The recruitment crunch

Despite an increase in the demand for skilled workers, there is a lack of qualified science, engineering and technology graduates

For the past few years, Germany's export-oriented economy has undergone impressive growth as the demand for its engineering products has increased globally. However, although this development has driven down national unemployment, it has also resulted in a labour shortage that has German companies urgently looking for skilled workers and engineers: vacancies for engineers rose by nearly 30% in 2006. Last year, the German Ministry of Economy and Technology warned that the lack of workers could result in revenue losses of more than €20 billion per year (Bovensiepen, 2007).

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Germany is not the only country faced with this problem. Across the European Union (EU), the lack of highly trained employees, coupled with the ongoing 'brain drain' of researchers to the USA, could stifle growth in high-tech industries (EC, 2007). Indeed, the EU estimates that the information sector alone could face a lack of up to 300,000 qualified staff by 2010 (EurActiv, 2007). The USA has been faring better, mainly owing to its ability to attract skilled workers from other nations and its demographic situation, but it has become highly dependent on immigrant labour; foreign students now earn about 30% of science doctorates and more than 50% of engineering doctorates in the USA (NSF, 2006). Moreover, rapidly developing nations, notably China and India, have been investing heavily in

research and education to advance towards a knowledge-based economy.

The result is an increased global demand and competition for workers in the science, engineering and technology sector. The only long-term solution to this problem—and to ensure growth in high-tech industries—is to increase the number of graduates in these areas and, more generally, to recruit more high-school and college students to science and engineering. However, any sustainable effort must address all stages of education, and tackle the cultural and public perceptions of science.

With regard to the latter, engineering and the life sciences—particularly medicine—are faring better than physics or chemistry. Our natural interest in our health ensures that medical research remains popular and well funded, although this is sometimes done to the detriment of fundamental biological research, notably plant science or environmental research.

Yet, even the life sciences have been suffering from a recruitment shortfall at the undergraduate level, particularly in the middle and lower ranks of student quality. "Often when people are complaining [about the decline in the standard of science graduates], they are referring to the rump in the middle," commented Celia Knight, a plant biologist and Director of the undergraduate school at Leeds University in the UK. She argued that, although there are still plenty of outstanding students, factors such as grade inflation and rising student numbers are diluting the quality. "As we expand student numbers, we expect to expand the lower end," she said. "It is clear there wasn't a huge population of highly able students out there not going to university in the past."

The Norwegian-led ROSE (the Relevance Of Science Education) study, which measured

the attitudes of school children to science in more than 20 countries, confirms this trend and highlights an additional gender gap in science recruitment (Sjøberg & Schreiner, 2007) that also appears at the top quality levels. "The most gifted students are not necessarily taking science—particularly girls," said Sharmila Banerjee, National Coordinator for the Nuffield Science Bursary scheme in the UK.

The quality problem, if the perennial comments of senior scientists are to be believed, is increasingly apparent as biology becomes more analytical and quantitative: the lack of basic mathematical and statistical knowledge among students becomes more obvious. But, as Jonathan Osborne, Professor of Science Education at King's College, London, UK, insisted, this does not represent the whole story. A lack of knowledge in some fundamental areas might, he argued, be compensated for by the student's broader grasp of the field. "Today's youngsters may not, say, be taught about cosines in the same way [that] we were," he said, "but they have different skills instead that we did not have [...] What people focus on too much is what people cannot do rather than what they can do."

But Osborne was far from suggesting that all is right with science education. He recently co-authored the report *Science Education in Europe: Critical Reflections* (Osborne & Dillon, 2008), which was published for the Nuffield Foundation (London, UK) in January 2008. In the report, Osborne and co-author Justin Dillon, President of the European Science Education Research Association (ESERA), advocated sweeping changes to the high-school science curricula across Europe. The report reflects

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the concerns of the Nuffield Foundation that science teaching is losing the battle for hearts and minds by placing too much emphasis on learning by rote. “The main changes needed are to make teachers of science realise that the main achievement of science is the explanatory theories that it offers of the material world and that a miscellany of facts is not the same thing,” Osborne said. “There is a need to provide a science education where the connections to students’ lives are more evident and where there is space to discuss the issues raised by science.”

