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Jacqueline Bell; James Donnelly

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Applied Science in the English school curriculum: the meaning and significance of 'vocationalization'

JACQUELINE BELL and JAMES DONNELLY

This paper is concerned with a specific example of an emerging international tendency within secondary education: the process of 'vocationalization'. It begins with an account of the wider international and historical context and then focuses on an empirical study of a recent reform of the late-secondary curriculum in England: the creation of 'Applied Science' as a so-called 'vocational subject'. This reform derives from an attempt to reconfigure the 14–19 curriculum, aiming to make it more relevant to future occupations and to break down institutional and status-related divisions between 'academic' and 'vocational' subjects. The paper draws on school-based fieldwork, national questionnaires, and other sources. It shows that the rationale for applied science was not clear, its support systems rudimentary, and the challenges it posed for schools considerable. Nevertheless it enjoyed some success, in part through its congruence with teachers established views of how science should be taught. The paper concludes with a broader analysis of the innovation and its applications for 'vocational' reform, focusing on: whether Applied Science constituted a 'resource' for schools; its differential social and intellectual 'positioning' across students; and the disciplinary meaning (in a neo-Foucaldian sense) of its progressivist pedagogy and assessment regime.

Keywords: applied science; curriculum reform; portfolio-based assessment; science curriculum; status; vocational education

Education is in part a preparation for life, and that, for most people, involves work. Yet the manner in which the aims and purposes of schooling should include preparation for work generates significant debate. UNESCO's International Centre for Technical and Vocational Education and Training recently surveyed what it calls the 'vocationalization of secondary education' (Lauglo and Maclean 2005). Governments around the world are seeking as a matter of policy to increase this vocationalization of the school curriculum, and to strengthen its relationship to the workplace. Although the UNESCO survey was particularly focused on developing countries, the trend is broader (Kincheloe 1995, Stern and Wagner 1999, Gill *et al.* 2000). In this paper we explore and analyse an example of this tendency within English secondary education, targeted on one of its highest-status subjects: science. In doing

Jacqueline Bell is an educational researcher who has worked on various research projects in curriculum development, including studies of religious education and applied science. Her most recent publication (with James Donnelly) is *Positioning Applied Science in Schools: Uncertainty, Opportunity and Risk* (Leeds, UK: Centre for Studies in Science and Mathematics Education, University of Leeds, 2007).

James Donnelly is professor of science education in the Centre for Studies in Science and Mathematics Education, University of Leeds, Leeds LS2 9JT, UK; e-mail: j.f.donnelly @education.ac.uk. His research interests centre on the philosophical, historical, and sociological aspects of curriculum reform. His recent papers have appeared in *British Journal of Educational Studies*, *International Journal of Science Education*, and *Science Education*.

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so, we draw out critical issues that face a vocationalized[1] school curriculum. We contend that a version of vocationalism has a legitimate educational role and provenance, but that it generates significant tensions in policy, pedagogy, and status.

The educational underpinning of vocationalization is problematic. For governents and some other organizations it can often appear to be related simply to the creation of human capital and 'skill sets' (Becker 1993). Although some see such an adaptation of schooling to workplace needs as uncontentious (Coles 1998), others see it as often deficient in criticality (Young 1998). The terms of the criticisms that are mounted may be traced back to Bowles and Gintis's (1976) 'correspondence theory'. Their focus was on the insertion of an unexamined, and often unstated, account of supposed workplace needs into educational institutions, and the mechanisms and consequences of targeting and tracking students. However, there is an older and more generous account of a vocationalized education available, drawing on the Deweyan pragmatist tradition. Here 'occupation', as Dewey (1966: 307) termed it, can yet provide a vehicle for education in its proper sense. This philosophical argument is instantiated within educational policy and practice: institutions such as the Chicago High School for Agricultural Science (Stern 1999: 166–168) offer a distinctive version of schooling, with discernible Deweyan roots. Grubb's (1996: 12–16) analysis of the modes of what is sometimes called the 'new vocationalism' in the US identifies this Deweyan strand as the most educationally promising.

Forms of strictly vocational provision are often localized. For example, each of the EU states has a distinctive pattern, sometimes extending back for many years. Our focus in this paper is, however, on reform within *general* education. In England there is an established pattern of political dissatisfaction with the relationship between academic and vocational provision, and of attempts systematically to dismantle differentials of status, pedagogy, and inclusivity. However, there is also sensitivity to pressure from some parents and professional and academic groupings to retain the academic integrity and distinctive role of traditional educational disciplines. This is an international pattern. In countries as diverse as Germany, Korea, and Australia there is evidence that general academic provision is often preferred, amongst knowledgeable groups, to narrower vocational routes, if the two domains come into direct contact or competition (Gill and Dar 2000: 511, Gill and Ihm 2000: 269–271, Barnett and Ryan 2005: 23–24).

The case with which we are concerned involves the creation in English schools of 'Applied Science', designated a 'vocational subject' and yet part of the generalist school curriculum for 14–16-year-olds. The newly minted course runs in parallel with more traditional versions of school science not carrying the 'vocational' label. It was introduced in 2002 and first examined in 2004. This account of the course draws on a study conducted between 2003 and 2007 (Bell and Donnelly 2006a, b, Bell *et al.* in press) which employed fieldwork in schools, national surveys, and documentary reviews (the methods are described in greater detail in the Appendix).

