderland's new Bunny Hill Centre:

I didn't think I would be brainy enough to do it, but I went. Once you get into learning, you want to learn all the time. For me it isn't about getting a better job, because I love what I do, it's self-satisfaction. It was enjoyable and gave me a real buzz. I have never felt any pressure. It's a more relaxed atmosphere, which I need because I work full-time and part-time jobs.

Jemal, numeracy skills for life, Wirral Metropolitan College:

Doing things makes me remember and understand more. Working together, learning from one another, using practical things to create a better understanding: it means that I have got a better understanding of how to work it out.

Tom, 52 Train to Gain, Durham:

I was a bit apprehensive at first. I hadn't done any education or training since I was 15 but I thoroughly enjoyed and it has proved a great confidence booster inside and outside work.

Virginia, 32, Hartlepool College:

The AS in Further mathematics has made me more confident in all my subjects. The teachers explain things in so many different ways.

Progression: challenges and successes

Where should further education STEM students go? The Ofsted report into Good Practice in post-16 science showed that providers that helped with careers, work experience and contact with industry had far better success in placing students in jobs or HE. Innovative teams of teachers of STEM subjects researched the changing needs of industry: for instance, that radiography now includes computer tomography, or, at City and Islington, an announcement by the Government of free hearing check-ups for the over-65s translated into an understanding that there would be expansion in the need for audiologists. In a further example, greater policy shifts towards greener consumption has underpinned North Devon's growing environmental offering, which has led to its winning a regional teaching award for sustainability in 2009.

There is a danger of neglecting the equally important non-graduate levels of employment: "bedrock" as the ETB report *Engineering UK* (December 2008) puts it. This report balances an improvement in numbers of Engineering HE students against a major shortage of technician-level engineers. Such jobs would tend to recruit through a further education route and their lack is serious.

However, on the whole, Engineering is a success story for further education. As the recent DIUS Report (2009) on STEM skills points out, Engineering is one of the largest apprenticeship areas with over 19,600 'starts' in 2006; over two thirds at Level 3 and a further 9,000 places in manufacturing industries announced in 2008. The report also sees the 14-19 Diplomas in Engineering, IT and Construction and the built environment as potentially important for further education and HE progression.

It is a false dichotomy to see 'Science for Science's sake' in opposition to Science in commerce. Enjoyment of the STEM subjects need not fade away simply because they are also seen as useful routes to earning a living. Particularly since, research shows, young women are more likely to be attracted in and successfully progress if they see the usefulness of programmes of study.

Of course, STEM is not just for high-fliers. Work done on shop floors, in city-wide initiatives like that in Sunderland, in secure units and prisons and in skills for life services all over the country changes people's lives, often dramatically for the better.

Links with local employers help with work experience and visits. Links with HEIs also pay dividends, either because many further education colleges now run the first two years of degrees for local universities, or because higher education institutions (HEIs) offer higher status outcomes for further education students. Universities themselves raise recruitment by running workshops, magazines and tasters for school and further education students. Subject Learning Coaches complete a virtuous circle by bringing top-quality research back into the classroom.

A number of teachers have taken advantage of LSIS Excellence and Innovation Awards to undertake classroom-based action research to improve progression through STEM. For more information on these awards see www.subjectlearningcoach.net/funding.aspx

In 2008, the further education Specialisation and Innovation Fund attracted huge interest from further education providers. The five chosen Pathfinder projects – aerospace, construction, land and marine-based, engineering and financial sectors – represent fast-changing industries with a very high demand for STEM. They point the way to the unique contribution which further education can offer its students and the country.

Trevor Hunter, Curriculum Manager for Applied Optics and Medical Sciences, City and Islington College, says:

Our college was awarded a Queen's Anniversary Prize for Pathways into Higher Education and Employment in the Sciences in 2007. In fact, it's the only general FE college to have won it twice. In the last six years, we've bucked the trend, growing from 300 to 900 students at the Centre for Applied Science.