Knight noted that the current science curriculum is also losing touch with the requirements of universities. As she pointed out, universities used to set the A-level exams—the final qualifications of the UK secondary school system taken at age 18—but now have minimal influence over them. This has led, she feels, towards too much medicine and human biology in the syllabus, often at the expense of other fields such as plant biology. Yet, despite

its partial omission from the science curriculum, plant biology itself is becoming increasingly relevant to society, particularly in the light of recent global food shortages and the drive towards solar energy conversion by using genetically engineered plants or artificial photosynthesis.

Osborne agreed that universities should not regain their old monopoly on setting exams, but emphasized that the current syllabus serves nobody, least of all those who plan to pursue a career in science. This, he pointed out, is why many universities in the UK and elsewhere are now considering setting their own entrance exams. “The reason is that the people who set the A-level exams are failing to write exams which discriminate and test understanding, rather than the ability to regurgitate information or follow algorithmic procedures,” he said. “In its worst incarnation, somebody once described this as ‘bulimic science education’—that is, you are fed a lot of indigestible facts which have no nutritional value and you instantly regurgitate.”

To address this trend, Newcastle University in the UK is pursuing an approach that introduces university-style education into the school curriculum and allows some students to bypass the A-level school exams altogether. A school local to the university, Monkseaton High School, initiated the scheme to provide an alternative route to university in the belief that some good students are deterred by traditional exams, which emphasize analytical skills and fact retention. Instead, students at Monkseaton can now take a science module at the Open University (OU; Milton Keynes, UK)—a distance-learning institution that allows degrees to be taken part time and mostly remotely. Newcastle University has agreed to accept undergraduate students from Monkseaton who have taken the OU module.

“We do not see this route as an easy route, nor is it a statement that A-levels are not appropriate as preparation for university,” explained Heather Finlayson, Head of the School of Biology at Newcastle

University. "The pilot was developed to try to encourage greater participation in science beyond GCSE level [the exams taken at age 16 at the end of compulsory secondary education in the UK]. We believe that the students entering by the OU route will have a broader but less deep knowledge in some subject areas, but their independent study skills, developed while studying the OU modules, will enable them to study effectively and rapidly to make up any lack of specific subject knowledge."

Some educators, however, are sceptical of how much difference systemic changes can make to the overall appeal of science. "We have had so many curriculum innovations, implemented in a top-down manner, that did not bring what was expected," said Jan Van Driel, a professor at the Leiden University Graduate School of Teaching in the Netherlands. "I would argue that, in general, science should be taught in a way that makes sense—that is comprehensible and relevant—to the specific target group, and this is primarily the responsibility of science teachers. What we need is highly qualified and motivated science teachers, rather than another curriculum reform movement."

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Van Driel was also sceptical of any trend that distances teachers from students, as could happen with a more university-like approach. "In our country, unfortunately, a belief seems to exist that students should work on their own, or in small groups, using computers, or doing practical work. In this context, the role of the teacher has been undervalued," he said. But, having school students involved in practical work, which could still be administered by universities, would be likely to stimulate their interest, he added. "For talented students in secondary education, in our country, we have had very positive experiences with extra-curricular activities, where students participate in university courses and are given opportunities to engage in research activities."

Van Driel argued that science education should not wait until secondary school when children might have veered towards other subjects or developed negative views of science. "In our country, science teaching at the primary level has been undeservedly ignored. This is mainly due, as in many countries, to teachers not being qualified and motivated to teach science," he commented. "Recently, we have begun to invest in this issue, on the one hand in projects aimed at stimulating young children to engage in inquiry activities and science projects, and the other hand in projects aiming at professional development of primary teachers. I think that, potentially, this is a very important development when it comes to making science more popular and better understood in our society."

