



# An invisible revolution? Applied Science in the 14-19 curriculum

*A Report to the Nuffield Foundation*

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## Foreword

Applied Science is a relative newcomer to the late secondary curriculum, and perhaps still unfamiliar to many of those involved with education. Despite this, in 2008 nearly 110,000 students, some 15% of the age cohort, gained a GCSE or equivalent qualification in Applied Science. Five years earlier the number was less than 20,000. This is by any measure a substantial rise, but it is a story that has received little public or policy attention.

In Summer 2008 Professor Jim Donnelly of Leeds University published a report, based on work funded by the Nuffield Foundation, on students studying Applied Science at Level 3 (A level or its equivalent). He found that GCE Applied Science and other qualifications such as BTEC Nationals were providing a progression route for a growing group of students not catered for in the past. However his study raised questions about the lack of systematic support in terms of resources, training and guidance. He also found worrying evidence that the proposed Science Diploma was causing planning blight, with uncertainty about the future of A level Applied Science leading some schools to consider withdrawing from offering the qualification.

Nine months later the policy position is no clearer. What is clear, however, is that the numbers taking Applied Science at level 2 have continued to rise. And what is highly likely is that many of these students, having enjoyed the experience, will wish to continue with the study of science at Level 3. The question of what provision is available for them, given that they will not be prepared for traditional A levels in science, does not have a satisfactory long term answer.

This is a matter of some importance, above all for the students themselves, but also in policy terms. The National STEM programme has set ambitious targets for increasing the number of young people entering scientific and technological training. The students taking Applied Science are a large and growing group, different from those following the traditional route, who have an important role to play in developing national capacity in STEM.

Against this background the Foundation asked Professor Donnelly to produce an overview of the current position, with the purpose of drawing attention to this "Invisible Revolution" and of informing wider debate. His report is characteristically thorough, well informed and well evidenced. We are grateful to him for producing a clear eyed analysis which, while positive about the potential of this new subject does not shirk from confronting the questions that need to be addressed. We hope it will be of value not only to policy makers but also to teachers and managers in schools and colleges who are considering how to respond to this encouraging but complex new development. The Foundation itself will be listening hard to the debate and will be considering its own response in the coming months.

**Anthony Tomei**  
**Director**  
**July 2009**

## Summary

1. In the last decade there has been a sustained growth in Applied Science qualifications at both Level 2 and Level 3 of the National Qualifications Framework. At both Levels the numbers of entrants have shown significant, and in some cases rapid, growth. At Level 2, national and other statistics for 2008 suggest that approaching 110,000 students, or some 15% of the cohort, have gained an Applied Science qualification. There is evidence from these national data and other sources, notably interviews with teachers in successful schools, that there are many students for whom these courses provide a motivating form of science education.
2. Despite displaying important differences, these qualifications share an emphasis on what has come to be called 'Applied Learning', and in many cases are described at some point in their documentation as 'vocational'. The meaning of these terms is the subject of some debate, but a central characteristic of all of the qualifications is an emphasis on the workplace, and scientific activity within it.
3. Schools do not generally see these qualifications as strongly vocational, in the sense of preparing students directly for scientific employment, but rather as a form of science curriculum and pedagogy with a distinctive character and appeal.
4. Applied Science courses also have in common an extensive use of student portfolios for summative assessment. This in turn leads to a pedagogy involving less direct teaching, and a greater emphasis on student autonomy in the creation and improvement of portfolios. They also lend themselves to an increased role for Assessment for Learning (AfL).
5. Longitudinal and other statistical data suggest that GCSE and A-level Applied Science qualifications are often used with students who have attained less highly at the preceding Key Stage, and that they commonly enable these students to reach higher levels of attainment than would be the case if they followed traditional courses.
6. Fieldwork in schools suggest that these qualifications have encouraged a group of students to pursue science post-16 who would otherwise have been less likely to do so, and for whom there might not have been suitable provision. Many of these students progress to science-related courses in HE, though not to the specialist sciences, or to some of the more sought-after 'vocational' courses such as Pharmacy.
7. It appears that, once entered on an Applied Science course at KS4, students are unlikely to be able to shift to the specialist sciences in post-16 education, or later, and that this may limit their progression opportunities.
8. Schools vary considerably in their experience of the qualifications, but a majority feel that they have been a success, and contribute significantly to the institution's curricular offer.
9. Some Applied Science qualifications (mainly GCSE Double Award, and A-level Applied Science) have not received sufficient support, especially given their innovative teaching and assessment methods. A significant minority of schools offering these two courses, maybe as many as 20%, appear to withdraw after a brief involvement, particularly, though not exclusively, for this reason.
10. Our knowledge of some of these qualifications (mainly BTEC Firsts and Nationals, and OCR Nationals) is limited. It is difficult to find systematic evidence about them from the point of view of take-up, support and professional development, and pupil or teacher response. This appears to be due in part to issues of commercial sensitivity. In some cases, awarding bodies appear to be allowed to withhold important data that might be expected to be available within national statistics.
11. Applied Science (or, more broadly, Applied Learning in Science) offers considerable promise of broadening the appeal and take-up of science within the 14-19 sector. However, in order to fulfil this promise,
  - a. its rationale and target student population will need to be identified more clearly than is the case at present, particularly at Level 3.
  - b. it will need systematic support in terms of resources and teacher development.
  - c. the framework of qualifications within which it functions will need to become more transparent and stable. One way of achieving this would be to create a version of the proposed Science Diploma specific to Applied Science, within which existing qualifications were assimilated.





# 1

## Introduction

It has long been accepted wisdom that the science curriculum can be made more engaging for many students through an emphasis on 'relevant' contexts, whether in students' everyday lives, in socio-political decision-making or in the industrial and commercial uses of science. Recent systematic reviews of research evidence have suggested that such approaches can indeed be effective in motivating students (Bennett et al. 2003; Bennett et al. 2005). This report is concerned with a specific version of relevance within the science curriculum: an emphasis on work and the workplace.

In England<sup>1</sup> this approach has in recent years come to be signalled by the title 'Applied Science'. The Applied Science qualifications that have been introduced are also sometimes described as 'vocational', though the associations of this term mean that its usage in contemporary curriculum reform is declining.

In England, the provision of Applied Science courses<sup>2</sup> for the 14–19 age range began just after the turn of the century, and they have experienced considerable growth in recent years. Despite this growth, it is not too strong to say that Applied Science provision has entered the curriculum 'by stealth', often receiving limited attention in national statistics and policy documents.<sup>3</sup> This situation probably reflects the largely independent and unco-ordinated character of the several qualifications involved, but it may also result from the perceived 'status' of Applied Science.

Numerically, the dominant qualifications involved have been GCSE and A-level Applied Science, Intermediate GNVQ, before its withdrawal, and, increasingly, BTEC. These qualifications will be the principal focus of this report. The situation is complex, and a summary of the main qualifications involved, including 'non-Applied' for purposes of comparison, is given in Appendix A. Some indication of what is distinctive about Applied Science has been given above. A recent report from the Nuffield Review of 14–19 education offers its own account (reproduced in Figure 1 (Pring 2008)) while an indication of the types of activities that courses involve is given in Appendix B. It should also be observed that these qualifications have in common a greater emphasis than established science qualifications on student practical work, student independent activity and the use of portfolios for formal, summative assessment.

**Figure 1** A view of Applied Science from the Nuffield Review

**Applied science**

- includes understanding scientific knowledge and methods of scientific enquiry which are embodied in techniques used by scientists. These techniques cross areas of application (e.g. in the use of microscopes by public analysts, microbiologists and others).
- develops this understanding through authentic work-related contexts – how science actually works (e.g. a nurse or paramedic dealing with an emergency or the reasoning of a building control inspector when confronted by a contractor's unsatisfactory standards).
- focuses on the people who apply the scientific techniques and knowledge, looking into the thought processes and skills involved (e.g. questioning the theoretical and practical limitations of a given technique that determine its application to different problems).
- provides opportunity for practical problem-solving, emphasising ability to use techniques, skills and knowledge for tackling science-related problems (for example, in the analysis of blood samples in the diagnosis of an illness).
- engages with contemporary scientific issues, especially the relation between science, technology and society.
- requires a high level of numeracy because of the centrality of 'quantity' and statistics in the work related science. Accurate measurement is crucial.

<sup>1</sup> Discussion in this report is limited largely to England, mainly because tracking and comparing change across the entire United Kingdom has grown increasingly difficult, particularly since Welsh devolution. See for example, Royal Society 2008.

<sup>2</sup> This report will tend to use the terms 'course' and 'qualification' interchangeably, though in principle they have quite distinct meanings. The relationship between specifications and the courses which result from them is an important issue for many curriculum innovations, including those discussed here.

<sup>3</sup> See for example the source note to Table 3.



This report examines the major issues of policy and practice that these developments raise, taking account of empirical evidence where it is available. The report is centred on the following questions:

- what is distinctive about Applied Science qualifications, compared with other science qualifications at KS4 and KS5?
- how are institutions making use of these qualifications and, in particular, with which students and with what outcomes?
- what issues of policy and practice do the qualifications and the courses based on them raise, and what are their prospects and potential contribution to 14–19 science education?

The science qualifications that are the focus of the report are congruent with a wider approach to the school curriculum, especially at 14–19, that has come to be designated 'applied learning'.<sup>4</sup> This term is particularly used in the context of a major English policy development that is relevant to our discussion: the introduction of Diplomas for the 14–19 phase of education. At the time of writing this important initiative includes proposals for three so-called 'academic Diplomas', including one in Science.<sup>5</sup> The Science Diploma would, if implemented, have major implications for the qualifications with which this report is concerned. The Conservative Party

has indicated that, if elected to government, it would not press ahead with the 'academic Diplomas'. These uncertainties, and the associated politicization of the Science Diploma, are not helpful. Nevertheless, as will be suggested later, the Science Diploma could be adapted to provide an over-arching framework for an applied route through the late secondary science curriculum.

The report consists of five further main sections. Section 2 briefly reviews the main qualifications with the title 'Applied Science' that have been introduced. It summarises their quantitative growth, drawing mainly on public statistics. Section 3 offers an overview of how schools and colleges are using the qualifications, drawing on findings from available studies of the qualifications. Section 4 integrates the available evidence to give an overview of the present situation. It argues that, despite their diverse origins, these Applied Science qualifications have sufficient in common to be seen as a single 'reform', raising a common set of issues. Sections 3 and 4 also suggest that there are significant gaps in the available public domain evidence about the impact of Applied Science. Section 5 of the report identifies the potential of Applied Science as an element of the 14–19 science curriculum, and the main challenges which need to be addressed if that potential is to be fulfilled. Section 6 draws some broad conclusions.

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<sup>4</sup> Applied learning is the practical application of theory that allows learners the opportunity to actively engage with the curriculum they are studying. It is relevant and meaningful to learners as it allows for learning within different contexts and environments. Applied learning allows the learner to interact with teachers, other learners and individuals from outside the classroom.

Applied learning encourages:

- linking understanding and learning activities to job roles
- interaction with professionals
- real-life investigations and active enquiry
- learning through doing
- interaction with other learners through group work
- learning in different environments.

[http://www.qca.org.uk/qca\\_13477.aspx](http://www.qca.org.uk/qca_13477.aspx)

See also the QCA document *The Diploma and its pedagogy*

[http://www.qca.org.uk/libraryAssets/media/The\\_Diploma\\_and\\_its\\_pedagogy.pdf](http://www.qca.org.uk/libraryAssets/media/The_Diploma_and_its_pedagogy.pdf) Accessed 22.4.09.

