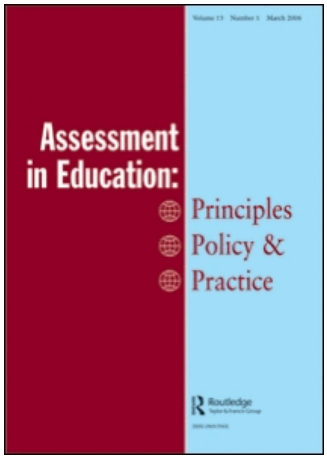

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Geoff Hayward [a]; Jane McNicholl [a]
[a] University of Oxford, UK

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Modular mayhem? A case study of the development of the A-level science curriculum in England

Geoff Hayward* and Jane McNicholl
University of Oxford, UK

This article investigates the costs and benefits of the increased use of modular or unitized qualification designs through a case study of the GCE A-level science curriculum in England. Following a brief review of the development of modular A-levels, the various proposed advantages of modularity—short-term goals and regular feedback, flexibility in curriculum design, and improved progression possibilities—are counterpoised by arguments about the disadvantages—such as fragmentation of knowledge and more instrumental approaches to assessment and learning. The article argues that on balance the costs of the move to modularization in terms of the impact on teachers' capacities to help young people understand science outweigh the perceived benefits of improved examination success rates. Given this balance we account for the growing popularity of modular approaches using a path dependency model and increasing returns process which combine features of the English educational landscape, in particular narrow accountability systems, to the increasing desirability of modular approaches to curriculum design for learners, teachers and educational organizations.

Introduction

At the start of the twenty-first century governments in most OECD countries are involved in ongoing debates about the structure and form of the senior secondary[1] school curriculum. Typically such debates are linked to growing concerns about maintaining economic competitiveness in the face of the pressures of globalization, and the need to develop a 'knowledge economy' in response to such pressures. This has resulted in two clear trends in arguments about the development of the upper secondary curriculum, which are linked to the concerns about mechanical and instrumental approaches to teaching and learning voiced in the other papers in this special issue:

*Corresponding author. Department of Educational Studies, University of Oxford, 15 Norham Gardens, Oxford OX2 8LR, UK. Email: geoff.hayward@edstud.ox.ac.uk

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- The growing use of learning outcomes to specify assessment models for qualifications
- The increased use of modular or unitized qualification designs.

It is the second of these trends that is examined in this paper. The proponents of modularity have long argued for its advantages in terms of curriculum flexibility, short-term assessment goals and enhanced extrinsic motivation for students. In addition, the increasing proliferation of National Qualification Frameworks (NQFs) requires a modular approach to specifying qualifications in order to provide opportunities to accredit and aggregate individual qualification components (Ertl, 2001; Young, 2003; Cole, 2006).

However, while the intrinsic logic (Raffe, 1992) of such a move in qualification design may reflect a desire to make qualifications transparent, reduce barriers to progression and maximize access, flexibility and portability, the development of modular qualifications within an NQF is based upon a number of key assumptions. Central to the argument in this paper is the assumption that all knowledge can be treated in a similar manner and that any differences between, say, academic, vocational and professional knowledge can be treated in an essentially arbitrary manner. Given this assumption, all qualifications can, as a matter of principle, be divided into modules or units using a set of standard processes that give 'priority to procedures and cross-sectoral level descriptors, not knowledge content' (Young, 2003, p. 233). However, and contrary to this assumption, some would argue that there are fundamental differences between types of knowledge that reflect major epistemological boundaries between fields and disciplines (Pring, 1995; Ensor, 2003). Simply eliding such distinctions in order to create an integrated qualification system and to overcome inequality (i.e. to realize the intrinsic logic of this particular policy), runs the very real risk of undermining 'the very basis on which knowledge is acquired and produced' (Young, 2003, p. 234). Ironically, while one outcome of such a move may be an integrated National Qualifications Framework, there is the very real risk of producing qualifications that are no longer fit for purpose.