Our concern in this paper is to examine the introduction of Applied Science within the wider framework just outlined. We trace its political origins and aims, so far as these are identifiable, its realization within schools and classrooms, and teachers' judgements on its outcomes. We consider whether the innovation involves more than a titular or rhetorical use of vocational language. We examine how the project engaged the hierarchies within schools' treatment of students. We also review aspects of the pedagogy of the new course, suggesting that it exemplifies important tendencies in the modes of learning and learner identity associated with modern vocational reforms. Overall, we suggest that this example of the vocationalization of the late-secondary curriculum speaks to the international agenda outlined above.

Background and immediate origins

To understand the significance of Applied Science it is necessary to note the policy background. The course was promoted through the ostensibly generalist qualification available at the end of compulsory schooling in England, the General Certificate of Secondary Education (GCSE). GCSE was introduced in the late 1980s and was based mainly on traditional academic subjects. However, in 2000 the then Secretary of State for Education announced the creation of a new set of GCSE specifications (as syllabuses in England are called, itself a quasi-industrial metaphor). They were to be called 'vocational GCSEs' (later renamed 'GCSEs in vocational subjects'). The other 'vocational subjects' were 'Applied art and design', 'Applied business', 'Applied information and communications technology', 'Engineering', 'Manufacturing', 'Health and social care', and 'Leisure and tourism'. The occupational character of the members of this list is apparent: however, Applied Science stands out as deriving from the standard academic curriculum. The list derived from an existing set of General National Vocational Qualifications (GNVQs). These had been targeted on late-secondary-age pupils, but had a distinctive name, assessment regime, and grading system.

Within the English education system the word 'vocational' is commonly heard as indicating a narrow, technical curriculum, often related to manual work, stereotypically plumbing or bricklaying. It is usually contrasted with 'academic' education based on traditional disciplines and ostensibly promoting generalized intellectual capability. However, efforts to create a more workplace-orientated *general* school curriculum (usually for working-class students) reach back through post-War technical schools (McCulloch *et al.* 1985), junior technical schools in the 1930s (McCulloch 1989, Sanderson 1994), higher grade schools in the late-19th and early-20th century (Vlaeminke 2000), and, arguably, even to the mid-19th century 'science of everyday things' (Layton 1973) taught in elementary schools. The notion of 'applied science' (derived historically from 'pure' and 'mixed' mathematics (Brown 1991)) was deployed early across the education system as a whole. It had a status dimension from the first, being associated with students unlikely to pursue 'pure' science further (Donnelly 1986, 1997). The emphasis on practical activity and 'relevance' as a key to good science teaching also has historical roots, deeply embedded within the collective memory of science teachers (and politicians), and much contemporary rhetoric (Hodson 1993, House of Commons Science and Technology Committee 2002).

Modern ‘vocationalized’ interventions within school curriculum policy have included a Certificate of Pre-Vocational Education in 1985, a government-funded curriculum reform, the Technical and Vocational Education Initiative (TVEI) in 1982, and other projects. ‘Vocational GCSEs’ thus form part of a long-term political project. That project shares the ambivalences identified earlier: it is difficult to disentangle Dewey-like claims for the educational role of occupations, economically-driven agendas, and differentials of status and progression. TVEI, for example, was appropriated by teachers themselves to more general, and often progressivist, educational purposes (Williams and Yeomans 1994).

GNVQ, the immediate ancestor of vocational GCSEs, had principally been addressed to students in the post-16 age-range. It is usually seen as a response to the changing labour market position of young people, the collapse of an immediate post-school labour market for all but the least ambitious students, and the consequent attempt to cope with the growing numbers remaining in post-compulsory education (Raggatt and Williams 1999: 190–198). GNVQ was a vocational qualification of a ‘general’ or perhaps preparatory kind, targeted on ‘subjects’ that broadly mapped against industrial sectors and occupations. Yet studies of GNVQs offered little evidence that those following the course had specifically vocational aims.[2] In many cases GNVQ was seen as offering a ‘second-chance’ route into higher education for students whose attainment at GCSE was lower than that required for acceptance onto A-level courses (Wolf 2002).[3] In this respect, GNVQ reflected the widespread tendency, already identified, for generalist education often to be valorized above the technical and the vocational.

As with other aspects of the ‘vocational turn’, the rhetoric and practices associated with GNVQ were not limited to manual or directly workplace-related training. Connections with progressivism have been examined in several academic studies.[4] Important aspects of these linkages include the attention given to ‘learning by doing’ through involvement with occupations (the tradition deriving from Dewey), the importance of student independent learning, and innovative modes of assessment. These ‘progressive’ characteristics were carried through into the new GCSEs.

Other characteristics of GNVQ were not carried forward into vocational GCSEs. Perhaps the most significant shift was an integration (in terms of titles, grading system, and governance) with the established ‘academic’ GCSE specifications. This strategy would be visible elsewhere, for example in the recreation of the Advanced GNVQ by 2005 as Applied A-levels. Overall, a systematic effort was made to move these new qualifications out of the vocational ghetto, while retaining the designation ‘vocational’. The new GCSEs thus participated from the beginning in the ambivalences and historical tensions associated with the word ‘vocational’.

Specifying Applied Science

In what sense was GCSE Applied Science intended to be ‘vocational’? No documents or other sources exist in the public domain or in the Qualifications and Curriculum Authority (QCA) files, which comment on the target student population or their likely progression routes. The original government press release had referred to 'craft and technician-type jobs'. This was a strong, but potentially problematic, marker for the specifications. The press release strayed into yet more dangerous territory by suggesting that these vocational qualifications would 'help in the drive to tackle truancy among disaffected young people' (Department for Education and Employment [DfEE] 2000). This association with disaffection was perhaps regretted, and certainly never restated, although there are indications that the new specifications were used with such students (Holland *et al.* 2003). The nearest thing to an official statement about purpose or progression is that contained in the subject criteria, which regulated the qualification:

> Applied Science specifications should enable students to develop a broad knowledge and understanding of the science sector. They should prepare students for further study on an applied course in science or in a science-related subject, or prepare for employment or further training in the industry. (QCA 2001: 1)

This statement raises more questions than it resolves: about the meanings of the 'science sector', the types of employment, or further training being referred to, and, centrally, how each of these might differ from those accessed through traditional science courses. The point is significant because the established route through science A-levels is itself arguably vocational. School science is routinely criticized within contemporary writing for having been principally a training route for professional scientists (Millar and Osborne 1998, Pike 2008).