<sup>5</sup> <http://www.sciencediploma.co.uk/pdf/LOL%20Statement%20060209.pdf> Accessed 9.2.09

# 2

## The emergence of Applied Science

In 2000 the then Secretary of State for Education and Skills, David Blunkett, announced the creation of a suite of 'vocational GCSEs', the members of which were eventually retitled 'GCSEs in vocational subjects'.<sup>6</sup> The suite included a new GCSE, 'Applied Science'. The inclusion of science within the suite was a significant departure. Science had been available at GNVQ, but, until 2000 only for post-16 students. The new GCSE offered a novel version of science as a core National Curriculum subject at KS4.



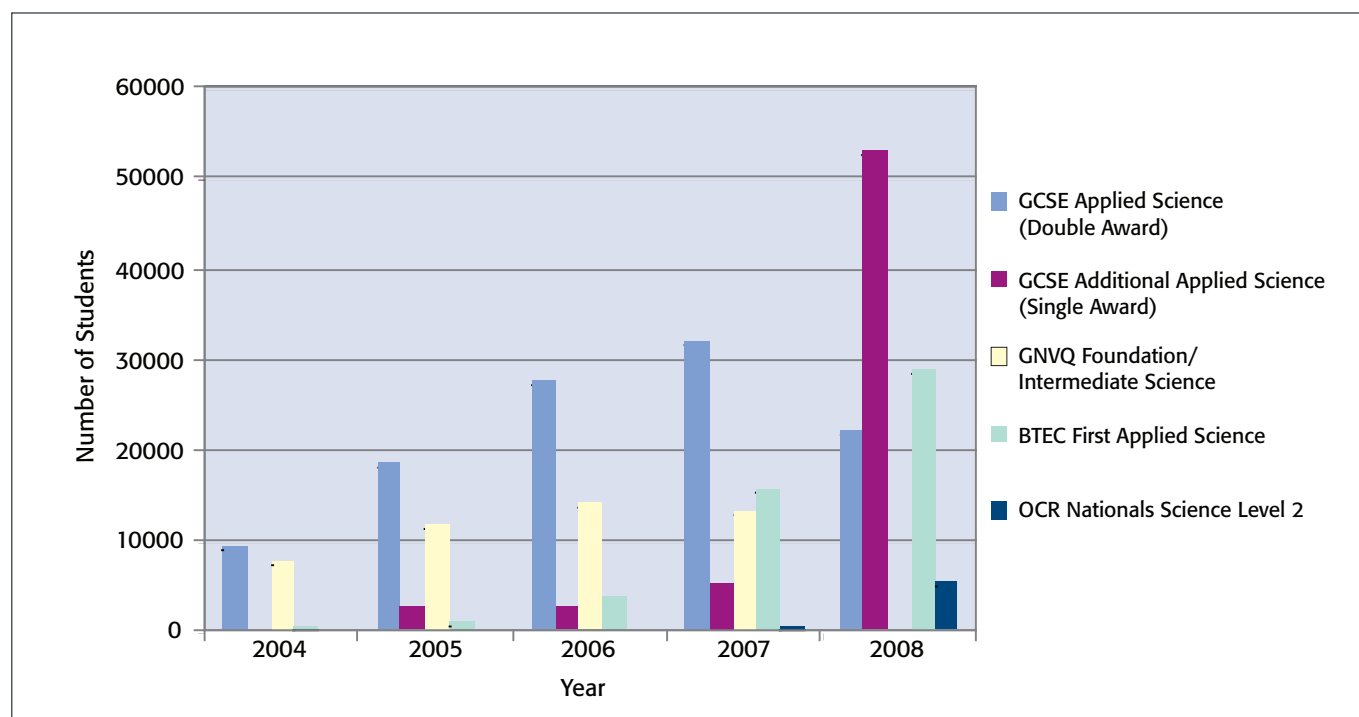
FAYE NORMAN/SCIENCE PHOTO LIBRARY

This novelty was signified both by the adjective 'Applied', and by categorizing it as a 'vocational subject'.<sup>7</sup> Take-up of the double award GCSE was modest. At what appears to have been its peak in 2007 the qualification attracted an entry of over 30,000 students. However, it was joined in 2006 by a single-award Applied Science qualification, as part of the national reform of GCSE Science undertaken in that year. In the first year of full national availability (2008) the single award Applied GCSE attracted an entry of over 50,000 students. Other Applied Science qualifications were also coming on stream. From 2000 schools had been able to offer Intermediate GNVQ Science at KS4. As GNVQ was progressively withdrawn, other qualifications, BTEC Firsts in Applied Science and OCR Nationals<sup>8</sup>, all potentially worth four 'good' GCSEs, began to be taken up in schools.

The combined impact of these developments was such that, in 2008, from a total cohort of some 740,000 students, around 110,000 (nearly 15%) gained an Applied Science qualification at National Qualifications Framework (NQF)<sup>9</sup> Level 2. The story does not end there: Applied Science qualifications have also been developed at Level 3. A-level Applied Science, which developed out of Advanced GNVQ and the Advanced Vocational Certificate in Education, was seen by many schools as a natural progression route for many students from the Level 2 qualifications just described. A-level Applied Science also offered an alternative to traditional specialist A-level sciences in physics, chemistry and biology. In 2008 it attracted an AS entry (combining single and double award) of some 3,000 students.

Data showing the overall entry to these Applied Science qualifications at NQF Levels 2 and 3 are given in Figures 2 to 4.

**Figure 2** The growth of Applied Science qualifications at KS4 2004–2008



**Sources:** these data and those in Figure 3 are taken from a range of sources including the relevant Statistical First Release and, by kind permission, internal data from Edexcel and OCR. It should be noted that they are the only data in report which relate to England, Wales and Northern Ireland. All other data refer to England only.

<sup>6</sup> That this subtle change of name was thought worth making is indicative of the sensitivities that the word vocational engendered.

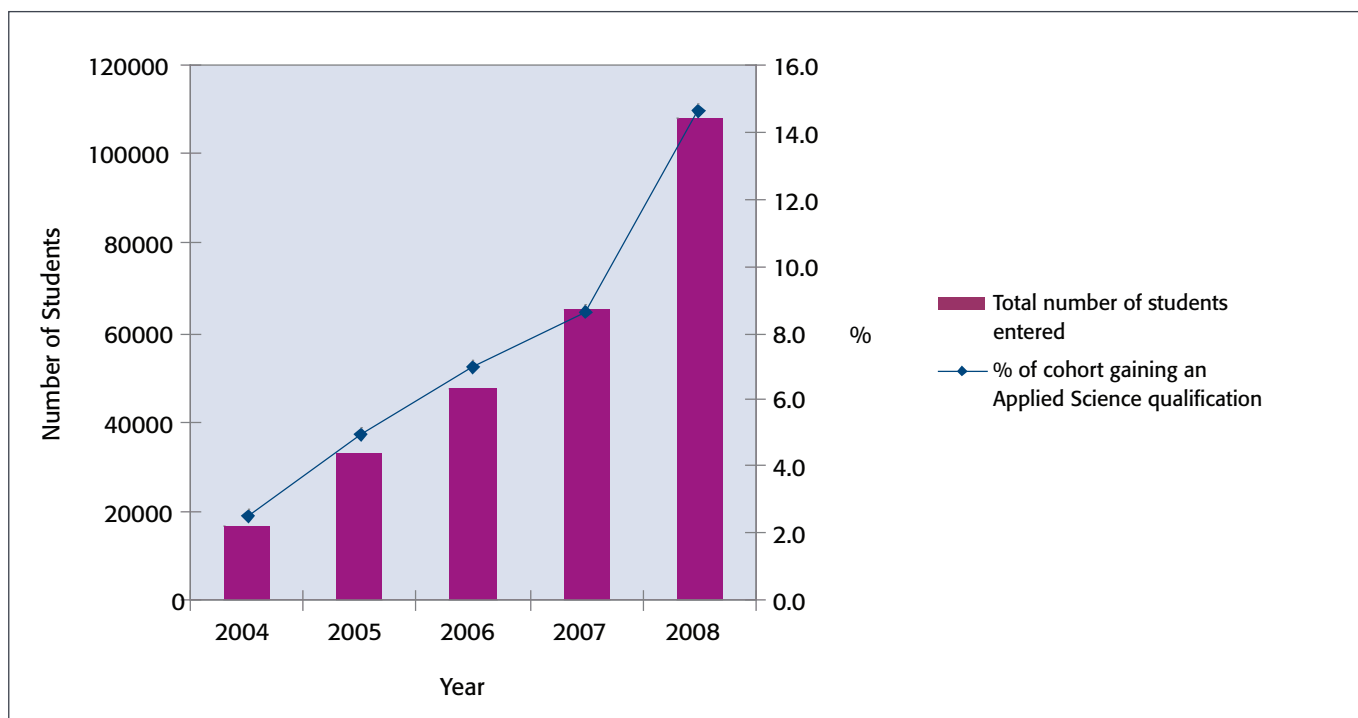
<sup>7</sup> The other subjects, most looking more obviously vocational, and with an ancestry as Part One GNVQs, are:

- applied art and design
- applied business
- applied ICT
- engineering
- health and social care
- leisure and tourism
- manufacturing.

<sup>8</sup> These qualifications are entitled Science, not Applied Science, though in other respects they are similar to the others described here.

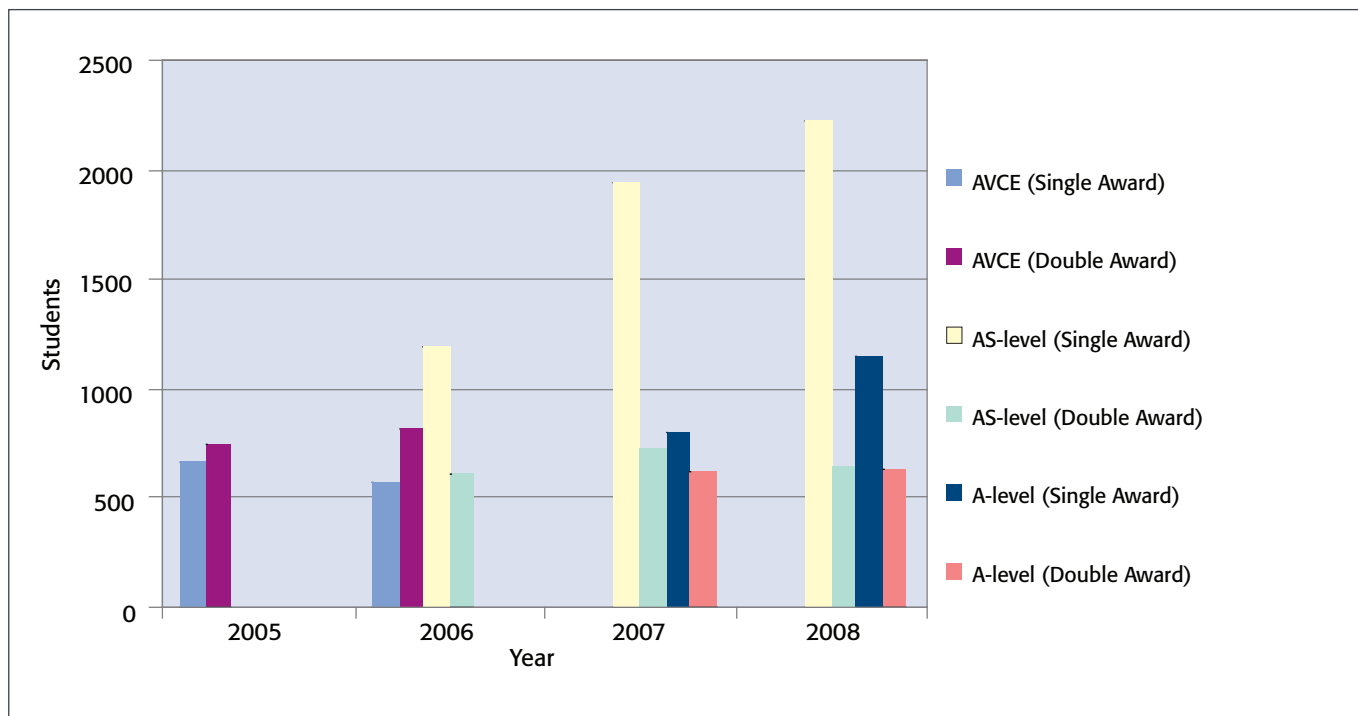
<sup>9</sup> To be replaced by the Qualifications and Credit Framework (QCF).