This is the issue that is explored in this paper through a case study of the modularization of the GCE Advanced Level (A-level) science curriculum in England and Wales. This involves reviewing a range of evidence, from published materials to analyses of data sets collected, for example, through the Nuffield-sponsored 14–19 Review (Hayward *et al.*, 2004, 2005, 2006) to ascertain the costs and benefits of using a modular assessment strategy in GCE A-level science subjects. Upper secondary science education in England makes a particularly suitable case study for two reasons. First, much of the debate about the knowledge economy makes explicit reference to encouraging more young people to become scientists. This supposed need is then used as a justification for adopting a modular approach in the science curriculum, for example, to make the subjects more attractive to young people thereby increasing their uptake and so facilitating the production of more scientists and technologists. Second, GCE A-level science subjects (and mathematics) have a long history of

modular developments which can be used to explore the costs and benefits of this approach to qualification design.

The development of modular A-levels

GCE A-levels were introduced in 1952, following a recommendation in the Norwood Report, to serve as matriculation qualifications for higher education and degree courses. Typically students studied three subjects over a two-year period with terminal examinations in each subject at the end of the programme. The specification of the content of the courses was led by higher education via a series of examining boards. Consequently, there was the opportunity to maintain a link between the specification of the content of GCE A-level courses and their assessment, and progression to study at degree level. GCE A-levels, it was believed, provided a depth of study within a subject that helped support the transition into higher education. Subsequently, there were a number of attempts to reform these qualifications, mainly instigated by pressure to make A-level study broader (The Higginson Report, 1988; Scruton, 1989; Kingdon, 1991; Dunford, 1993; Lawton, 1993; Macfarlane, 1993; Dearing, 1996). In addition, control of GCE A-levels passed out of the hands of higher education tutors working with teachers through the examination boards, and fell under a series of regulatory agencies, such as England's Qualifications and Curriculum Authority (QCA), through which the state could maintain a greater degree of control over the specification and assessment of these qualifications.

The earliest attempts to modularize A-level, and so move away from total reliance on terminal assessment, occurred in the 1980s. For example, the Wessex scheme was the result of a bottom-up collaboration between schools and colleges, three local education authorities and the Associated Examining Board (AEB). The drive behind 'Wessex A-levels' came predominantly from teachers in schools and colleges seeking a means to make the A-level curriculum more relevant to their students, to provide increased extrinsic motivation through the setting of shorter-term assessment targets,[2] and a greater use of coursework for assessment purposes. An alternative to this was the University of Cambridge Local Examination Syndicate (UCLES) scheme. Essentially, this involved dividing existing qualifications into modules of delivery typically combined with a step-by-step approach to assessment, with examinations taking place at the end of each module. The UCLES scheme differed from the Wessex model in that it was a national scheme, centrally devised by an examination board and offered to all schools and colleges.

By the early 1990s there was growing government concern about modular A-level courses being too easy in comparison with linear, terminally examined courses for a number of reasons: modular courses in the past had been associated with lower attaining students; candidates could retake modules to improve grades; and candidates could be examined on parts of a subject rather than the entire syllabus (Dearing, 1996; Pinnell, 1996). Others argued that these concerns were not well founded and that modularization could make study at A-level more

difficult because candidates were expected to work and be assessed at A-level standard from the first module taken early in the first year (Year 12) of a two-year programme (Years 12 and 13; Stobart, 1995; Pinnell, 1996). One study suggested that for mathematics and physics this was the case (Taverner & Wright, 1997).

Nonetheless, the political concerns persisted as reflected in the requirements for modular examinations set out by the Schools Examination and Assessment Council (SEAC) in 1993. In particular, modular A-levels were to have external assessment, both at the end of the course and at the end of each module, at a level of demand equivalent to A-level in order to maintain the standard of the qualification. At this point the A-level modularization process became linked to a developmental path that had, as its main design feature, the association between a module of delivery and a unit of assessment. In this development, science subjects along with mathematics led the way.

It was the Dearing Review (Dearing, 1996) that provided the template for the current model of modular A-levels. Following the election of New Labour in 1997, a post-election consultative process was initiated by the publication of *Qualifying for Success* (DfEE, 1997), which adopted most of the recommendations made by Dearing and led to the development of the 'Curriculum 2000' initiative. Overall its aim was to provide flexible 16–19 education that encouraged broader study at A-level and a unified academic and vocational qualification system. A modular approach lay at its heart with modularization providing the 'building blocks of a national and unified qualification system' (Hodgson & Spours, 1997, p. 108).