More than 90 per cent of our students go on to HE or industry. For example, 98 of 100 ophthalmic dispensing students got jobs. Of UCAS applications, 83 per cent were successful. We run foundation degrees in partnership with City University, London Metropolitan University and Queen Mary, University of London in subjects like biomedical sciences, sport sciences, nursing, optometry and forensics. We also place students on medicine and dentistry courses.

Our success – we are a beacon college, rated by Ofsted as ‘outstanding’ year on year – is down to several factors. Our wide mix of inner-city ethnicities is a strength, as is the age range from 16 to 55. We employ staff from industry who are skilled practitioners – like opticians or science of crime officers – and we then support them through their PGCEs. Their enthusiasm relates to the real world and students pick that up. And we all continue to practise and bring that flavour of the real world to the classroom.

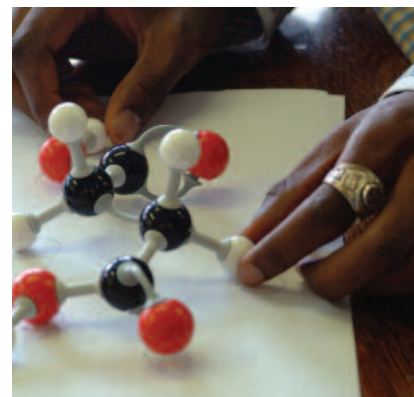
We develop degrees with employers. The Metropolitan Police force told us that they don’t need forensic scientists, they need scene of crime officers. So we developed a foundation degree in forensic crime scene investigation, running about 20 simulations. Arsenal Football Club and London Metropolitan University are developing a foundation degree in football coaching with us.

We see enormous potential in the market place and we are always looking to find new areas to develop. Currently, we are growing courses in sustainability (environment and land-based studies), pharmacy, audiology, and radiography: all areas where shortages have been declared. We are proactive.

Research from the former Learning and Skills Development Agency has called for more ongoing explicit partnerships between schools, colleges, training providers and industry. Teachers need to be informed about opportunities for progression through vocational and work-based pathways; assistance and support for learners; and provision for extracurricular activities to stimulate enjoyment.

They also need to be able to point their students in the direction of practical help, like Aimhigher, and call on ready sources of inspiration, like ambassadors schemes such as that run by STEMNET.

Visit www.stemnet.co.uk to find out more about STEM ambassadors and how they can support your STEM offer by enthusing and inspiring students.



Jim Mutton, Principal of Loughborough College says: *Begin with expectation. There's a general expectation that many of our students will go to university, and most Level 3 learners – around 65 per cent – do. Some switch course to more FE courses and some go on to work with partners such as Brush Engineering and E.ON. We help students complete HE programmes whilst working, even if not sponsored by their employer.*

One student, began her A Levels with us in her late-30s, went on to a BSc in Mathematics and then a PhD at Loughborough University. We also have a number of college staff who began as students, stayed to their final degree and came back to teach Sports science or Engineering.

Another exciting development is the creation of Knowledge Transfer networks, described as “a group of individuals ...” Perhaps the most exciting development is the Knowledge Transfer Networks (KTNs), defined on the KTN website as “a group of individuals that have a shared interest in an area of emerging technology”. An apt description of a STEM education department, surely?

KTNs have been set up and are funded by government, industry and academia. They bring together diverse organisations and provide activities and initiatives that promote the exchange of knowledge and the stimulation of innovation in these communities. There are currently 25 KTNs with a membership of around 45,000. The newest KTNs are in Digital communications and Creative industries. A KTN in Financial services is planned.

Visit www.ktnetworks.co.uk to find out more about Knowledge Transfer Networks and how you and your organisation can get involved.

Anthony Malpass, 26, Business Development Manager at Fortvale Engineering, says:

I disliked school-based learning. I liked friends and football but I didn't want to go to college and university. I wanted to be hands-on. My apprenticeship in Mechanical engineering at Pendle Training (now Training 2000 – www.training2000.co.uk), involved more solid academic work than I expected, learning principles of Engineering and Mathematics. But it was still practical. We had machines like in the factory, though smaller, and did what you'd do in your future career. There was a lot of Maths and Science but I didn't mind it.