**Figure 3** Total Applied Science entry at KS4 2004–2008



Figures 2 and 3 relate to qualifications at Level 2. Equivalent data for Level 3 are not available, mainly because of the absence of information about BTEC Highers, which is withheld by the awarding body, apparently on the grounds of commercial sensitivity (See Royal Society 2008, p.19). There is anecdotal evidence that take-up of Level 3 BTECs is growing significantly, particularly in schools, but authoritative evidence is lacking. Figures 4 and 5 below are therefore confined to AVCE and A-level qualifications. Again there are signs of considerable growth, though numbers remain significantly less than those for the traditional sciences.

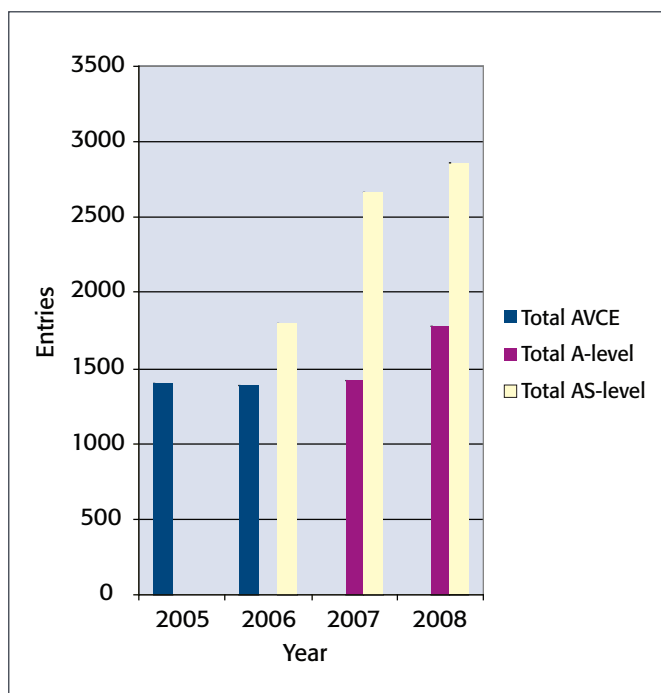
**Figure 4** AS and A-level entries 2005–2008



**Sources**

2005 <http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000663/Addition1.xls>  
 2006 [http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000703/SFR02\\_2007\\_tables\\_Rev\\_Oct\\_07.xls](http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000703/SFR02_2007_tables_Rev_Oct_07.xls)  
 2007 <http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000755/sfr35-2007alltables200801.xls>  
 2008 [http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000816/sfr29\\_2008\\_tables.xls](http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000816/sfr29_2008_tables.xls) (Accessed 20.1.09)

**Figure 5** Total entries for AVCE, AS-level and A-level Applied Science 2005–2008\*



\*For AS and A-level, single and double award have been combined

Taken together, these figures give the quantitative story of Applied Science. They indicate that the introduction of these qualifications has had a significant impact within late secondary science education, particularly at KS4. Given its national character, its quantitative scale and (as will be discussed below) the major shift in teaching methods and assessment regime that it embodies, the introduction of Applied Science can be seen as a potentially significant and radical reform within English secondary science education. Yet the process has been largely unnoticed and is regularly ignored in official statistics and policy documents.<sup>10</sup> This lack of visibility no doubt has several sources, including the piecemeal nature of the process and the independence of the various qualifications. In the light of this relative official invisibility schools' use of the qualifications is the key influence on their significance, and their likely contribution to 14–19 science education. The following two sections focus on this issue.

<sup>10</sup> See for example the note to Table 3 below.



# 3

## How schools use Applied Science qualifications

This section draws on evidence from public statistics and those few studies of the qualifications which have been undertaken (Bell and Donnelly 2007; Donnelly *et al.* 2008). It will discuss each of the main qualifications in turn, beginning with those at Level 2, though little information is available publicly about BTECs or OCR Nationals.





## Level 2 qualifications

### GCSE Double Award Applied Science

Some insight into how schools are using this qualification can be gained from the distribution of raw grades obtained. Table 1 shows the profile of grades for Double Award Applied Science from a typical year (2005), compared with the then-standard Double Award Science, which was taken by the large majority of students.

**Table 1** Grade distribution for students entered for GCSE Applied Science, 2005

Course followed	Grades obtained (% of entry)							
	A*A*	AA	BB	CC	DD	EE	FF	GG
Double Award Applied Science	0.1	1.2	7.6	23.5	26.8	19.7	12.0	5.7
Double Award Science	4.7	9.1	14.1	28.6	19.3	12.2	7.0	3.0

**Source** GCSE and Equivalent Results for Young People in England, 2005 (Provisional)  
<http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000610/contents.shtml> (accessed 12.12.08)

These raw grades show a significantly lower level of attainment among Applied Science students compared with those entered for Double Award Science. This pattern may be interpreted in various ways, though the most obvious conclusion is that schools entered less highly attaining students for the Applied qualification.

Further light was cast on this issue in a study which compared the performance of these two groups of students at KS3, employing longitudinal data from the National Pupil Database (NPD) (Bell *et al.* 2009). Table 2 shows the mean KS3 science level for students entered for Applied Science and for standard Double Award Science respectively, in those schools offering both qualifications.<sup>11</sup>

Table 2 shows that students entered for the Applied specification had performed significantly less well at KS3 than those entered for the then standard Science specification. This finding is confirmed within fieldwork data derived from the same study. Schools appeared to choose students whom they judged likely to benefit from a greater emphasis on portfolios based on written work; were consistent attenders; and were unlikely to follow traditional .

A-level sciences. Schools were also sensitive to the views of parents, and often appeared to allow them an effective veto over students' participation in Applied Science. Schools' attitudes are illustrated by the following quotation from a teacher at one of the fieldwork schools:

**"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."**

(Bell and Donnelly 2007: 25)

**Table 2** Mean KS3 levels for students in Applied Science schools, 2005

Course followed	Number of students	Mean science level at KS3
Double Award Applied Science	16,033	4.6
Double Award Science	52,617	5.3

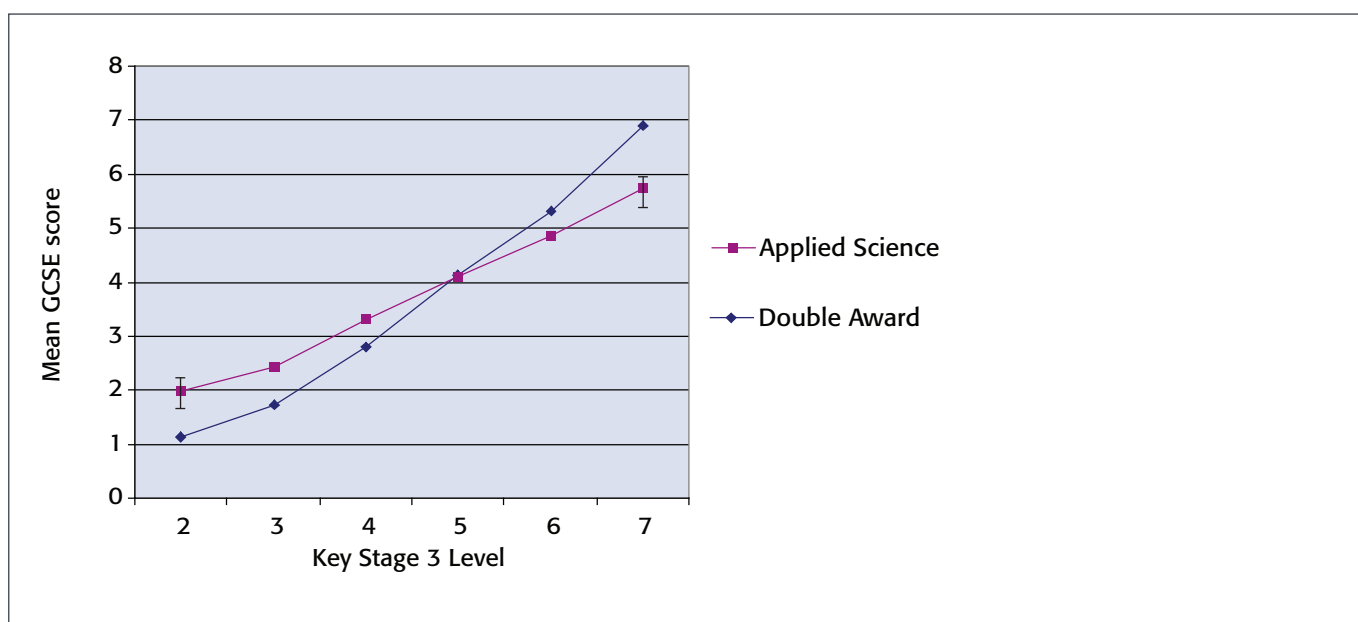
<sup>11</sup> A full account of the source of these data is given in Bell *et al.* 2009. Student samples are drawn from schools which offered both Double Award Applied and Double Award so as to avoid any effect due to Double Award Applied schools differing significantly from the general population of schools.

Whatever the detail of this process (and the accuracy of the judgement about parental views), it is consistent with a range of evidence that GCSE Double Award Applied Science quickly, and uniformly, came to constitute not just a distinctive route through KS4 science, but a route appropriate to a specific group of students.

In a national survey of schools, nearly 58% of respondents identified the course as suitable for students on the C/D boundary who were thought likely to move over that boundary and gain a grade C if following an Applied Science

course (Bell and Donnelly 2007:Table 3). This survey found also that, in general, schools felt that the course would benefit these students in terms of motivation and final attainment. The value-added analysis of the 2005 cohort reported earlier tends to support teachers' instincts on this (Bell *et al.* 2009). Students around the C/D boundary did indeed outperform equivalent students (equivalent, that is, in terms of performance at KS3 in science) who were entered for traditional Double Award Science, though the pattern was reversed for higher attaining students. (See Figure 6).

**Figure 6** A comparison of mean Science GCSE score (A\* = 8) and KS3 science level for students following Double Award Science and Applied Science\*



\*95% confidence intervals are included where this is practicable: most are too narrow to be discerned. All differences except that at Level 5 are significant at the 5% level or below. Entries for Applied Science amongst students gaining levels 6 and 7 at Key Stage 3 were however very small.