The US Government has also taken up the idea that science teaching needs to be improved. In July 2008, Congress approved the US\$40 million Robert Noyce Teacher Scholarship Programme to prepare science and maths teachers for selected schools. "We are also implementing the new Section 10A of the America COMPETES Act, which provides a good stipend to support a mid-career STEM [Science, Technology, Engineering and Maths] professional while they get a Master's in teaching and then provides a salary supplement," said Myles Boylan, Lead Program Director for Course, Curriculum and Laboratory Improvement at the US National Science Foundation (NSF; Arlington, VA, USA). "It is expected that as these teachers move into high need schools, the quality of instruction in maths and science will improve and that more high school graduates will go to college and major in STEM."

The USA is also considering offering students alternatives to traditional university exams—similar to the Newcastle University model—as Boylan explained: "I think the traditional exams are pretty good predictors of which students will be high performing and likely to graduate. But I also believe that these tests are poor predictors of which students will be academic failures, because a significant number of students will become solid achievers despite poor scores on entrance exams," he said, but insisted that this was not tantamount to 'dumbing down' the system. "Many students are still quite immature at age 17 when they take these tests and thus can make spectacular gains

in learning as they finally 'grow up' [...] I believe the right approach is to give students multiple chances to succeed."

The main challenge therefore goes beyond improving science education; there is also a serious need to counter the misleading perception that science is in opposition to conservation or sustainable development

This chimes with the findings of a 2007 report by the Urban Institute, a US non-profit group in Washington, DC, which collects data and provides advice on science policy and education questions. The report suggests that the USA should no longer compete on the basis of scores in science and maths tests, but instead on creativity within the context of a more broadly based education (Lowell & Salzman, 2007).

Yet, Banerjee suggested that educational reforms alone might not be sufficient to improve recruitment to science. She referred to the ROSE study, which found that a student's response to the statement "I like school science better than other subjects" was more likely to be negative the more developed their country (Sjöberg & Schreiner, 2007). Banerjee commented that this might just reflect the increased range of choices that students have in these countries, but it could also result from a negative perception of science, as portrayed in the media or by the environmental lobby. The main challenge therefore goes beyond improving science education; there is also a serious need to counter the misleading perception that science is in opposition to conservation or sustainable development.

But, there is cause for some optimism in the UK, at least, where the Higher Education Funding Council for England announced in October 2008 that its £350 million six-year programme to increase the number of science students was now working. In the academic year 2007/2008, the number of entries to chemistry courses, a subject that had been in decline, was up by 5.3%; a clear sign that trends can be, and are being, reversed in some countries. Despite this success, however, much more still needs to be done to counter negative cultural perceptions and to attract more women.

Moreover, much more needs to be done to ensure that there are sufficient lucrative and attractive jobs for science graduates. The Urban Institute's 2007 report therefore suggests that leading countries like the USA need to rethink their approach to science education, as they produce large numbers of students with bachelor's and master's degrees but fail to keep them interested in these areas. As the study said: "One to two years after graduation, 20 percent of S&E [science and engineering] bachelors are in school but not in S&E studies, while another 45 percent are working but in non-S&E employment (total attrition of 65 percent). One to two years after graduation, 7 percent of S&E master's graduates are enrolled in school but not in S&E studies, while another 31 percent are working but in non-S&E employment" (Lowell & Salzman, 2007).

Indeed, the chance of finding an interesting and well-paid job after graduation seems to be a main factor in solving the problem of recruitment, notwithstanding attitudes or perceptions. The economic boom and the ensuing competition for qualified engineers among German companies in the past few years—although times are now less certain—markedly improved the attractiveness of engineering fields to undergraduates. This year, German universities reported that the number of students enrolling in engineering fields rose by up to 16% for the fall semester (Anon, 2008).

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Philip Hunter

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