In fact, I got the bug. I've built on my NVQ, ONC and HNC qualifications in Engineering and Business by studying a BA Hons in Business studies at the University of Central Lancashire: all studied on day release and/or part time. I'm thinking of a master's in Business and Engineering at the University of Central Lancashire.



Government has identified a crucial role for further education in business innovation services and knowledge transfer into the small and medium business sector, as well as the provision of industry-standard vocational training, embedded in the dual requirements of the Standard for Employer Responsiveness and Vocational Excellence.



As part of the LSIS STEM Programme, a toolkit is being developed for further education providers who are interested in exploring knowledge transfer activities. For more details, email info@lssystem.org.uk

Learners say:

Raihazah, AS Mathematics and Science, Salford City College:

The pre-med course really helped me to realise I could achieve my ambition to become a doctor! The Med Link course was great and the fact that college paid half the cost allowed me to go and really experience the different aspects of life as a doctor. From the course in college, I found the admissions tutors really helpful in preparing my application.

Gillian, numeracy course, HMP Low Newton:

I've never had a certificate for anything before and now I have a numeracy certificate!

Joanne Giles, Level 2 numeracy, Sunderland:

It was one of the biggest moments in my life when I got the award. I just want to encourage everyone else to do it, too.

Where next?

To keep up to date with knowledge and pedagogy while at the same time responding to the fast-changing picture of industry – be that in fibre optics, scene of crime investigations, sustainability or composite metals – STEM in further education needs to move to a new model, that of dual professionalism⁴.

The Institute for Learning's CPD model is founded on a dual professionalism, meaning that teachers, tutors and trainers have a subject specialism and expertise in teaching and learning. Both parts of your professional practice are equally important, but the balance of the activities you undertake will inevitably be decided by a consideration of the context in which you work.

The model of support for CPD within the LSIS Teaching and Learning Programmes aims to:

- reflect the variety of situations in which learning can happen and in which you work
- encourage CPD actions that are responsive to your needs
- stimulate and support you as you create tailor-made programmes of CPD that are flexible, adaptable to individual needs, team needs and organisational objectives
- promote a systematic approach to reflective practice by using the Institute for Learning's professional development cycle.
- encourage exploration and use of the rich and wide-ranging resources that are now available.

To explore the LSIS Teaching and Learning CPD resources, see www.excellencegateway.org.uk

Further education has to respond to the burgeoning growth of qualifications, embracing new diplomas and vocational degrees as well as more traditional academic routes.

National STEM director Professor John Holman has outlined some key ways in which further education is involved in responding to these demands:

- STEM Subject Learning Coaches and STEMNET's Ambassadors who actively seek out learners with personalised learning and lively activities
- networks like STEMNET and the Further Mathematics Network which engage with young people and overcome fear of 'hard' STEM
- Regional Development Agencies supporting local STEM agendas; for instance, STEM Skills Strategy, One North East supports innovative approaches like those of City and Sunderland
- the National Skills Academies, working in nuclear, construction, financial, manufacturing, process and food and drink manufacturing
- cross-curricular initiatives like the Design and Technology Association joining the 5-19 STEM Programme Board and the development of science-based CPD for Design and technology (D&T) teachers. Both these initiatives show a step change: they begin the process of giving D&T a voice alongside other professional associations and help the development of pathways other than science and mathematics into engineering
- the Engineering and Technology Board's 'Engineers Make it Happen' campaign
- organisations focused on the participation and progression of women in STEM like Women into Science Engineering and Construction (WISE), Women's Engineering Society (WES) and UKRC for women in STEM.

To find out more, contact

LSIS STEM Programme:
www.excellencegateway.org.uk/STEM

The interim report and executive summary can also be found at:
www.excellencegateway.org.uk/STEM

⁴ *Dual Professionalism: maintaining a professional standard in their area of expertise together with maintaining excellence in their teaching practice (Institute for Learning, 2007).*



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LSIS STEM Programme



The Royal Academy
of Engineering

National Centre
for Excellence in the
Teaching of Mathematics