The principal function of the QCA criteria was to identify the requirements placed on the 'awarding bodies'[5] which develop and administer specifications under QCA's authority. The criteria were produced by an ad hoc process within the QCA committee structure. They were written by a committee drawn from awarding bodies, science professional bodies, and other groups. Fundamental strategic questions about the purposes of the specifications were not within this committee's remit. Its focus was instead on the detail of the criteria, the central characteristics of which can be summarized as:

- the structuring of the qualification around three Units;
- the requirement that two-thirds of the assessment be through coursework (consisting largely of student-created portfolios reporting specified activities);
- a reduced emphasis on scientific knowledge; and
- a strong orientation to student practical activities and workplaces where science might be used.

These characteristics are reflected in the titles of the three Units (QCA 2001: 5):

- Unit 1: Developing scientific skills;
- Unit 2: Science for the needs of society; and
- Unit 3: Science at work.

The tone of the criteria in relation to science was celebratory. It contrasted with the more analytical stance of another, near-contemporaneous, science curriculum development: 'Twenty First Century Science' (Millar 2006). All specifications were required to have a 'vocational nature', but the meaning of this requirement, in terms of teaching activities or the likely kinds of employment in view, was not further explored. There is a degree of circularity here: the word 'vocational' was deployed but never seriously engaged. The most distinctive aspect of the specifications was the requirement that two-thirds of the assessment be conducted through portfolios of coursework, based on specified types of task, and conducted independently by students. These independent activities represented an important vehicle for the progressivist agenda identified earlier. Overall, this combination of official requirements offered the possibility of a significant, although not clearly envisioned, shift in the form of the science curriculum.

The questions of who might pursue the course, why they might do so, and where they might progress to, were approached more explicitly within promotional and other documents directed at parents, students, and schools. To some extent, however, these documents compounded the issues already identified. They tended to broaden the specifications' range of applicability and lessen their distinctiveness from generalist qualifications. Thus, according to the Department for Education and Skills (DfES) in 2003, Applied Science would allow students 'to gain an understanding of the professional world of scientific activity and research' (DfES 2003: 2). This is hardly the world of 'craft and technician-type jobs', still less of disaffection. In 2004 QCA guidance suggested that:

> GCSEs in vocational subjects keep your options open. They are valued by schools, colleges and employers, and will be useful *whatever you're planning to do when you're 16*. They can lead to *any of the courses or qualifications that are available for you to take after year 11*. (n.p.; emphases added)

This document offered a pen-portrait of 'Alison', who intended to become a teacher:

> She is taking Applied Science rather than [traditional] science because she feels that she is a 'practical learner'. Alison is now enjoying science much more than in the past and feels that the applied course has taught her to take more responsibility for her own learning. (QCA 2004: n.p.)

Material from another public body, the Learning and Skills Development Agency, painted a similar picture of 'Rhini Kapoor', who was voiced thus:

> I had a lot of fun on the Applied Science GCSE course. I bet I enjoyed myself more than if I had taken the traditional Science GCSE, and I reckon I learnt a lot more as the practical side of things really put the theory into context. Some of what we learnt helped me loads on my health and social care course and this is really where my interests lie. I enjoyed the biology aspect so much that I have decided to take AS level Biology as I know that what I learn will be transferable to a healthcare profession. (Quality Improvement Agency 2007)

Applied Science, it seemed, would provide a distinctively independent and practical approach to learning, and, again, constituted simply an alternative route through the science curriculum. There is no suggestion of any limitation in possibilities. In its report on Applied Science the statutory

Inspectorate of schools (Office for Standards in Education [Ofsted])[6] judged that such limitations on progression did exist (Ofsted 2004: 27), and commented further that they 'have rarely been made clear to pupils'. We note shortly that most schools and teachers agreed with Ofsted's view of the progression implications of Applied Science.

Realizing Applied Science

Take-up of the new specifications was moderate during the first four assessment cycles (see table 1). By 2007 they had attracted entries from ~ 20% of schools, but a much smaller percentage (~ 5%) of students, suggesting a strong targeting of the latter within schools.

Purposes and positioning: schools' perspectives

Applied Science may have been called a 'vocational subject', but for those schools which adopted it the vocational emphasis was muted. Within both interview data and national survey responses, teachers' reasons for taking up the specifications were dominated, first, by the aim of increasing the relevance of science to students, and, second, by the possibility that it might improve examination results for middle-attaining students, in a challenging area of the curriculum.[7] There was very little emphasis on vocational preparation in its usual sense of preparation for work.

> We felt that […][8] the traditional type of science course didn't really meet the needs or interests of the kids, and the applied courses provided greater scope for […] learning which was directly relevant to the real world, in terms of science technologies. (SMT)[9]

Such comments appealed to the well-established teacherly view of how science should be taught. They were usually expressed in generalized terms, as if relevant to all students. However, the deployment of the course itself was highly targeted. This targeting occurred rapidly and quite uniformly across schools. It had two aspects. The first was positive, and involved a focus on students judged likely to perform better if assessed through coursework, particularly where this might be critical to crossing the grade C/D[10] borderline:

Table 1. Applied Science: schools and participating students in England.

