DESIGNING APPLIED SCIENCE SPECIFICATIONS

Ken Gadd, 4science, and Peter Campbell, the Nuffield Curriculum Centre

History lessons

The original GNVQ intermediate and advanced science specifications were based on answering the question 'What do scientists do?'. Units were built on the idea that the work of science practitioners may be described within three broad areas:

- characterising, analysing and identifying
- making, growing, building and synthesising
- monitoring, controlling, managing and regulating.

At the time GNVQs were driven along a competency model closely aligned to that used for National Vocational Qualifications (NVQs). The assessment load was heavy, with portfolio evidence and a written test for each unit. Some would argue that the physics component did not really fit the general rationale. Certainly, during development of the pilot specifications, biologists and chemists found it easier to engage with this idea and to provide examples of what scientists do in the workplace. It was interesting that areas of engineering were not considered. Further, it is interesting to note the lack of engineering at GCE (there is just one specification).

Level 3

Changes to the advanced level specifications were made within less than one year of their introduction and again a year or so later. Changes were made predominately in response to the demands of HE and their requirement for more conceptually defined content and external assessment. This reflected their conventional expectations of students entering university. A consequence was that the qualification was never allowed to settle and there was no formal evaluation.

GNVQ Advanced Science became an AVCE (Advanced Vocational Certificate of Education) in 2000 and finally GCE Applied Science in 2005. However, changes were made hurriedly, allowing insufficient time to consult, identify real problem areas and address them.

With both types of qualification, the assessment burden was reduced (units being assessed either by portfolio work or by external tests, but not both). However, the rationale and structure became lost during this journey. Some specifications fragmented the physics, making it incoherent and compounding the original problem of inappropriate

physics content. Opportunities to go across traditional science disciplines were, on the whole, not taken. Reasons for assessing units by portfolio or external tests are not clear. For example, a topic common to AQA and OCR is internally assessed by one awarding body and externally assessed by the other. Further, it is an AS units with one and an A2 unit with the other.

Levels 1 and 2

These qualifications remained largely unchanged as criticism was aimed largely at the advanced qualification. However, in due course they metamorphosed into a vocational GCSE in Science. Much debate led to a change of name and the introduction of the term 'applied' in an attempt to rid it of the 'vocational' tag and associated stigma and the qualification was reborn as GCSE Applied Science (Double Award). The specifications were revised in 2006, with the 'knowledge' content of unit 2 increased to ensure the qualification met the Key Stage 4 Programme of Study. It has a clear rationale and structure. Science in the workplace has a strong position in the qualification.

One disappointing feature, perhaps, is that two qualifications (Foundation GNVQ at level 1 and Intermediate GNVQ at level 2) merged. This resulted in the absence of a level 1 applied qualification.

National Vocational Qualifications

There may be useful lessons to be learned from the structure of NVQs and their assessment when reviewing the design of applied science specifications. However, at present while the number of science-related NVQs is high, the number of candidates is low. It is difficult to get precise figures, but just as an example SEMTA says of the Apprenticeship and Advanced Apprenticeship for Laboratory Technicians that "Take up has been pretty slow to date with approximately 30 registrations."

Science diploma

Plans for such a diploma have now been put on hold. There will be no diploma in the near future, if at all. However, much of the thinking behind the diploma would usefully inform the future development of GCE applied science specifications.

Design basics

The design of coherent specifications depends on a clear rationale and structure for the qualification. As a basis for discussion it is suggested that applied science specifications should[1]:

[1] This list has been synthesised from the rationales for a number of applied science qualifications, e.g. the original GNVQ intermediate and advanced science specifications, GCSE Applied Science (Double Award) and OCR GCSE Additional Applied Science (21st Century Science).

- emphasise skills and knowledge used by professional scientists when:
    - applying science knowledge, understanding and techniques to tackle a range of practical problems (this would include concepts that underpin the techniques used and some of the 'big' ideas of potential value for progression)
    - communicating to a range of audiences both verbally and in writing, and using ICT
    - managing of time and workloads, physical resources such as materials and equipment, and
    - working with others
- encourage plenty of practical and investigative work for which students can gain credit, using authentic procedures, protocols and techniques 'where the results matter', adapted as necessary for school and college laboratories
- offer scope for differentiated learning activities and assessment tasks to match the needs, interests and abilities of all students regardless of ability and progression routes.