Specifically, all A-levels were split into six units of assessment with an examination for each unit. This structure mirrored that in use for the General National Vocational Qualification (GNVQ), which in turn reflected the long-standing design of BTEC[3] qualifications, both types of vocational qualification. In part, the rationale for this move to a common qualification design framework was to allow students more choice, for example by picking and mixing modules, as well as offering a chance to broaden study at A-level, for example, by combining vocational and academic qualifications. In addition, it was hoped that spreading the assessment process over a number of modules, and thus over a longer time period, would make GCE A-level more attractive (Taverner & Wright, 1997), a particular problem in the physical sciences and mathematics where the proportion of the student population taking these subjects has declined rapidly. Furthermore, enabling students to retake the modular examinations meant that summative assessment could be used, it was argued, in a formative way, so helping students to pass the exams with higher grades.

The challenge of assessing these new qualifications was recognized during the 2001 examination period, which prompted a number of evaluations and reviews. These began to reveal for the first time the costs of adopting this particular modular approach to qualification design in terms of both assuring the validity and reliability of assessment, and in terms of the potential challenges to the quality of teaching and learning.

The rapidity of change

A striking feature of the shift to modular science A-levels was the rapidity with which apparently entrenched views about the science curriculum were overcome. Following the publication in March 1993 of ground rules for the construction of modular examinations by SEAC, by 1995 there had been a swift expansion in the number of modular syllabuses made available by all examination boards. There were, for example, then about 42 traditional linear and 45 modular syllabuses in mathematics. Across all subject areas, some 133 modular syllabuses were available (Dearing, 1995). Although in 1996 the uptake of modular A-levels was mainly confined to mathematics and science accounting for about 20% of candidate entries, by June 1998 the number and range had grown to over 50% of A-level candidates being examined on modular courses (Richardson *et al.*, 1995; Ofsted, 1999; Hodgson & Spours, 2004). Hoyles *et al.* (2001) report that in two LEAs 90% of respondents had changed their examination board for mathematics between 1989 and 1997 and that in every case this change was to a modular A-level course.

However, it is clear that as late as 1995, only five years before Curriculum 2000 mandated modular structures for all GCE A-levels, there was concern over modularity as a threat to academic standards, and so to the currency of A-level as the 'gold standard' qualification among higher education admissions staff and employers, at the highest political levels. This concern is reflected in a speech given by Sir Ron Dearing (1995) at the mid-point of his deliberations into the future of the 16–19 qualifications framework:

> It was also a reflection of a concern to maintain standards that, when the Government asked me last April to advise on strengthening, consolidating and improving the framework of 16–19 qualifications, it directed me to do so bearing in the need to:
>
> a) maintain the rigour of A–levels and build on GNVQ and NVQs;
> b) increase participation and achievement in education and training and minimise wastage;
> c) prepare young people for work and higher education;
> d) secure maximum value for money.
>
> In discharging that remit on the rigour of A-levels I proposed … to look at several aspects of them. One of these was to be satisfied that the modular A-levels now introduced are equally as demanding as the A-level in its traditional linear form … Whilst the modular A-level is still new, and whilst we have without doubt lessons to learn, I counsel the merits of the traditional A-level we know so well, for those for whom it is well fitted. (p. 2)

This concern was still reflected in his final report on the new 16–19 qualifications framework:

> Modularity has a great deal in its favour, but there are, for want of a better word, enthusiasms in education for one approach or another, and dangers in an enthusiasm becoming universal practice, before the full consequences have been digested and evaluated. (Dearing, 1996, p. 93)

These concerns were shared by some members of the science education community. For example, the Institute of Physics stated in a letter to SEAC that it favoured

'assessment in the latter part of a modular course which tests the accumulated understanding by students of the relationships between different elements of a subject'.