Year of assessment	*n* of schools	*n* of students
2004	238	8 916
2005	477	18 184
2006	730*	27 711
2007	840*	31 817

Sources: Joint Council for Qualifications 2008 (students); National Pupil Database 2008 (schools).
Note: * estimates.

> We recognized that we were very definitely going to do this as a pilot and we said: 'OK, who are the kids who aren't going to do well on the other course but who should be able to get a C? Let's try them on this other course'. (Course Leader)

Nearly 60% (n = 149) of schools surveyed, and almost all of the case-study schools, identified students just below the grade C/D borderline as their principal target, at least initially.

The second aspect of targeting involved the exclusion of students who might go on to follow A-level sciences, or even higher-attaining students with other aims:

> With the nature of Applied Science at the moment we felt that we had to say to pupils who were considering doing A-level sciences that maybe this wasn't yet sufficient preparation, there wasn't the obvious progression there. (SMT)

> I don't ever see us being allowed to say to our very bright kids: 'You can do Applied Science'. I just don't think parents will wear it. (Head of Science)

The relative uniformity of these judgements about the course's position was striking and contrasted with the more ambivalent and unstable messages from government and statutory bodies cited earlier. The gap between the two groups of students did however leave significant space for schools to manoeuvre, as the characteristics and impact of the course became clearer. There was evidence of successful schools broadening the target population (in one case to include all students except those studying the separate sciences, the route followed commonly by only the most able students), but these kinds of development were localized and contingent on individual schools' experiences and circumstances.

Developing the course

Teaching Applied Science involved significant changes in teaching approach. For large parts of their time students were to be organized and supported rather than 'taught' in a traditional sense so as to develop the portfolios that would contribute two-thirds of the weighting to their summative grading. This approach reflected a tendency already discussed for vocational curricula to promote a version of independent learning. For some schools and teachers these pedagogic changes were central to the attraction of Applied Science. This pedagogic approach was sustained by the assessment regime: teachers were left to develop novel teaching approaches as they saw fit, held to account only by the mechanisms and criteria used by awarding bodies to assess portfolios.

Except for that minority of teachers with experience of GNVQ, this form of teaching was novel and posed considerable challenges. Support was therefore important. A range of commercial textbooks and other resources was available and the DfES funded awarding bodies to provide supplementary training. DfES also commissioned the Centre for Education and Industry at Warwick University to develop teaching materials (Bell and Donnelly 2005). Fieldwork and questionnaire data suggest that teachers' knowledge of these and other resources was very patchy and their use of them limited. The resources themselves were largely untrialled. Most importantly, there was no central development team with a commitment to the course or the approach that it was promoting. There was thus no systematic management of the resources and no possibility of offering schools targeted guidance or of assessing and responding to their development needs. Commercial textbooks, with directly usable resources, had the widest penetration, and teachers adapted these materials as they saw fit.

Predictably, school staff varied in their capacity to respond to these pressures with such limited support mechanisms. Few started confidently. Some fieldwork schools, after a hesitant start, responded vigorously when the scale of the challenge and the possibilities became clearer. One teacher, in a school which ultimately judged their course a considerable success, responded to a question about how it was planned as follows:

> Do you want the honest answer here? It wasn't planned […] This year I organized some INSET [Inservice Training] time when we first came back to sort out the coursework. […] So we spent a whole day with all the staff that teach Applied and we made a scenario, as it were, for every single piece of coursework that we need to cover. So every single piece is now vocationally[11] linked. (Head of science)

Schools experienced a gradual and often somewhat random accumulation of expertise, resources, and assessment case law. It was rare for those responsible to judge that they had understood the issues from the beginning, although a teacher in another school where the course was again ultimately judged a considerable success described the foundation of her own successful approach as follows:

> I researched it well beforehand and I had gone to meetings, I'd chatted to the Exam Board representatives, so I sort of wanted to know before I stepped into a classroom that I was going to start in the right way, so I haven't changed a lot. (Course Leader)

The threat to the innovation from these circumstances is clear enough. However, given some sympathy with the published aims and assessment criteria, which most teachers did display, take-up of Applied Science could lead to a form of professional empowerment. There is evidence from both fieldwork and questionnaire responses (see below) that, despite, indeed because of, the challenges, the introduction of Applied Science was eventually experienced as positive by many schools:

> [T]hey haven't just got prescribed schemes of work or, you know, feel that they have to be restricted to the use of textbooks, […] they have some sense of ownership and it kind of grows organically, if you like. Teachers actually feel that they are delivering, that they have been part of developing, rather than something that, you know: 'Turn to page 15 and this is what we are going to do today'. (SMT)

Nevertheless, it is clear that working in this way, marshalling the resources needed, developing new classroom practices, and anticipating, reviewing, and responding to the novel assessment requirements involved large commitments of time and energy, and some luck. For a significant minority of schools the course was a failure. Their circumstances included lack of energy or foresight, lack of leadership and teamwork, and failure to keep in contact with the guidance on portfolio assessment provided by the awarding bodies (and the moderation which would be applied to it). The major direct cause was poor examinations results, which commonly only became apparent after moderation of coursework. Two such schools were in our initial fieldwork sample and both quickly dropped the course, one after a single assessment cycle. The first described the process as follows:

> '[P]lanning' is maybe being a bit generous. […] I did roughly map it out, but I gave ownership, initially, for the Physics and the Biology sections, to the other members of staff and then when it all went pear-shaped, we were just on fire-fighting, and it's whatever worked, you know. (Head of Science)

From national data (see National Pupil Database 2008) we estimate that a similar proportion nationally, some 50 schools (20%), dropped Applied Science after the first year. We will not pursue further this aspect of the introduction of Applied Science—the circumstances under which genuine teacher initiative and independence can be promoted—although it seems that there is a linkage between the real possibility of failure and genuine professional independence.