Other key findings from the fieldwork undertaken in this study are summarized below, with quotations in some cases (the quotations are illustrative, not representative).

- A majority of teachers and students were positive about the impacts of GCSE Applied Science on motivation and attainment.

“...we 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.”

“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 ...although with that there’s extra pressure because there’s more work, there’s a heck of a lot of marking.”

- Teachers commonly felt that the course provided considerable challenges for them in terms of devising activities, organising the classroom and seeking to give greater independence to students so as to allow them to benefit from the portfolio work.

“Probably the thing that we’ve learnt the most since we have started teaching the Applied Science course, which we’d thought about, but perhaps hadn’t realised 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.”

- There was much variation across schools in terms of their ability to meet these challenges: NPD and other data suggest that a significant minority of schools (approaching 20%) withdraw after one assessment cycle.<sup>12</sup>
- Liaison with workplaces was limited.

“I’m sure it’s this thing that could be fantastic, but getting it into a school curriculum, I mean taking them out for trips as often as you’d like to is just impossible. Getting people in is easier said than done, especially when you have to get seven pieces of coursework done each year – it’s very difficult. [...] So I’m sure it’s a good thought, and somebody has come up with a very good idea, but it hasn’t quite worked, and whether it hasn’t quite worked in this school yet, or whether it hasn’t quite worked nationally, I don’t know.”

- Whether they employed the course successfully or not, schools felt that national support for the development of the course was inadequate, particularly given the demands it made. It seems likely that this contributed to the relatively high school drop-out rate just noted.

“...when we first started it two years ago in September, we knew very little about the course. We had no textbooks because [...] no books came out on time. We didn’t actually receive the books I don’t think until February, so we were kind of teaching it off the top of our heads, without any resources at all, and using normal GCSE textbooks [...] ‘teaching blind’ I think, would be a good description.”

<sup>12</sup> This figure was obtained by using the NPD to identify schools which entered students for the first assessment cycle but not the second. The proportion of withdrawals was approximately replicated across the 20 schools in which fieldwork was undertaken.

## GCSE Additional Applied Science

The single award GCSE Additional Applied Science was examined for the first time in 2008, as part of a major reform of GCSE Science. It attracted some 50,000 entries. A prototype form had been developed within Nuffield–Salters 21st Century Science (C21) and was offered more widely as part of the 2006 GCSE science reforms. The C21 pilot course received sustained developmental support in terms of conceptualization, teaching materials and on-going teacher INSET. Though this aspect of C21 was not independently evaluated, there is some evidence that its Applied Science element was a considerable success. Schools reported that it motivated and engaged students, through its

emphasis on practical uses and workplace settings for science, though again it seems that it was offered to less highly attaining students (Campbell 2006). There is no significant evidence available about how the other awarding bodies' versions of Additional Applied Science, first introduced in 2006, have worked in schools. However, the pattern of grades obtained in 2008 (see Table 3) when compared with those for the single award Additional Science GCSE (also introduced in 2006) suggest that entry is again focused on less highly attaining students.

**Table 3** Grade distribution for students entered for GCSE Additional and Additional Applied Science, 2008

Course followed	Grades obtained (% of entry)								Entry
	A*	A	B	C	D	E	F	G	
Additional Applied Science	0.1	0.7	6.5	23.1	29.6	20.4	10.9	5.4	52,811
Additional Science	5.8	11.6	21.4	29.2	16.6	8.3	4.3	2.0	317,312

**Source** Additional Applied results as published on awarding body websites; the DCSF Tables available at the time of writing do not give results or grade distributions for Additional Applied Science: [http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000826/SFR02\\_2009\\_AdditionalTables\\_Amended160109.xls](http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000826/SFR02_2009_AdditionalTables_Amended160109.xls) Table 13.

## BTEC First Applied Science and OCR Nationals in Science

There is almost no information available in the public domain about schools' experiences of BTEC Firsts or OCR Nationals, despite the fact that some 30,000 students seem to have been entered for these qualifications in 2008. Indeed it is even difficult to obtain statistical information about entry for these qualifications, since the information is judged commercially sensitive, though Figure 2 above suggests that they are experiencing considerable growth.

## Level 3 qualifications

### A-level Applied Science

Though schools' judgements of the success of the Double Award GCSE varied, a significant proportion of those which offered it successfully found themselves with a potential new market for post-16 science. This included students who would otherwise have not considered, or been accepted for, the specialized science A-levels. For these students the new A-level Applied Science, available from 2005, provided a valuable progression route. Although AVCE Science could in principle have fulfilled this function, it appears that the A-level Applied Science, which effectively replaced it, offered greater cachet, through its position as a mainstream A-level qualification. A study funded by the Nuffield Foundation in 2008 identified progression from KS4 Applied Science as a principal reason for schools' take up of the A-level.

“We had a cohort of students, about 10–15 students, who had done the Applied Science [GCSE] course and had done extremely well. They had got Bs instead of Cs, certainly a lot higher than their predicted levels. They were really into science and they wanted to continue, so they spoke to me about doing traditional A-level, and we just didn’t think it was a good fit. So we came up with this idea of Applied Science A-level and they were quite keen and enthusiastic. We started with about 18 students...and then this year we were oversubscribed”  
(Donnelly et al. 2008: 19).

Raw data suggest that the pattern of attainment in A-level Applied Science is significantly lower than that seen amongst students following the traditional courses of physics, chemistry and biology. This can be seen in Table 4, which relates to 2007, the first year in which students could reach A2 level.

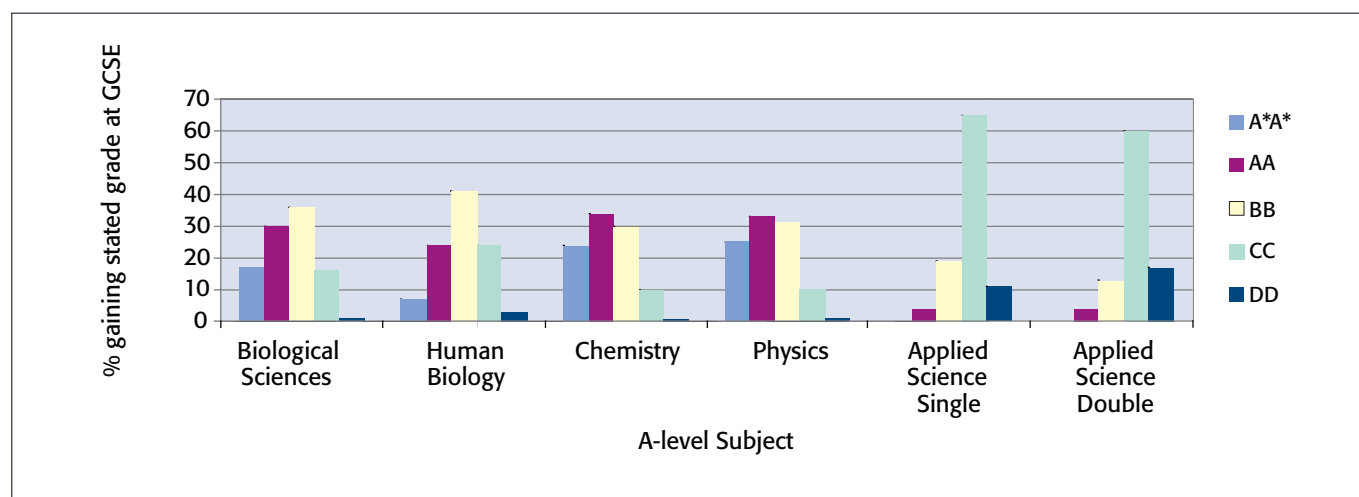
Again a longitudinal study using the National Pupil Database (NPD) indicates that this pattern reflected a lower level of precursor performance, this time at KS4. Figure 7 shows the patterns of GCSE grades in Double Award Science for students who went on to follow science AS-levels in 2007.

**Table 4** Results for the A-level Single Award<sup>13</sup> Applied Science and the specialist science A-levels, 2007

Course	Percentage achieving grade					Entry
	A	B	C	D	E	
Applied Science	1.8	8.4	18.9	29.0	29.1	797
Biological Sciences	26.0	21.7	20.0	16.9	11.3	46,916
Chemistry	32.4	24.6	18.5	13.4	8.0	35,157
Physics	31.3	21.2	18.5	14.5	10.5	23,973

Source <http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000755/sfr35-2007alltables200801.xls>

**Figure 7** GCSE science grades of students who were subsequently entered for AS-level science courses, 2007



<sup>13</sup> The course is available as a single and double award, but it appears that the former is the more popular.

Other findings, from the fieldwork element of the study, show some similarities to those for GCSE. Again case study schools appeared to have carefully positioned A-level Applied Science, not as a competitor to specialist A-level sciences, but as an alternative for less highly attaining students. Schools where the course had been successful felt that it offered a good progression route in science for a group of students for whom traditional sciences would not otherwise have been appropriate. One teacher commented:

“I feel it fills a niche really [...] you know we run Triple Science, and we would expect those taking more traditional A-levels would come from that cohort, but we want to have a Level 3 post 16 science option that students not doing Triple Science can access... within reason a post-16 science course that any student could apply for.”  
(Donnelly et al. 2008: 21–2)

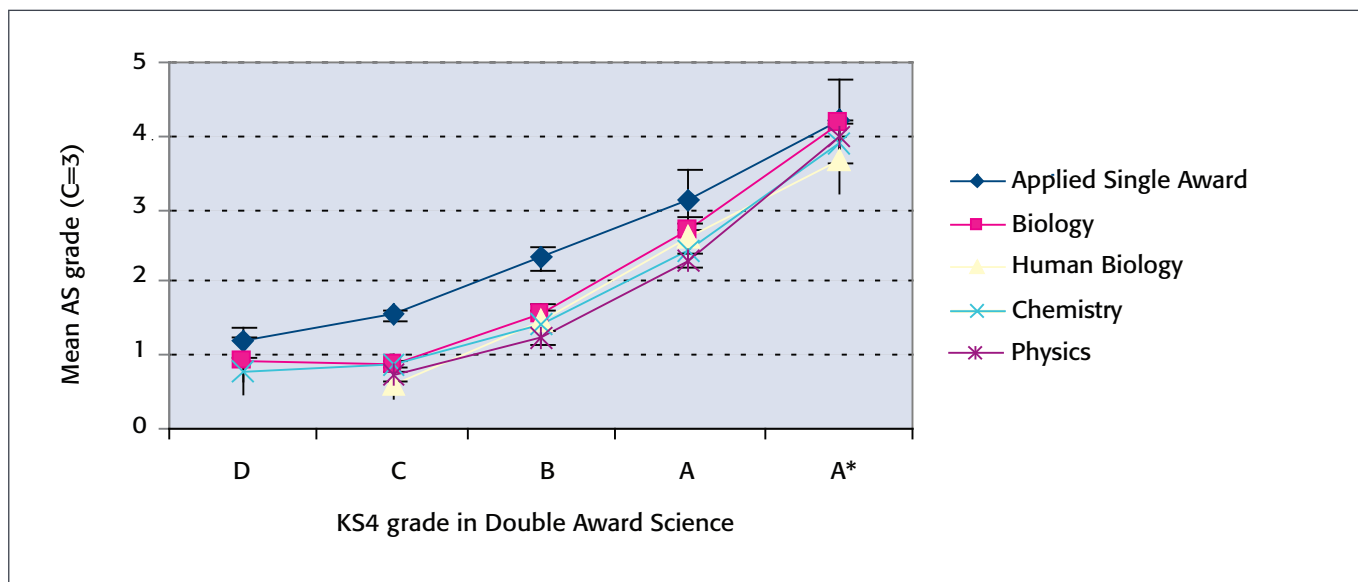
and another:

“We get a lot who do it as another option [...] as another thing to do, because they like science and they like practical work. I think some of them like the idea of a general science qualification... we have some who are after specific careers so some who want to be midwives, some who want to go to Sports Science. (ibid., 25).”