Given these concerns and given the long-term, institutional stability of linear GCE A-levels, this rapid reform process is perhaps surprising. By 2000 all linear A-level syllabuses had disappeared, a sea change in which science subjects led the way. This change is indicative of the strength of the increasing returns process within the path-dependent model chosen to modularize A-levels. Modular A-levels swept all before them. As the Royal Society of Chemistry (1996) pointed out in their discussion paper on standards, comparability and modular assessment: 'Modular A-levels seemed to appear without much consultation. They are now very much a fait accompli' (p. 9).

In part, this rapid adoption of modular science A-levels maybe a reflection of the long period of experimentation with the upper secondary science curriculum in the UK through charity-funded research and development projects such as Nuffield Science and Salter's Science, and a strong curriculum development focus in the work of the Association of Science Education. Thus the modularization debates within science of the 1980s and 1990s may have occurred at a tipping point, allowing the rapid shift from a linear qualification structure with terminal examinations to a modular assessment structure. Certainly there is evidence of the support for modular approaches to curriculum design within the teaching profession growing throughout the 1980s and 1990s.

In addition, the rapid adoption of modular A-levels can also be seen in terms of a set of anticipated outcomes that were deemed desirable for economic, social and personal reasons. In particular, modularity was thought to provide a means of overcoming the academic–vocational divide by permitting timetabling arrangements that would enable young people to mix and match academic with vocational qualifications, such as GNVQs, thereby raising the parity of esteem of the vocational route (Stobart, 1995). In addition, the modular approach allowed the opportunity, in the event of a whole course proving too much or simply being a bad choice, of gathering sufficient modules to be awarded an AS qualification (i.e. half an A-level). This, it was believed, would encourage young people to attempt subjects that would otherwise have seemed too daunting, especially science and mathematics. Finally, it was thought that formative assessment using information gleaned from performance on earlier modules would enable teachers and learners to plan a way forward and to remedy weaknesses before it was too late (Dearing, 1995, 1996).

Another factor at work was largely market driven. Schools pay fees for every examination taken by their students and a market economy between the examination boards arose where examination boards competed for students' fees (Hoyles *et al.*, 2001). Making less popular subjects like science and mathematics a modular option was perceived by examination boards as one way to attract schools to sign up to their specification and examination. As Hoyles *et al.* (2001) point out:

> None of those [representatives from four major boards] had a clear idea of the reasons underpinning the various changes, other than the hope that the board would attract more candidates … It appeared that increasing the market share of examination fees was almost

> the only arbiter: one board's success in increasing numbers resulted in other boards following suit. (p. 836)

The switch to a modular curriculum has had significant financial implications with, for example, secondary school head teachers spending on average £150,000 on examination entry fees, which is more money than they spend on text books (Tomlinson, 2004; TES, 2006). However, such a cost might be justified if it led to improved examination results thereby maintaining or improving a school or college's reputation in an increasingly marketized and competitive education system.

The publication of school league tables and the pressure on schools to improve examination results, meant that competition between examination boards was further heightened as the institutional logic of the new accountability systems heightened the search for examinations in which, it was thought, students would be more likely to succeed. Ironically, a senior member of one of the main English examination boards in England recently signalled the detrimental education impact of competition and the commercialization of examinations:

> One effect is the syllabus becomes less a description of educational opportunities and more a contract with consequent effects on the way it is written and, of course, the way it is taught. Teaching to the syllabus, teaching for results, must narrow it and tend to depress the sense of inquiry and the desire to inquire. (Duncan Fraser, Edexcel, quoted in the TES, 21 October 2005, p. 4)

The impact of the current approach to specifying and assessing modular curricula on the learning experience of students is examined next.