Key issues in teaching the course

Although individual teachers and schools identified many issues in connection with the Applied Science, we comment on three that had a wide currency. These are:

- the emphasis on practical work;
- the management of assessed work and student portfolios; and
- the relationship with workplaces.

The emphasis on practical work

It was acknowledged by almost all teachers that the course facilitated, indeed required, a strong emphasis on laboratory and other practical work. Most claimed that this had a positive impact on students:

> Yes, there is huge emphasis on coursework. I mean their Unit 1 project is seven pieces of work. The practical aspect again is huge, [students] are doing practicals almost every lesson […] I think that is a definite improvement, something that is very obvious. I think that's helped their general confidence in themselves as well. (Course Leader)

This view was echoed by some students:

> This year because we're on the Applied Science course it makes it more fun so we're not, 'Oh, we don't want to go'. So we'll go, and then the work that will be set for us will be practical, or coursework and practical, or practical and coursework afterwards. (Year 10 girl)

Much of this activity was related to the assessment requirements for the specification, but it was also a consequence of the freedom staff had to devise activities within the broad remit of the specification. Again this echoed the established view amongst teachers of how science should be taught most effectively. The activities that we observed in lessons (and over 60% of observed lessons involved practical activity) were not radically novel. They often resembled the kinds of activity that might have been seen in English science classes from the late 1970s and early 1980s, reflecting a range of resources available at that time, for example, Nuffield Secondary Science (Misselbrook 1971), the Association for Science Education's Less Academically Motivated Pupils (LAMP) Project (Lamp Project Staff *et al.* 1976), and the early *Science at Work* series (Nuffield Curriculum Centre 2008a, b). In sum, teachers appeared to appropriate 'vocational' language into this older tradition.

The management of assessed work and student portfolios

The course required teachers to integrate laboratory activity and the creation of assessed portfolios. This was complex in terms of record-keeping and management, but it also involved a strong pedagogic shift:

> Probably the thing that we've learned the most since we have started teaching the Applied Science course, which we'd thought about, but perhaps hadn't realized how important it was going to be, was that changing to a vocational course is actually about changing your whole teaching style and the learning style for the youngsters, [...] and it's only really now that we are starting to come to terms with that. (SMT/Science teacher)

In the most successful schools this often involved a novel day-to-day classroom environment but also a new longer-term rhythm to teaching activities. Students undertook work against the criteria, were given feedback, and then revised their work. This emphasis on (a form of) student independence appeared increasingly important to teachers and had implications for the types of student to whom the course was offered:

> The course gives well-motivated but less academic students a better chance of attaining something. Modular double award is too content-heavy and keeps confirming lack of ability in exams. We have experienced students coming back at lunch time etc. to catch up, as they know they can control the portfolio part. (Course Leader)

Our national survey and case studies suggested that these more iterative ways of working were very common. A large majority of respondents to the national questionnaire stated that, by the time they reached Year 11, students were encouraged to work independently using the assessment criteria and other guidance ('most of the time' in 55% of the respondents' schools; 'occasionally' in a further 40%). According to the respondents, nearly half of the students (47%) were occasionally able to do so and a further third (37%) were able to do so for most of the time. Although the interpretation of these statements is clearly problematic, they communicate an image of the teaching process that distinguishes it from traditional English science teaching. A comment from one Year 10 student illustrates both the positive outcomes and some of the ambivalence in these processes:

> She's the best teacher ever, to be honest. She puts a lot of effort in making sure everyone gets everything done, but you don't feel under pressure, it feels like you do it in your own time. She uses lots of post-it notes in your work, she puts

> lots of little labels telling you what you should do to get more marks, a better grade. (Year 10 boy)

This is perhaps an extreme example of interventionist feedback, but the practice of offering students comments that targeted the detail of the assessment criteria was common, as the following examples demonstrate:

> [T]here's actually effectively a 2-page pro forma that you could fill in. It says: 'Have you done this?', 'Have you done this?', 'Have you done this?', 'If you do everything that's on this, it's stage 1. If you use this to write your own, it's stage 2. If you do this and you go off and find out lots of other things as well, and you […] whatever, then you get to stage 3'. (Head of Science)

> They take it back, they can make those changes, they can see because we have gone through the mark grid, and they can see where they're at, and where they could get to, whether they make that change, again, and then they hand it in, again. So it is a very fluid type of marking, and that is quite stressful, but that is how you're going to get the best out of your students. (Course Leader)

> But the way I have got round it is by questioning them, so they've sort of said, 'Well, what have I got to do to get to here?' And we have gone through the mark scheme and said, 'Right this one says simple calculations. Show me on your coursework where you've used simple calculations.' So they've identified it to me and I've said, 'Right so that's what you've done, for example, the resistance on the wire, you've used Ohm's Law, you've divided your amps into your volts, so, therefore, that's a simple calculation. Write about it.' So they've identified it to me, I reinforce it and then they write about it. (Teacher)

The relationship with workplaces

Seeking to involve real workplaces was an important element of the vocationalism of the course. The limited vocational emphasis in this and other respects was commented on by Ofsted (2003, 2004: 25). In our fieldwork schools it did not seem that this was simply an early difficulty in getting to grips with the issue, as had been the case with the organization and assessment of the course, where we saw clear signs of progression in most schools. The difficulty was more systemic, and during the course of our study we saw little evidence of progress or a resolution. Practical and organizational issues were referred to, but there were other aspects, some to do with status:

> The science industries around [here] are quite happy to work with schools, but they want to work with the absolute high flyers […] for whom the Applied Science course isn't […] appropriate. … They're less willing to get involved working with the average student. (SMT)

Ofsted and other sources identify some schools that displayed ingenuity in their exploitation of local resources, and creating a workplace-like environment.[12] Yet only one of our fieldwork schools successfully developed a wide range of workplace connections, identifying unusual settings such as the local ice-rink. Overall, 60% of the Heads of Science who responded to our questionnaire thought that maintaining a vocational emphasis was still a major issue for the course. From our fieldwork we judge this to be an optimistic figure: at best only two of some 20 schools appeared to us to have developed ongoing workplace links. In no case was it clear that the involvements were distinctively vocational, in the sense of involving preparation for work. They appeared closer to the kind of curricular enrichment that has long been an aspiration in science teaching.

Indirect evidence that this issue is not merely a localized or short-term difficulty can also be found from other policy sources within 14–19 education. Thus, even in the high-profile and highly resourced Diploma programme,[13] employer involvement was found to be the least developed aspect (National Audit Office 2007: 25–27). Anyone in teaching who has liaised with industry will know the difficulties of establishing and maintaining such links, not least because they are rarely a high priority for firms or their employees. The work is commonly delegated to relatively junior staff, dependent on goodwill, and viewed as expendable when economies are required or workload is pressing.

Evaluations of the course

We have already indicated that for a minority of schools the course was judged to have failed in a sufficiently serious way to abandon it. However this was by no means the norm: the following excerpts from interviews at three separate fieldwork schools demonstrate a very different view:

> I love it. I think it really, really works. It's got a lot of work to it. It's a huge workload for the teacher, but if the school can manage to keep the classes small, the feedback is, you know, the benefits are so obvious. (Course Leader)

> I really like it. I think it's much better for the students. I personally get a lot more out of it professionally because I think it's something new to do. (Teacher)

> [W]e had kids who were really underachieving before, and were quite a challenge in terms of their demands and behaviour issues, but were really taking off. So we were getting this feedback really quickly. (SMT)

When asked to form an overall judgement of the success of the course in meeting the school's aims for it, over a third of questionnaire respondents (37%) described it as very successful, while a further 49% judged it reasonably successful. For an innovation of this demanding kind, particularly given the lack of systematic or well-focused support, we judge these evaluations to be very positive.

Teachers' responses referred both to the learning benefits and the motivational impact of the course. However, many commented on the improvements in GCSE examination results compared with those that would have been predicted in traditional science course on the basis of attainment at age 13. The following quotations from questionnaire responses illustrate this judgement:

> 100% obtained C against predicted 50% on (the usual course).
> None predicted Cs at modular science. 40% achieved Cs.
> Target = 30% grade C or above. Achieved = 60% grade C or above.

Over half (60%) the schools thought that students were performing better than they would have done if following traditional science courses.

Nor were these views confined to teachers. One Year 10 girl, speaking in a group interview and discussing in-house grades, identified the outcomes of the course in a strikingly candid way:

> And for us to get As, […] we're not really the keenest people in school. In science we do knuckle down a lot, don't we? Like, for us, getting As, it's a big achievement.

Overall, nearly half (48%) of Year 10 students surveyed claimed to enjoy science more than in Year 9 (n = 248), while over half (54%) claimed to find it more interesting and 68% to try harder. Although we have not space to report them here, a longitudinal analysis of national statistics demonstrates clearly that among students who had been of lower attainment at age 13, those following the Applied course performed very significantly better than peers who followed the standard course (Bell *et al.* in press).

The divergent meanings of the reform

Despite its many challenges, and an undoubted failure in a minority of schools, Applied Science proved a considerable success (in terms of motivation, student performance, and teacher professional development) in the eyes of the majority of teachers and schools that chose to adopt it. We have offered some of the evidence for this in the preceding sections. Having clearly registered that judgement, in this concluding section our principal purpose is to examine the innovation more critically. We will focus on two issues, although the first is sub-divided: the policy role of Applied Science, including both its social positioning and the curricular adaptation in schools; and the pedagogic realization of its assessment regime.

In contrast with the many governmental policies that *prescribe* action, a generous reading of Applied Science might construe it as a *resource*, potentially enabling schools to cater for students' needs and preferences more effectively. 'Needs' and 'preferences' are, however, not naturalistic concepts: they are heavily mediated by other judgements. Schools have tended to distribute students across available science courses according to judgements of their likely attainment. Applied Science increased the range of possibilities, but with a strong governmental steer. As an intervention it was thus situated somewhere between a centralized 'operational statements of values', in the older language of Maurice Kogan (Kogan and Bowden 1975: 55), and the programmatically readerly texts[14] of the National Curriculum (Ball 1994: 14–27). It is not news that, however 'readerly', policies are in significant part re-interpreted by actors on the ground, who select, resist, and modify the intentions of policymakers. Moreover, what policymakers and practitioners engage under the name of 'curriculum' are radically different entities. The well-known conceptualization generated in the earliest ancestors of the Trends in International Mathematics and Science study (distinguishing the *intended*, *implemented*, and *attained* curriculum (Rosier and Keeves 1991: 3–2)) offers a somewhat over-rationalistic and -linear account of this phenomenon, whereas Doyle's (1992) version (identifying the *institutional curriculum* and the *experienced curriculum*) only partially captures these categorical differences. Although phrases like 'top-down' and 'bottom-up' are sometimes used in the context of policy studies (Younis 1990), perhaps the most apt term to describe the process involved here is 'co-production' (Hill and Hupe 2002: 137). Schools and teachers did not merely supply pedagogic and curricular detail, they also created social and intellectual status and other practices and meanings.