Post-18 progression amongst Applied Science students was a significant issue for schools. The aim of the majority of the students was to enter higher education, and in many cases the opportunity to follow an A-level in science was judged to contribute to achieving this. While it was an accepted view that A-level Applied Science was not likely to enable entry onto traditional university science courses,<sup>14</sup> students had progressed onto a wide range of other courses, including many that were science-related.

Most schools took the view that A-level Applied Science students performed better than they would have done had they been entered for the traditional sciences. Again, value-added data (see Figure 8) derived from the NPD appear to confirm this enhanced performance, though most clearly for lower attaining students.

**Figure 8** A comparison of mean AS score and GCSE grade for students following AS-level sciences (2007; Single Award Applied Science only)\*



\*95% confidence intervals are included but not all are discernible. Grade D is suppressed for Physics and Human Biology because of small numbers.

<sup>14</sup> It is not clear to what extent this view had ever been tested. There is a degree of self-fulfilment about the prediction, as is regularly the case in the Applied Science area. Since higher attaining students were almost universally absent from A-level Applied Science courses it is difficult to know how they might have progressed. See Table 4 and Figure 7.



The possibility that A-level Applied Science offered a potential post-16 science curricular element for higher attaining students was recognized by a small number of teachers, but there was limited evidence of this happening in practice.

As with the GCSE Double Award Applied Science, and arguably to a still greater extent, the study suggested that the A-level Applied Science qualification suffered badly from a lack of support and guidance for teachers. There were even fewer resources, yet the pressures on teachers, particularly because of the importance of the outcome to students, were significantly greater. There can be little doubt that this situation reduced the quality of the teaching that students received. Despite these problems, the majority of fieldwork schools were positive about the course, albeit with some reservations. As with GCSE Double Award Applied, there was evidence of schools not persevering with the course, perhaps as a result of this pressure.

**Very successful [...] I think that in terms of grades there is still a way to go to get the grades up, but then again I think there's more opportunity than there is at the core subjects like biology, physics, I think there's more opportunity to get a higher grade, because you've got the portfolio work [...]**

**They do better: the students that we have, the value-added is going to be better for this course than the core sciences [... It's] making the science more inclusive science, fully inclusive to students.**

(Donnelly et al. 2008: 41)

**I like the idea of it and I like the units and I like the set up. I think it does give them a nice broad base for further studies in science. ... I think, seeing as we are taking on kids who've got double-C, that maybe we need to recognize that and give them something that more suits a double-C ability, although the trouble is that if we give them something that's too vocational, maybe the universities won't accept it and a lot of the kids, [...] maybe half, want to go on and do science at university, or want to go to university to do something else, and they need the [UCAS] points. (43)**

**I'm not sure the course knows its own identity. Is it a BTEC, which is generally a skills-based qualification?... where that side of it—the work is valid, the independent learning, the production of a portfolio.**

**Or is it an examined A-level, an academic A-level...and I don't think it knows its own mind. (45)**

This last is an important point for a qualification which is so critical to the future of the students who embark on it, and which represents such a large investment on their part. It illustrates the need for qualifications to have a clear rationale and target population: ambivalences in this can significantly undermine the qualification, and, more importantly, the position of the student.

## BTEC Nationals

Again there is no information in the public domain which would allow a commentary about BTEC Nationals (the Level 3 BTEC qualification). Little information is given about them even in government statistics, at the level of individual subjects<sup>15</sup> and it seems likely that the qualification is often associated with provision at FE. It also allows a substantial degree of specialization in such fields as Forensic Science, Applied Physics and Environmental Science, and has a strongly vocational emphasis. Nevertheless, there is some anecdotal evidence that schools and sixth forms are identifying BTEC as a better replacement for Advanced GNVQ than the A-level Applied Science in its present form. Their reasons for this are focused particularly on the absence of an A2-level examined component, which some teachers see as posing a major hurdle to the type of student who is encouraged to follow this applied/vocational route within post-16 science. Studies of GNVQ from early in its deployment have suggested, by the mid-1990s, it had come to occupy a niche broadly similar to that identified above for A-level Applied Science (Solomon 1995; Coles 1997; Edwards *et al.* 1997). It seems possible that BTEC will follow suit. While it needs to be recalled that BTEC has its strongest position in the FE sector, there appears to be a significant effort by the awarding body to extend its range into schools and other colleges.<sup>16</sup>

<sup>15</sup> [http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000827/SFR01-2009Final\\_Tables\\_1\\_8.xls](http://www.dcsf.gov.uk/rsgateway/DB/SFR/s000827/SFR01-2009Final_Tables_1_8.xls) (Table 8) (accessed 26.1.2009)

<sup>16</sup> [http://www.edexcel.com/migrationdocuments/BTEC%20Nationals/327136\\_BN018348\\_NACD\\_in\\_Applied\\_Science\\_L3\\_Issue\\_2.pdf](http://www.edexcel.com/migrationdocuments/BTEC%20Nationals/327136_BN018348_NACD_in_Applied_Science_L3_Issue_2.pdf). (accessed 21.4.2009).

# 4

## Key issues within Applied Science qualifications

The previous section reviewed available evidence about the deployment and outcomes of Applied Science qualifications. Despite their diverse origins, and evident differences, it appears that these qualifications and courses have important characteristics in common. They embody versions of 'applied learning' resembling that defined by QCA, and thereby offer a distinctive route through the 14–19 science curriculum. Accordingly, the aim of the present section is to review the evidence about these qualifications more thematically.



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It will look at aspects which are common across the qualifications, often of course differently modulated. Though these aspects will be addressed separately, it should become apparent as the section progresses that they are linked, and that their impact is cumulative. It is the cumulative effect which gives Applied Science provision its distinctive position within the post-14 science curriculum, and leads to the major challenges which it faces.

## Relationship to the workplace

Above all, these Applied Science qualifications set out to place science in the context of the world of work. However, there is little evidence that teachers or schools associate these qualifications in any direct way with *preparation* for work. Part of the reason for this seems to be simply pragmatic: developing a close association with workplaces presents considerable challenges for schools. Indeed some have come to the view that Applied Science can be taught, at least for GCSE and A-level qualifications, with only limited direct workplace contact. It may be that this is also true of BTEC, though little or no systematic evidence exists, and the situation in FE colleges may be significantly different. In any event, few schools appear to see extensive contacts with workplaces as critical.

It would be a mistake to see this broad approach to science education as entirely novel: in fact it has a long history (see for example, McCulloch *et al.* 1985). These applied courses are able to exploit an established view amongst science teachers that the appeal of the science curriculum to students can be increased by a strong emphasis on the uses and practical significance of science. Activities such as those identified in Appendix B would not have looked out of place in the pre-16 teaching of energetic and innovative teachers in the 1970s and 1980s, and in the resources which supported them, e.g., *Nuffield Secondary Science*, *Science at Work* or even the Association for Science Education's *Less Academically Motivated Pupils* (LAMP) project and some SATIS project materials. This appeal to the 'folk wisdom' of teachers, and perhaps the availability of a wide if unsystematic range of resources relating to the industrial and practical significance of science, have probably played some part in persuading and enabling schools to take up these specifications. The key difference from the older resources just identified is that, in its modern form, Applied Science is linked to specific qualifications, and to distinctive assessment approaches which relate directly to the

aims and outcomes of those qualifications. This provides a more effective, though, as will be seen, still incomplete, framework for innovation than has previously existed.

Post-16 Applied Science courses in schools have a less extended ancestry. They bear a superficial resemblance to some more recent specifications, notably *Salter's Chemistry*<sup>17</sup> *Salter's–Nuffield Advanced Biology*<sup>18</sup>, or *Salter's–Horners Advanced Physics*.<sup>19</sup> These do however tend to be more in the vein of Science, Technology and Society courses, or to use industrial and other practical settings as contexts for learning science of a more traditional kind (Bennett and Holman 2002; Bennett *et al.* 2003; Bennett *et al.* 2005; Nentwig and Waddington 2005; Bennett and Lubben 2006). Applied Science courses place a stronger emphasis on industrial and commercial settings as workplaces, generally require a more innovative pedagogy and have a somewhat reduced emphasis on traditional science content.

In several cases, though not all, the word 'vocational' is employed to capture the distinctive character of Applied Science.<sup>20</sup> However, this can raise problems: in particular one might ask why these Applied Science qualifications are more 'vocational' than traditional science subjects, since these latter are a pre-requisite for professional employment in science. This erratic usage of the word vocational reflects an ongoing tradition where certain forms of education, evidently related to future work (e.g., training for medicine or law), are not described as vocational, while others (e.g., training to become a hairdresser) are. Overall, the word 'vocational' is problematic in this context, with a strong linkage to questions of status. It appears to be avoided in the language surrounding the new Diplomas.

## Science content

An important characteristic of Applied Science courses, which influences judgements about their deployment and status, is the emphasis on scientific knowledge ('content'). This emphasis is usually reduced, relative to 'non-applied' qualifications. The issue is particularly significant at NQF Level 3, where the reduction is visible to HE institutions, as well as to some, though probably not all, parents. It has a distinctive impact within A-level Applied Science, since the reduction in content is required to be quantitative rather than qualitative. That is to say, the science that is taught may be reduced in scope, but must still ultimately be of A2 standard, with the result that it is sometimes judged to be too challenging for

<sup>17</sup> [http://www.ocr.org.uk/qualifications/asa\\_levelgceforfirstteachingin2008/chemistry\\_b\\_salters/index.html](http://www.ocr.org.uk/qualifications/asa_levelgceforfirstteachingin2008/chemistry_b_salters/index.html) (accessed 2.2.09)

<sup>18</sup> <http://www.advancedbiology.org/> (accessed 2.2.09)

<sup>19</sup> <http://www.york.ac.uk/org/seg/salters/physics/> (accessed 2.3.09)

<sup>20</sup> Thus OCR A-level Applied Science is described as

"...a new broad-based qualification in Applied Science which may be used to give a general vocational introduction to science..."

[http://www.ocr.org.uk/Data/publications/key\\_documents/L\\_GCE\\_App\\_Science\\_Spec.pdf](http://www.ocr.org.uk/Data/publications/key_documents/L_GCE_App_Science_Spec.pdf) (accessed 2.2.09)

By contrast OCR National documentation does not use the word 'vocational', preferring a more circumspect wording:

"The learners carry out a range of tasks that have been designed to recognise their achievements in a modern, practical way that is relevant to the workplace."

[http://www.ocr.org.uk/qualifications/ocrnationals/science\\_level\\_2/](http://www.ocr.org.uk/qualifications/ocrnationals/science_level_2/) (accessed 2.2.09)

some of the students who follow the course. Schools are very aware of this issue, and in some cases it appears to have contributed to a decision to abandon the course. Though the comments in this section are focused on Level 3, the issue is already visible at Level 2, and tends to condition schools' judgements about students' possible progression. We revisit this issue, of Applied Science as a 'pathway' from which it is difficult to transfer, below.