The impact on learning

There is strong evidence to suggest that the learning experience of A-level students has been compromised by the approach to modularization that underpinned the introduction of Curriculum 2000. For example, in one study, teachers and students reported that Year 12 (the first year of A-level study) was both rushed and superficial (Hodgson & Spours, 2004):

> Many teachers resented the fact that they were not able to build in the types of skills, exemplification and underpinning knowledge for which they had found space when teaching the old A-levels. (p. 447)

Priestley (2003) reports the effects of modularization of A-level study to be more didactic teaching, teaching to the test, and what Hargreaves (2004, p. 3) terms a 'climate of cramming' (see also Taverner & Wright, 1997). Such problems, Priestley suggests, are exacerbated by the fact that many A-level course specifications are content heavy. However, Hodgson and Spours (2001) suggest that most of this 'overload' was associated with modular assessment rather than excessive content; a regime of regular formal assessment meant teachers spending much valuable learning time preparing for examinations. Tomlinson (2004), for example, estimated that a typical young person who goes on to study for three A-levels will lose overall about two terms' worth of learning preparing for and taking examinations.

This increased assessment load also has other implications: increased workloads produce student stress leading to dropout, and less opportunity for enrichment, such as taking part in extra-curricular activities (Priestley, 2003 ; Coll, 2002; McVeigh, 2002; Hodgson & Spours, 2001). In part this can be attributed to the modular assessment regime with students having to prepare twice a year for high stakes examinations rather than once at the end of the second year. This cuts into time for participating in other activities. Students may be working harder in terms of learning their subjects because they are more extrinsically motivated, but this may have been bought at the expense of other sorts of learning experiences of equal value in forming a person.

An over-emphasis on assessment can also lead teachers to adopt teaching styles that emphasize the learning of factual information (Black, 2004). Evidence from the literature on teaching science in higher education indicates that qualitatively different approaches to teaching are associated with qualitatively different approaches to learning. For example, Trigwell *et al.* (1999) report that in classes where teachers describe their approach to teaching as having a focus on what they do and transmitting knowledge, students are more likely to report that they adopt a surface approach to the learning of that subject. In the classes where students reported adopting deeper approaches to learning, teachers reported that they were adopting approaches to teaching that were more oriented towards students and to changing students' conceptions. If a purpose of teaching science at A-level is to help students to understand at a deeper level than previously the subjects they are learning, to form a relationship with the conceptual artefacts—the theories, ideas and concepts that constitute a body of knowledge—in order to act intelligently with those artefacts (Bereiter, 2002), then the sorts of surface approaches to learning identified by Trigwell *et al.* (1999) are unlikely to achieve this outcome.

However, the evidence consistently shows improving examination scores in science A-levels over the last ten years, coincident with the shift to modular assessment. For example, the proportion of candidates gaining the top grade in biology increased by 9.3%, in chemistry by 9.6% and in physics by 8.9% between 1996 and 2005 (DfES, 2006). Given that the modular examinations are assessing validly across the four assessment objectives for the A-level, which include evaluation, synthesis and application of knowledge, then these data suggest an improvement in understanding. Thus, even if teachers are teaching to the test, and are apparently getting better at so doing, then that is to be applauded as it is, according to the examination data, leading to improvements in the ability of students to synthesize, evaluate and analyse information. Developing these skills in a knowledge domain such as science must involve, one assumes, the development of understanding, i.e. forming a relationship with the conceptual artefacts—the theories, ideas and concepts that constitute a body of knowledge—in order to act intelligently with those artefacts at least in terms of answering examination questions.

Set against this are repeated expressions of concern from higher education admissions staff in focus groups run by the Nuffield 14–19 Review (Wilde *et al.*, 2006) about the fragmented nature of new students' knowledge of science, a highly instrumental

and surface approach to learning, a lack of understanding and critical engagement with ideas.

> Students show an instrumentalist approach, and it is difficult to combat that. There is a commodification of knowledge, and a sense that they want to move on, get the badge.
>
> There is too much focus on coursework and repeated assessment. The Lower Sixth loses a third of the year to examinations, and students are frightened of examinations and want to learn and forget, rather than learn and know.
>
> Three-month modules mean students present a mosaic rather than a picture.
>
> With modules, students sometimes focus on peripheral items and not the basis of subjects. They lose the synoptic aspects.
>
> The only thing they are interested in is getting a mark in the short term. The modular system means they forget what they've learnt.
>
> There has been a change because of modular developments in A-levels. The focus is on gap-filling rather than coherent approach. Physics, though, is a linear subject, so this is a real problem. I would like to see a backtracking from modular examinations, although our hands are not clean at universities either. There is a need for longevity in the learning process (Wilde *et al.*, 2006, pp. 9–12)..