Importantly, in all applied specifications there is a shift from the idea 'how science works' to 'how scientists work'.

Content and structure

QCA has recently developed subject criteria for the new separate science GCEs being introduced September 2008. Criteria for applied science GCEs are also in place and, in the normal QCA cycle, might be expected to be revised for 2010.

Consideration might be given to new applied science specifications that, in terms of content if not assessment, meet QCA's subject criteria for 2008 science GCEs. As one industrialist suggested at a December 2006 meeting at the Nuffield Curriculum Centre, it might be useful if students were to progress from both applied science and separate science courses sharing a common language.

Content

A GCE Applied Science qualification may lead either directly into employment or on to a vocational degree, and in that respect is different from GCEs in separate sciences. Of course, it may also lead to the study of non-vocational degrees. It is important therefore to think about:

- the problems and tasks tackled in science-based workplaces and the techniques, skills and knowledge used[2], as well as
- the content required for university entrance.

In contrast to descriptions of science qualifications being concept-led or applications-led, applied science GCEs might sensibly be described as technique-led.

In real workplaces, most science-related problem-solving tasks require a quantitative approach. This suggests full integration of relevant and appropriate mathematics within the applied science qualification itself.

Structure

To meet QCA criteria, any science specification must consist of AS and A2 units, with a single award A level comprising six units. This is the present structure for GCE Applied Science and allows four qualification outcomes: single (3-unit) award AS; double (6-unit) award AS; single (6-unit) award A level; double (12-unit) award A level.

An alternative, but potentially more flexible model might based on a bank of 24 units:

Biological Sciences	Chemical Sciences	Engineering	Physical sciences
3 x AS units	3 x AS units	3 x AS units	3 x AS units
3 x A2 units	3 x A2 units	3 x A2 units	3 x A2 units

Based on:

- a rationale of how scientists work by applying techniques and knowledge to tackle science-based problems
- a principle that this is done in the context of contemporary science as practised in the workplace

This would allow single awards (AS and A level) in:

Biological Sciences, Chemical Sciences, Engineering, Physical sciences

More interestingly, perhaps, would be the ability to generate single and double awards (again AS and A2) in:

Biological and Chemical Sciences, Engineering and Physical Sciences

Generating single award GCEs may be important for the school sector.

[2] Though outdated, The Council of Science and Technology Institutes (1993) analysis of occupational groups that use science is useful (see Appendix).

Biological and Chemical Sciences		Engineering and Physical Sciences	
Single award	Double award	Single award	Double award
3 x AS units 3 x A2 units	6 x AS units 6 x A2 units	3 x AS units 3 x A2 units	6 x AS units 6 x A2 units

An attraction of this approach is that some units can explore areas where an integrated science approach is used in the workplace. The engineering aspect of this proposal in particular would need careful exploration, because the engineering institutes have clear and rigid rules about entry to their professional qualifications.

Appendix

The Council of Science and Technology Institutes (1993) identified occupational groups where science:

- was the main component of their job
- critical to their effectiveness
- significant to their effectiveness
- enhanced their effectiveness.

Occupational group	**Number**	**Category**
Nurses and midwives	467 000	critical
Agriculture/horticulture/forestry/fisheries	329 000	enhanced/significant
Engineers (all types)	311 000	critical
Chemical/gas/petroleum process operatives	161 000	enhanced
Medical doctors & dentists	156 000	critical
Laboratory science technicians	130 000	main
Medically related occupations	128 000	main/critical
Food processing operatives	113 000	enhanced
Secondary school science teachers	106 000	significant
Product, works and maintenance managers	86 000	significant
Marketing sales managers	73 000	significant
University/HE/FE teaching professionals	64 000	main
Engineering technicians	60 000	critical
Biological scientists and biochemists	49 000	main
Chemists	39 000	main
Physicists, geologists, meteorologists etc	28 000	main