Policy silences were thus important in the realization of Applied Science. Despite an occasional slippage (as in the early reference by the then DfEE (2000) to 'disaffection' and to 'technician' jobs) the student population for which Applied Science was intended was left vague. This vagueness offers a significant contrast with the handling of these issues a generation earlier. An ancestor of Applied Science, the Nuffield Secondary Science course, developed after the better-known specialist Nuffield courses, explicitly targeted students unlikely to be entered for the high-status General Certificate of Education 'O'-level examinations (Misselbrook 1971: vii). Such a formulation is no longer possible within GCSE, where there is a common set of specifications, common metrics of student performance, and a less explicit approach to the ways in which schools differentiate and direct students. Applied Science was presented by government simply as a parallel version of existing late-secondary science. Yet, despite this apparent openness, schools' decisions to target lower-attaining students were quickly, indeed instantly, evident.[15] There was a *de facto* acknowledgement that Applied Science was not equivalent to the traditional course in terms of likely progression routes or the attainment of the students who followed it.

The mechanisms by which the positioning was achieved were rarely made explicit or its rationale identified; references to reduced scientific content came closest. These mechanisms were nevertheless real and powerful. The absence of explanation to students and parents of the consequences of following the course reflect a degree of systemic disingenuousness. That disingenuity is exemplified also in some of the public documents cited earlier. Parents were significant, if largely silent, participants. A kind of Bourdieuan social/cultural capital was deployed by proxy, as it were, in the anticipations of teachers (Bourdieu 1986), although at need that capital could be deployed more actively if parents knew how to do so (Ball 2003: 79–110), through the vetoes and other interventions that many schools allowed for this 'experimental' course. However, the process was in large measure submerged and reflexive, in the sense that teachers' expectations of parental sensitivity, communicated through language and procedures that signalled 'difference', themselves configured Applied Science, and its students, as 'different'. Overall, although a shift away from prescriptive, centralized innovation undoubtedly facilitated local flexibility and responsiveness to student diversity, it was clearly positioned within established modes of differentiation, employing already existing criteria. The space that Applied Science was to occupy was already articulated within the structures, discourses, and expectations of schools. 'Resource' is too innocent a term fully to encompass its role.

A subordinate but still very important element of this co-production was the adaptation of the meaning of vocationalism to teachers' existing understandings of good science teaching. Without this possibility Applied Science would clearly have struggled to gain a foothold, particularly given the weakness of its support systems. No school was compelled to offer it and, given the large demands it made on teachers, this could have been fatal to any prospect of its being adopted. Another aspect of the meaning of 'vocational' science teaching in schools was created through this process.

A further key aspect of Applied Science was the scale and consequences of the assessed coursework for pedagogy and assessment. The day-to-day rhythm of classroom life was commonly altered from that within established science courses. Students spent much time working on reports and other aspects of portfolios, receiving feedback, and then reworking them. The scale and patterning of this activity varied across schools, but it was largely spoken of by teachers in the language of student independent learning, formative assessment, and student autonomy. That formulation fits well with contemporary political and professional rhetoric, and, as we have shown, was exploited from an early stage in promotional material. Yet it, too, deserves critical examination. The articulation between the assessment criteria and pedagogy derived from that established within the GNVQ. The meaning of this 'independence', even in the post-16 context, has been the subject of considerable academic attention. For both students and teachers it has been characterized as often involving a game of 'find the bullets' (meaning bullet points within lists of assessment criteria) (Ecclestone 2002: 126, 96–114), rather than a properly autonomous process of understanding, reflection, and progression. Ecclestone has characterized this at its lowest level as 'procedural autonomy'. Bates (1998) has gone further, critiquing the realization in practice of the broader notion of student 'empowerment' that had been canvassed for GNVQ. Teachers' commentaries and their observed practices suggest that Applied Science could be even more prone to convert into a tightly constrained form of procedural independence.

'Teaching' Applied Science in many schools could be construed as inscribing (often literally) the assessment regime into student activities through the procedures by which portfolios were generated. Such a network of activity, legitimated and sustained by assessment requirements, echoed shifts that are occurring within other areas of assessment, sometimes under the rubric of 'assessment for learning'. It can be interpreted more broadly and more critically: as a manifestation of Foucauldian discipline, within which power is deployed through the micropractices and day-to-day activities of a disciplinary regime (Hoskin 1990). It also echoes Foucault's view that discipline is not merely constraining (Foucault 1979: 194) but creative (in some sense). The historical link to vocational courses speaks of the strong relationship with economic productivity that Foucault also identified (p. 220–221).

This disciplinary process has two aspects. One is, so to speak, quantitative: to ensure that the sufficient outputs are produced which fit the constraints and positive demands of the assessment regime. The other is qualitative and arguably both more subtle and more insidious. It involves an iterative process in which students continuously revisit their work in order to judge it against the increasingly explicit, and often extrinsic, demands of the assessment regime. Programmatically at least, students ought never to be satisfied until they have fully met the 'quality' requirements of the assessment regime. It might even be argued that there is a slippage from these quality requirements back towards a simple quantitative enumeration of 'meeting' bullet-points. In any event, while the procedural target of this process is the portfolio, the actual target is the student. Indeed the word 'target' is an unhelpful metaphor. As Foucault (1980: 98) commented: 'individuals are the vehicles of power, not its points of application'. The process is one of inscription into the student's very self. Through this process the traditional notion of academic discipline is reconstituted into a Foucauldian discipline, through a proceduralized, indeed instrumentalized, focus on individual subjectivity. The outcome is indeed vocational, equally relevant to 'hospital, clinic, school [and] factory' (Ransom 1997: 40, 184). This is not, in our view, the most educationally defensible reconciliation of the academic and the vocational.