## Assessment and teaching methods

Applied Science courses employ distinctive modes of assessment. They make more limited use of examinations than other science courses, and in some cases there are no externally set examinations. There is a correspondingly greater emphasis on assessment through portfolios of students' work. The overall impact of these two characteristics varies across the different qualifications. For example, there is no formal examination in the assessment system used for BTEC Firsts (Level 2), while in GCSE Double Award Applied Science it represents one-third of the total assessment. In C21 Additional Applied Science coursework is weighted at 50%. Similar patterns are visible at Level 3 within the BTEC National and A-level Applied Science qualifications respectively. Overall, while there is a range of assessment approaches across the different Applied Science qualifications, in general, portfolio-based coursework is weighted at at least two-thirds, compared to a one-third weighting for examinations. In more traditional qualifications the relative weightings of coursework and examinations are roughly reversed.

This approach to assessment has as a corollary distinctive teaching methods, involving a set of mutually dependent elements. Students spend much of their time working on assignments which are potentially, though not necessarily, assessed as part of their portfolio, and there is less formal teaching. Teachers spend more time supporting students in this work, with a corresponding increase in forms of teacher feedback intended to promote learning (and, simultaneously, summative assessment outcomes) through the reworking of assignments and portfolios. Teaching/learning and procedures of assessment thus show significant overlap. In Applied Science students also have greater responsibility for monitoring, assessing and extending their own learning and outcomes, against the criteria that will be employed to assess their work. Overall, these approaches are intended to increase significantly the emphasis on student independent learning, though, as we will see in a moment, the reality of this independence is sometimes questioned. Nevertheless, all of this fits well within the current movement towards 'Assessment for Learning' (AfL), and greater student autonomy in learning.

These emphases within teaching and learning in schools has gradually developed in the period since the first modern initiatives labelled 'vocational' (notably TVEI and CPVE) were established in the mid-1980s. Underlying this approach is a view that the best preparation for the world of work involves increased personal independence, based within concrete, realistic tasks, rather than the ostensibly more artificial and inward-looking activities associated with traditional academic study. It also reflects an association between vocational curricula and so-called progressive teaching methods, which might be summed up in the term 'learning by doing' (Hodkinson 1991; Sedunary 1996; Bates *et al.* 1998). These qualifications are then very different in approach from the kinds of skills training for specific manual activities which have in the past often been linked with the term 'vocational'.

It is important to qualify this picture somewhat. One of the studies referred to above, focusing on Double Award Applied Science (Bell and Donnelly 2007) observed that the integration of teaching and assessment in the context of high stakes assessment could, if pursued too vigorously, tend to undermine student independence. Research into practices within GNVQ suggested that students' and teachers' attention were sometimes directed excessively and continuously to assessment criteria, resulting in an approach which Ecclestone described as 'find the bullet points' (meaning assessment criteria) or 'procedural autonomy' (Bates 1998; Ecclestone 2002: 126, see also chapters 4 and 6). However, there is much variation across the requirements of the several Applied Science qualifications under discussion here, and it is important not to overstate this point. Overall, care needs to be taken to ensure that assessment requirements in all of these qualifications encourage genuine student independence and do not lead to contrived outcomes.

## For whom?

Section 3 above indicates that those qualifications for which we have data have one key characteristic in common which can be a source of difficulty. Put bluntly, Applied Science courses are often seen as appropriate for less highly attaining students, and that judgement is commonly central to how the courses are positioned within schools' curriculum offers. This issue, while it tends to be skated over in policy and promotional documents, is a significant theme of the present report. To be more specific, Applied Science tends to be targeted on students of middle attainment at KS4, who ideally also display a strong commitment to the production and improvement of portfolios, and to maintaining good attendance. This pattern is broadly detectable within teachers' commentaries, and partially confirmed by national attainment data. As section 3 indicates, these data also suggest a generally increased level of value-added attainment amongst the target group of students. (See Tables 2 and 4, and Figures 6 and 8 above.)

How this positioning of Applied Science came about, and how it is sustained within institutions is not always clear. The latter is most likely to be a combined outcome of the informal advice given by teachers and school admission policies to courses post-16. Nor is the outcome surprising. The courses' use of the word 'vocational' is itself a signal: in the United Kingdom and across the world, the word is associated with lower status activity, historically often involving a narrow training for routine, unattractive and less financially rewarding occupations (see Wolf 2002: chapter 3). In schools and colleges, qualifications carrying this title have been marked by a failure to achieve what has historically been termed 'parity of esteem' with so-called academic qualifications. The situation of Applied Science is of course not simply due to mere impression or prejudice. We have indicated that the scientific content of these applied courses, as such content is conventionally understood, is usually less than that found within 'academic' courses at the same level in the National Qualifications Framework. Judgements made by several groups, including especially those who set admissions policies within universities, are influenced by this perception. The networks through which such judgements are made are extensive and powerful, particularly among knowledgeable parents, though not particularly visible (see for example, Ball 2003). It is also worth observing that some promotional material for applied courses, with its emphasis on the suitability of the courses for so-called 'practical learners', carries messages of 'difference' from established courses. Such messages, while understandable and well meant, are not without consequences in terms of the impression they create of the students and courses involved. The upshot of all of this is that Applied Science courses are viewed as being of lower status, and appropriate for lower attaining students.

The word 'status' has been used here a number of times. It is not any easy quality to measure objectively. Nor is it traceable directly to any single source. Yet differences in status across courses are not usually difficult to detect. The simple fact of being 'other' to established science qualifications is itself a key aspect. The position of 'poor relation' to A-level, offering a second chance to those who had attained poorly at GCSE, was quickly established as the role of the precursor Advanced GNVQ in Science, and once established it was never significantly altered (see for example, Solomon 1996; Edwards *et al.* 1997). To combat this (for example, to try, to overcome parents' wariness of novel courses with non-standard assessment regimes) schools would need to be highly proactive, and even then would have perhaps limited prospects of success. There is no evidence that they are inclined to pursue this strategy. However vague and undesirable the term 'status' may be, it seems likely that it will remain significant in characterizing Applied Science qualifications. Before pursuing the point further we will give some attention to the issue of progression, an aspect of these qualifications that is also deeply implicated in judgements of their position in school.

## Progression

Progression opportunities and expectations are critical to the judgement of parents, students and teachers alike. They encompass access to post-16 and post-18 qualifications as well as employment possibilities. Comments about progression opportunities in the promotional and other material surrounding Applied Science qualifications are carefully phrased, though they are in several cases ambivalent. Thus QCA suggested, in relation to the suite of which GCSE Double Award Applied Science is a member, 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, for example vocational A levels, which emphasise the same things that these GCSEs do. (Qualifications and Curriculum Authority 2004, emphasis added)**

This statement is ambivalently phrased and, as will be seen, not consistent with either Ofsted's view, or the findings of empirical studies of Double Award Applied Science.

The reality is that the difference in the character and content of the qualifications, together with the more indefinable issue of status, means that progression opportunities for Applied Science are not identical to those for traditional science qualifications at GCSE and A-level. This issue of progression is significant from the beginning of KS4. Students who are seen as likely to be capable of undertaking specialist scientific courses post-16, or whose HE or career intentions (assuming they are judged realistic) require this, are discouraged from pursuing Applied Science. In addition, there is very limited evidence of schools or parents seeing Applied Science courses as a way of broadening the curriculum for higher attaining students with other, or indeterminate, aspirations. This situation is reinforced at KS4 by government pressure to increase the take-up of 'triple science'.

The types of HE courses aimed for by students who follow Applied Science courses post-16 are, then, not specialist sciences, or other fields such as the humanities, but more broadly 'technical'. Students' responses when asked about their intentions in one of the studies identified above included progression to such fields as Radiography, Engineering, Food Technology, Geography, Agriculture and ICT (Donnelly *et al.* 2008: 31). These are of course aspirations, and probably at the upper end of what is likely to be attained by the students concerned, but teachers confirmed that students were regularly being accepted onto these or similar courses. Teachers also commonly felt that students' intentions were

realistic. Subjects they mentioned as attainable included Sports Science, Nursing and Midwifery, Health Care generally, Dietetics and Marine Studies. Several less technical possibilities were also mentioned, e.g., Film Studies and primary school teaching (*ibid.*, 29). Some students' aspirations to study in competitive fields, such as Physiotherapy and Pharmacy, were seen as problematic by their teachers, though it is not easy to determine whether this was due to the general academic level of the students, or the view taken of Level 3 Applied Science qualifications by HE institutions.

Across the curriculum as a whole there is evidence that distinct 'pathways' are appearing within the late secondary education (Higham and Yeomans 2007). It is not clear whether schools encourage, or even allow, much opportunity for transfer between these different 'pathways'. In the post-16 science context this applies particularly to movement between Applied Science and the specialist sciences pathways (though the reverse movement does seem to be allowed). Referring specifically to students directed onto the Double Award Applied Science GCSE specification, Ofsted commented that the consequences of following this course for progression were not always made explicit to students, and by implication, to their parents (Ofsted 2004a: para 90). Some parents will of course be highly sensitized to and knowledgeable about these issues: this is one of the less visible mechanisms by which access to different forms of provision within schools is achieved. It is perhaps worth observing that the OECD has found evidence of the growth of such pathways across developed countries, though there is considerable political pressure to maximize their flexibility (Raffe 1998).

Throughout this commentary on progression, we must bear in mind the possibility that the process has a partially self-fulfilling character. It is rarely possible to test how HE institutions would react to applications from highly-attaining Applied Science students for entry to more academic courses, since almost all students who might reach the required academic standard are effectively deselected from following Applied Science.

## Resourcing and support

The introduction of Applied Science courses, with their distinctive teaching methods and, to a degree, content, have made large demands on often-inexperienced individual teachers and departments. There are considerable differences in how the specifications identified earlier support teachers in meeting these demands. In some cases the absence of support appears to have influenced significantly the impact and overall success of the qualification. In particular, almost all teachers appear to express concern about this issue for the Double Award Applied Science GCSE and, especially, for A-level Applied Science.

These two qualifications were largely 'specification-led': that is to say they were implemented by first developing a specification and then allowing awarding bodies, teachers and schools to 'get on with it', within the framework thus defined. It is perhaps necessary to qualify this bald comment. Support is provided by awarding bodies, and teachers' comments on this support, while inevitably mixed, are relatively positive. But the most pressing responsibility of awarding bodies is for the mechanisms and standards of assessment, and their support activity, and to a degree expertise, is principally focused on these areas. Indeed it is not to be expected that they would be knowledgeable about teaching methods or have developed extensive resources for novel courses, unless they were able to fund extensive development and trialling work. In the Applied Science context some knowledge could perhaps be transferred from BTEC or the now-withdrawn GNVQ. The then-DfES provided some support for GCSE Double Award Applied Science, again mainly via awarding bodies. It also commissioned work which resulted in the development of suggested schemes of work, and a website was established, under the auspices of SEMTA.<sup>21</sup> There is little evidence that this activity had significant impact, or that schools were even aware of it.

Commercial textbooks and some other resources eventually appeared, especially for the GCSE qualification. However, A-level Applied Science in its first few years was too small-scale to attract such commercial investment. The first published textbook seems not to have appeared until 2008.<sup>22</sup> There is a striking contrast between the two specification-types just referred to (Double Award Applied Science and A-level Applied Science) and C21 Additional Applied. The last was developed as part of a centralized project, with support mechanisms that included publications, discussion forums, apparatus recommendations and CPD for teachers and technicians. It also embodied a clear vision of its curricular aims and modes of assessment. These distinctive characteristics probably go some way to explaining the reported success of C21 Additional Applied. There is no information in the public domain about the other single award Additional Applied qualifications.