Vocationalization in schools: issues and research questions

In the commentary above we have moved some way from judgements of the 'success' of this example of a vocationalized curricular innovation in terms of examination results or even teachers' evaluations. Such judgements, although clearly significant, still demand a critical eye. Of course, we do not wish to argue against attempts to diversify the curriculum, or to give schools flexibility in its deployment, or to relate schooling to 'occupation' (in the Deweyan sense), or to promote student independence. Each of these outcomes is possible within the specific example of vocationalization with which we have been concerned and is potentially characteristic of most attempts to vocationalize the school curriculum. It can be argued that such outcomes represent the legitimate educational rationale for the many manifestations of vocationalization to which we referred at the beginning of this paper. However, we think it important to examine critically both the process of vocationalization and its concrete outcomes, and not merely to accept the representations of them within political and other rhetoric. Key questions relate to establishing a distinctive but properly educational purpose, and to accommodating the pressure to cater for a narrowly stratified student body. Our study also highlights the need to configure innovative assessment regimes so that they do not simply promote procedural autonomy but encourage a more open and less instrumentalized student involvement. The balance between teacher authority and centralized support within innovation also appears important, although this might be judged a generic issue in all curriculum development (Donnelly and Jenkins 2001). Critical but constructive engagement with such issues is the more necessary because the international political and economic imperatives towards vocationalization within the late-secondary curriculum seem likely to intensify.

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Notes

1. We will treat the word 'vocationalize' as referring to the effort to make the school curriculum more relevant to the world of work, but will not further seek to define it except by example.
2. See Edwards *et al.* (1997), Major (1997), Solomon (1996), and Young *et al.* (1995).
3. A-levels have been the established route into universities since their creation in the 1950s.
4. See Bates *et al.* (1998), Edwards *et al.* (1997), Hodkinson (1991), Major (1997), and Sedunary (1996).
5. There are three such awarding bodies for GCSE in England, and their specifications are effectively in competition with each other, although governed by the same QCA criteria.
6. 'Ofsted' is an acronym for the Office for Standards in Education.
7. These data are available in greater detail in Bell and Donnelly (2007).
8. In quoted extracts, we use the following conventions: … indicates the omission of text or speech to improve clarity; […] indicates pause or hesitation; [text] indicates text inserted by us to improve clarity.
9. Member of the school's Senior Management Team.
10. Grades A to C are increasingly judged as the key criterion of 'success' in GCSE, although there is no 'pass' as such.
11. For most teachers this meant setting activities in a real-world context.
12. Most vividly, by having students 'clock in'.
13. The Diploma programme is an ongoing government policy attempting to create a system of qualifications with, in most cases, a strong link to industrial 'sectors'. According to QCA (2008), 'It will enable students to gain knowledge, understanding and hands-on experience of sectors that they are interested in, while putting new skills into practice'.
14. i.e. Policy texts which the teacher simply 'read' rather than interpreted and 'rewrote'.
15. The targeting also applied more structurally: very few selective or independent schools adopted Applied Science. Only two out of 150 schools which responded to our second questionnaire were of these types.

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Appendix: Methodology of the empirical study

Data collection

Data collection in the project consisted of the following main elements:

- fieldwork in schools (including documentary studies, teacher interviews, lesson observations and some student focus groups);
- observation of training sessions by awarding bodies and others;
- interviews and documentary surveys at QCA;
- two national questionnaires addressed to Heads of Science;
- a student questionnaire; and
- analysis of the National Pupil Database for the 2004 and 2005 GCSE cohort.

Interviews and focus groups

Teachers from 20 schools were interviewed, over three rounds of data collection, in a rolling programme, with some continuities to introduce a longitudinal element:

- Round 1: (2004) 10 schools;
- Round 2: (2005) Four round 1 schools plus new schools, together with telephone interviews of Heads of Applied Science in other schools; and
- Round 3: (2006) a more intensive 3-day site visit to a round 1 school, plus two new schools.

Interviewees also included other support providers, including related national projects and awarding body Chief Examiners. The total number of adults interviewed was 64, and the total number of students interviewed 45. The numbers of training sessions (by awarding bodies) observed were: Assessment and Qualifications Alliance (AQA): 5; Oxford, Cambridge and RSA Examinations (OCR): 5; Edexcel: 6.

Questionnaires

In 2005 a preliminary national questionnaire (NQ1) was addressed to all secondary schools to ascertain which schools were following Applied Science or intended to do so. The total response was: 248 offering or intending to offer Applied Science, and 333 not doing so. The total number of maintained secondary schools at that time was 3367. The total of schools entering students for Applied Science in 2005 was 476. In 2006 a more detailed questionnaire was sent to schools following Applied Science. The total response was 149: this represents a response rate of just over 60%.

A questionnaire was sent to the Year 11 students of a random sample of 50 schools (SQ) A total of 248 responses from students were received, from 11 schools: it is not possible to estimate the response rate by student, but that by school was 22%.

National Pupil Database for the 2004/2005 GCSE cohorts

These data were obtained after a request to the DfES Schools Statistical Unit. The dataset consisted of anonymized performance data for the entire 2004 and 2005 GCSE national cohort, including anonymized school data, and selected data about students' Key Stage 3 test results.

For further details see Bell and Donnelly (2006a, b) and Bell *et al.* (in press).