<sup>21</sup> <http://www.gcseinappliedscience.com/default.aspx> Accessed 12.2.2009

<sup>22</sup> <http://www.heinemann.co.uk/Series/product.aspx?isbn=9780435692124> Accessed 12.02.2009



It is of course possible for innovations to be over-centralized, in ways which diminish teachers' professional responsibility and their scope for innovation. GCSE Double Award and GCE A-level Applied Science could certainly not be charged with this (the comment is not meant to be an entirely ironic one). They allowed scope for teachers to show initiative, and it would be wrong not to acknowledge that some teachers and science departments exploited these opportunities. But there is another side to this coin. Evidence from the National Pupil Database suggests that for a significant minority of schools, maybe up to 20% of those which adopted Double Award Applied Science, the challenges were too great, and they quickly withdrew from it, in some cases after only one cycle (Bell and Donnelly 2007: 59-60). A similar situation was found in the study of GCE Applied Science (Donnelly *et al.* 2008). Overall it is fair to say that, despite their broadly positive impact, both specification-types have been implemented less than optimally, as a result of the absence of systematic, co-ordinated professional support.

In terms of resources, some aspects of the situation with BTEC Firsts and Nationals appears broadly similar; with a significant amount of textual material, and no doubt some face-to-face training, available from the awarding body. A small amount of commercial material has also appeared for BTEC

Firsts. It is however not possible to comment on the response of teachers to these resources, or on the impact and experiences in schools and colleges, in the absence of evaluation data in the public domain. This is an unfortunate gap, since BTEC Firsts and Nationals appear, along with OCR Nationals, to be displaying potential for significant growth in schools, and to have a quite distinctive character compared with the GCSE and A-level Applied Science qualifications.

The industrial linkages referred to earlier might be loosely placed under the heading of 'support' (though they might also be understood as a type of teaching method). Such liaison can take several forms, but the evidence available suggests that it is an area which is seriously underdeveloped (Bell and Donnelly 2007; Donnelly *et al.* 2008). This is a source of concern, though, as we have seen, many schools appear to have judged that such liaison is not essential to teaching the courses, and tend to see it instead as an enrichment. Evidently this issue is related to the question of whether these courses are in any strong sense vocational. A similar pattern exists across the precursors of these qualifications, and their potential successor; the Diploma (Ofsted 2004b: para 134; National Audit Office 2007: 8, 25). It is unclear how much industrial liaison occurs in the, more clearly vocational, BTEC courses.

# 5

## The future of Applied Science and its challenges

This review has sought to offer a positive but realistic view of the various forms of Applied Science which have developed in recent years across England (and Wales and Northern Ireland: Scottish qualifications are significantly different.) The introduction of these qualifications represents a significant opportunity for science curriculum reform, but also raises important questions of principle and practice.



These questions are rendered more complex because they relate to a set of independent qualifications which range across NQF levels, and often are in direct competition. Nevertheless, the qualifications appear to have sufficient in common to justify being treated, with caution, as a single approach to reform. This concluding section sets out to identify the key challenges Applied Science needs to resolve if its potential is to be fulfilled. It focuses on three key interpenetrating themes: **rationale, support and status.**

## Rationale

It is appropriate to restate here as simply as possible the key differences between Applied Science and more traditional science qualifications. In general the courses discussed in this report:

- involve teaching and learning activities that are set in workplace contexts
- include learning outcomes of a more diverse kind than is usual in science education, with an emphasis on student independent activity, including individual research and report writing
- employ portfolios of student work for summative assessment, weighted at between 50% and 100%
- involve a reduced emphasis on substantive scientific knowledge compared with other science qualifications at the same NQF level.<sup>23</sup>

Why might we wish to offer such a distinctive version of the science curriculum in the 14–19 phase of education? Let us note again that setting the science curriculum in the context of the world of work does not necessarily imply a focus on preparation for specific types of work. It is generally acknowledged that science must form part of the entitlement of all students to a fully-rounded education. Some might argue that treating science within the general school curriculum as 'vocational', or 'work-' or 'sector-related', risks undermining that general educational role. Yet, as Richard Pring has argued in a publication from the Nuffield 14–19 Review (Pring 2008), this linkage of education, occupations and work can offer an important educational opportunity, not merely vocational in the narrow sense of training for a job, but aiming to relate education to work as a central aspect of a fully-realized human life. Pring also points out that such an approach has a distinguished philosophical pedigree, most notably in the writings of John Dewey. Applied Science is a promising example of this approach, rendered the more important because science is a curricular area which is often seen by students as abstract and remote.

Speaking more concretely, it is possible to identify a range of important potential contributions that Applied Science (recalling that this term is being used as a shorthand for the courses under review here) could make within current educational agendas. It could **support a greater involvement with science at KS4 and beyond, for students who might otherwise tend to withdraw from science.** Though the study of science is of course compulsory in maintained schools at KS4, there is evidence that Applied Science can promote a real, rather than merely timetabled, engagement, for many students. Realistically, in the current situation, Applied Science courses are unlikely to be the route of choice for the most highly attaining science students, particularly given the government's growing emphasis on the separate sciences at KS4. Yet, in a more obviously 'vocational' guise it could **support routes into employment and/or HE for post-16 students entering technical or science-related occupations.** When combined with subjects from the humanities and other curricular areas, it could **broaden the post-16 curriculum for those with different forms of progression in mind,** offering a flexible and potentially motivating form of science not involving a commitment to the individual specialist sciences. In these ways Applied Science might contribute to the promotion of more engagement with STEM subjects at the intermediate levels identified as deficient in the Leitch report (H.M. Treasury 2006: 8.5).

Overall, it is not difficult to identify a rationale for Applied Science, on the basis of both educational principle and the potential benefits for specific groups of students. The rationale may be somewhat heterogeneous, but, it can be argued, no more so than that for traditional forms of science in schools.

## Support

In seeking to fulfil these possibilities, the quality and effectiveness of Applied Science teaching is critical. This carries through into a need for the creation of trialled, good-quality curriculum materials and teaching methods, and for teachers' professional development. It has been observed at intervals in this report that the situation across the different qualifications differs considerably, and all are developing over time. Some are much better supported than others. Nevertheless, it should be apparent that, overall, teachers do not have access to adequate support for these still quite novel courses. Where this is the case teachers will, at the least, teach them less effectively than would otherwise be the case. Schools may even be unable or unwilling to find the energy and initiative that the courses demand, and withdraw, or at least undertake 'false starts', shifting between different qualifications. Most importantly, in these circumstances students will suffer; through following undeveloped courses, through instability or through

<sup>23</sup> At Level 3 the comparison is with the specialist science disciplines.

not being offered potentially appropriate provision. A cycle can easily be established which could cause individual qualifications, or in some schools the very idea of an Applied Science curriculum itself, to fail. The former might be thought inevitable, perhaps even desirable as part of rationalized qualification suite: the latter would be judged by many to be a major lost opportunity. Systematic support is needed, though it must be recognised that the disparate and competitive nature of the qualifications which have grown up, almost randomly, together with political uncertainties about their future, means that targeted support will be not be easy to mobilize.

The lack of resources for these Applied Science qualifications presents a significant contrast with a range of other curriculum projects which have been undertaken in 14–19 science. These generally involve less radical innovation, but are targeted on more highly attaining students. They include Salters–Nuffield Advanced Biology, Advancing Physics and the Triple Science Support Programme.<sup>24</sup> There are several reasons for this disparity of treatment, some no doubt simply reflecting historical contingency. However, it is difficult to ignore the sharp difference in status between Applied Science and these other qualifications, and it is tempting to invoke this difference to explain the neglect that it has experienced.

## Status

'Status' can be an ugly word when used in an educational context. It triggers associations in which subjects, and sometimes the students who pursue them, are classified into those of greater and less significance. It seems, unfortunately, but perhaps inevitably, to be linked to the level of attainment of students, and to judgements about the HE institutions and courses, and the employment, to which they progress.

The issue of status differentials is particularly visible when Applied Science is seen as a distinct pathway through science at KS4 and beyond. At present, in most schools, the 'direction' of students onto an Applied Science course at the beginning of Year 10, signifies a judgement about potential attainment, even where the applied qualifications involved are GCSEs and A levels, and offer the full range of grades. Furthermore, by taking up an Applied Science course at KS4 the student is, in most schools, moving onto a track or pathway which constrains future progression opportunities within science itself. This point needs qualification. There is some, largely anecdotal evidence, e.g. within C21 schools, of more highly attaining students who are not science specialists pursuing GCSE Additional Applied Science, or A-level Single Award Applied. However, it is too early to say whether these patterns of more flexible student take-up will gain any real momentum. The lower status of applied courses as a whole, independent of their educational suitability for students, works against such developments. Parents and students will hesitate to participate in such a broadening of curricular experience, including for 'non-scientists', if it involves pursuing a qualification perceived as second class. Overall, in respect of rationale and support, the notion of 'status', despite its vagueness, is central to the challenges that have been identified.

<sup>24</sup> <http://www.triplescience.org.uk/> (accessed 06.02.09)





# 6

## Conclusion

The future of Applied Science as a distinctive approach to 14–19 science education will ultimately be decided by the judgements and choices of ‘consumers’: students, parents, HE institutions and employers. However, it is the actions of policymakers and practitioners that will determine the nature and quality of the reform about which they make these judgements.

The key issues around which action is needed are:

1. *educational role, and target population.* Should Applied Science provision pursue the elusive 'parity of esteem' historically sought by vocational/applied qualifications, in this case effectively putting them in competition with the specialist science disciplines? Alternatively, should it be accepted that Applied Science is best adapted to fulfilling the distinctive roles sketched earlier? Adopting this latter position would mean that energy could be focused on making provision as good and fit for purpose as possible, with its likely progression routes transparent to students and parents. It would mean accepting whatever cost in 'status' that might entail. This is a long-term issue, which those responsible for regulating Applied Science provision ought to face up to squarely and realistically.

This approach corresponds closely with the argument made in the report of the Nuffield Review of 14-19 Education and Training (Pring et al., 2009: 7-8)

2. *provision of sustained support at the level of teaching methods and resources.* Only C21 Additional Applied Science is known to have received proper developmental support (though the situation of BTEC Firsts and Nationals is largely unknown). There are evident difficulties in providing generic support for such a disparate 'reform'. Providing it might involve some difficult choices, for example, on the part of the traditional supporters of curriculum development, about where to place resources. Nevertheless, without high-quality support, probably co-ordinated nationally, the innovative and demanding curriculum and pedagogy associated with Applied Science will be unlikely to fulfil its potential.
3. *assessment practices.* This represents a specific, but critical area for such support. The emphasis on portfolios of independent student work is a key distinctive aspect of Applied Science, and is intimately linked with teaching. Development work on effective (that is, practicable, valid and reliable) methods for this type of portfolio assessment could be undertaken generically.

Some of the necessary work just identified in point 2 and point 3 might be supported by institutions with a longstanding interest in science education, including Gatsby, Leverhulme, Nuffield and Wellcome. However, such organizations are unlikely to invest precious resources in a reform whose position and rationale is uncertain within policy, and this leads to the final area urgently requiring attention.

4. *creating a stable and transparent qualification framework.* The need for such a framework, and associated rationale, should be obvious. It might be achieved in several ways. Perhaps the most obvious possibility at the present time would be to exploit the framework offered by the Science Diploma. Recent announcements relating to the Diploma indicate that its relationship to the existing specialist academic science qualifications remains fluid.<sup>25</sup> The Diploma could be seen as an appropriate and powerful 'brand' for Applied Science, within which some or all of the existing applied qualifications could be convened and rationalized. It can be argued that that potential is undermined by attempts to draw in and/or compete with the specialist science qualifications. Identifying the Diploma as distinctively focused on Applied Science, in a way which is transparent in terms of content, pedagogy, assessment and likely progression, seems, by contrast, a clear and coherent approach, if one requiring courage. Ideally, however, the flexibility allowed by existing free-standing Applied Science qualifications would be retained.

Only the last of these four issues is a matter of 'policy', in the sense that it is dependent on the actions of government and regulatory bodies, though it is critical to the enterprise as a whole. By contrast the first three can be influenced by the collective judgements and actions of teachers, school management teams and the science education community more broadly. With a regulatory and policy framework and rationale which was fit for purpose, that community could be motivated to develop Applied Science as a coherent and distinctive form of provision. It would then be open to students, parents and other stakeholders to judge whether it met their needs.

<sup>25</sup> [http://www.dcsf.gov.uk/pns/DisplayPN.cgi?pn\\_id=2009\\_0075](http://www.dcsf.gov.uk/pns/DisplayPN.cgi?pn_id=2009_0075) (Accessed 23.4.09)

## 7

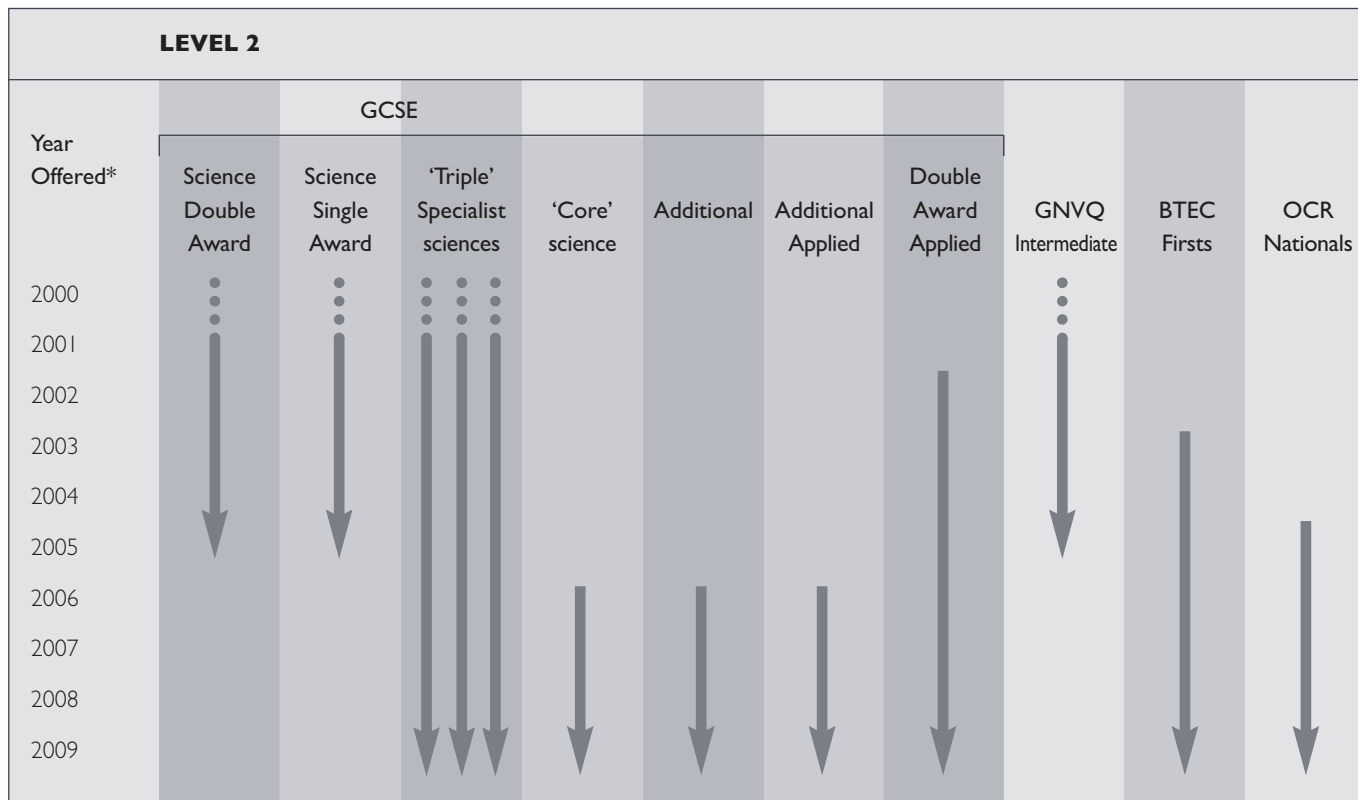
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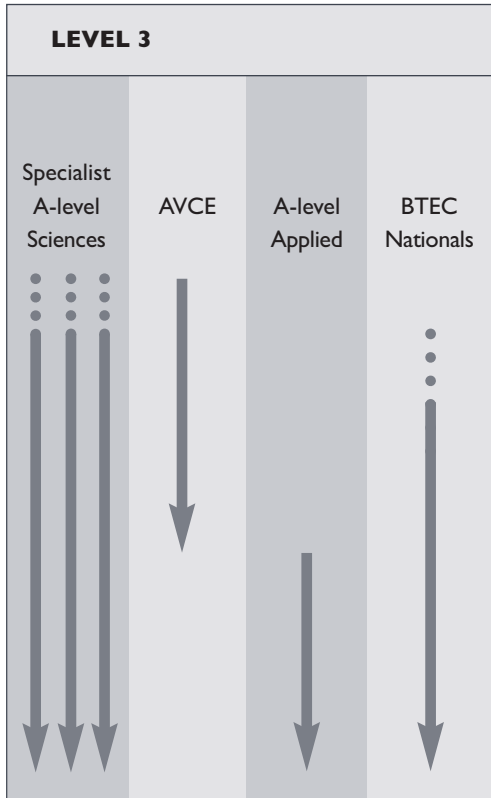


# Appendix A

## The pattern of Selected Level 2 and Level 3 science qualifications 2000–2009



\* note that the year is the year offered for teaching, not examined



# Appendix B

## Examples of Level 2 activities used within Applied Science teaching

The following materials are drawn from articles in *School Science Review* which focused on Applied Science courses (at Level 2) (Campbell 2006; Gadd 2006), and from some other sources. They are presented here to give some indication of the types of activities and approaches in use. It is important to stress that these activities are not cited here because they are judged to be radically new. What is distinctive is their systematic use on Applied Science courses (particularly at GCSE and A-level), their direct linkage to the aims and assessment objectives within the specifications, and the fact that they are critical to the student portfolios employed for summative assessment. The examples shown here are all from Level 2: those at Level 3 are similar in approach, but require a greater depth, and are often more extended.

The first excerpt gives a summary of the broad pattern of C21 Additional Applied Science.

GCSE *Additional Applied Science* is designed for students who have either completed, or are studying concurrently, GCSE *Science*. This could be any of the GCSE *Science* courses offered by the Awarding Bodies. The course focuses on procedural and technical knowledge underpinning the work of practitioners who regularly use science. There are six possible modules, any three of which make up the GCSE course.

- A1 Life care
- A2 Agriculture and food
- A3 Scientific detection
- A4 Harnessing chemicals
- A5 Communications
- A6 Materials and performance

**[For their assessed work]** students produce a Work-related portfolio, which counts for 50% of their marks. This simple portfolio, which teachers find manageable, comprises

- 2 standard procedures for each module (i.e. a total of 6) and, across the whole course,
- 1 work-related report
- 1 suitability test

**Source** Campbell 2006

The following activity is one that is recommended for use within the BTEC First Certificate Course.

The Principal Engineer with a large Water Authority needs to know about electricity supply. Why? Well, it takes 10% of the output of a major power station just to pump the water for a city like London. It's one of the main costs in supplying water.

The scenario is that the Principal Engineer has set up a team of engineers to look at electricity supply for the pumping stations. The team has to provide information so that the best decisions can be made.

Students work in a team to find out more about electricity generation and transmission. They work in pairs, sharing the work. Each pair works on one of these:

- Fossil fuel power stations
- Nuclear fuel power stations
- Hydroelectric power stations
- Power from wind and waves
- Power from biomass and power from the sun
- The National Grid

Their research is structured using worksheets and prompt cards.

Students work alone to collect the information. They share this with their partner engineer. The pair writes a joint report and explains the key points to the rest of the team. The full report is displayed so that others can read it.

Having listened to or read all the reports, each student writes a summary.

**Source** BTEC First Certificate in Applied Science Workbooks (Edexcel)

The following activity is used with C21 GCSE Additional Applied Science, supporting the module Life Care.

First students watch a video clip, which shows an exercise physiologist interviewing and testing a climber who is about to begin training for Mount Everest. Next students use standard procedures to assess a partner's body mass index and body fat, before analysing data in charts of weight-height and weight-waist measurement. Finally they assess their own level of aerobic fitness. The sequence of activities also provides a context for learning about the structure and function of the respiratory system.

**Source** *Life care* iPack, (Oxford University Press)

Ken Gadd has suggested that often 'activities fall into two broad types'.

- A scenario is established and students imagine they are a scientist working for an organisation. For example:

*You are a materials scientist working in the quality control laboratories of a company specialising in manufacturing thin plastic films. Your task is to test a number of products to check that they pass the quality control standards.*

This is useful and may be used to highlight the types of work scientists carry out in the workplace. However, it is not always possible to realistically reproduce a method used in the workplace. Arguably, if it is too far removed from the real thing students may not take it seriously or get the wrong idea about working in a scientific environment.

For example, students might be asked to compare the tensile strength of strips of plastic sheet. They may do this by adding masses and measuring the extension until the sample breaks. In industry, however, tensile properties are always determined by applying a force that produces a constant rate of deformation.

- Techniques used by scientists are highlighted, with examples of where they are used. Students are given activities which mimic the processes used by scientists, but without the precursor statement 'you are a scientist working ...'.

In the example above, there is mileage in not pretending students are making measurements in a quality control laboratory, but instead focussing on the difference between the industrial methods and the one they use in school.

**Source** Gadd 2006

This example is taken from the 4science Resource Pack for Applied Science.

A related, but more complex, investigation involves giving students river water samples and a map showing where they were obtained. A river flows past a farm, with two other rivers joining it, one just before it flows past the farm and another beyond the farm. The 'samples' are prepared in advance to simulate the seepage of agricultural material into the river.

Students work in pairs. All the necessary information is provided in the workbook, together with space to record data and to interpret results. Students use water test kits to determine pH and concentrations of one or more of the following: ammonia, oxygen, nitrite, nitrate, phosphate. The tests involve colour-matching (solutions and test strips) and drop tests (simple titrations).

The Environment Agency publishes standards for river water quality. Students assess the significance of their results by comparing them with these standards. Questions guide them to an evaluation of their work. The exercise is completed by suggesting causes and implications of the levels of solutes found.

**Source** *The Resource Pack* (4science)





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