This is a difficult circle to square. On the one hand we have what is claimed to be a robust and valid system of assessment that is highly regulated and is intended to demonstrate whether learners have developed a conceptual and synoptic understanding of the subject they have been learning for two years and, on the other hand, we have end users of the system complaining that this is not happening. In so doing, they call into question the fitness for purpose of a qualification originally intended to support progression into higher education. The result is an erosion of trust in an assessment process which, it is felt, no longer provides valid and reliable information. This is fatal for a qualification which, 'like so much in social life, depend on trust, not just rules, laws or criteria' (Young, 2003, p. 235).

These concerns echo those reported in other papers in this special issue. In addition, such concerns were also reported by Smith (2004) following the inquiry into mathematics post-14:

> In addition to these considerable concerns about the organisation of the curriculum and the serious effects of the Curriculum 2000 changes, there are also serious concerns about the frequency of assessment of material in GCE AS and A-level mathematics. This is felt by many respondents to hinder the development of the learning and understanding of mathematics at this level. It is the consensus view that far too much time is devoted to examinations and preparing for examinations—'teaching to the test'—and that this is at the expense of understanding of the subject itself. Many identify the problem as splitting of the subject matter of A-level mathematics into six separately examined modules. This is seen as having the effect of splintering the unity and connectedness of the mathematics to be learned at this level. It is felt that this fragmented presentation makes it virtually impossible to set genuinely thought-provoking examination questions that assess the full range of mathematical skills. It is also felt that the style of short examination papers result in a race against the clock that adversely affect weaker candidates (pp. 93–94).

Unfortunately there are very few studies that compare the attainment of those taking modular assessments with those taking examinations at the end of a course. Taverner and Wright (1997) reported improvements in A-level results among those taking modular courses but this may have been due to those receiving a poor grade or a fail in a module exam not cashing in those credits for their final A-level. McClune (2001) investigated the level of attainment of learners on the same physics exam taken by candidates in Years 12 (modular assessment) and 13 (terminal examination). He found that learners in the second year of the course had a higher level of attainment than those in the first year of the course. However, he points out that the attitudes of the teachers and learners to modular examinations might have played a significant role in producing this outcome.

There is also evidence from higher education programmes that modularization can lead to poorer degree results. Bailey and Barber (cited in Newstead, 2000) claimed that law degrees broken into semesters result in lower grades than those retaining the traditional term structures with terminal examinations. In part this can be explained by the fact that more selective universities retained term structures. However, the research claimed that there is a year-on-year decline in grades in institutions with semester structures, which does not occur in the term-based institutions.

Newstead (2000) argues that the reason why semester-based assessment systems could lead to poorer results is that it may encourage rote learning of material. Such a claim is supported by Conway *et al*. (1997) who found that assessments at the end of a module measure remembering based on recall from episodic memory, while assessment that was delayed until the end of the next semester measured knowing responses, suggesting the semantic memory was involved.

> The worrying aspect of this is that modularised and semesterised programmes almost universally examine students at the end of each semester, which means they are assessing episodic memory. If we want to measure whether knowledge has been conceptually mastered, in other words has become semantic memory (as surely we do), we need to assess students some time after the material has been presented. (Newstead, 2000, p.185)

Proponents of the current modular arrangements could counter this argument by pointing to the regulated nature of the assessment procedures, which requires an assessment of conceptual understanding to be made, and the requirement for synoptic assessment in the final module examination at both AS and A2 to test overall understanding. However, just because something is regulated does not make it a sensible practice to assess conceptual understanding. More work clearly needs to be done on deconstructing examination questions, and students' responses to them, in AS and A-level papers to assess the extent to which they do assess synoptic understanding. However, if teachers are being encouraged by the current qualification system to teach to the test, then the likelihood is that the focus on the synoptic element of the assessment will come towards the end of a programme of learning. There may be some validity in this approach. Stobart (1995) for example argues that 'assessment imminence' is a great spur to learning, to pulling ideas together, to thinking around and conceptually organizing the disparate material taught throughout a

course. However, subjects like science and mathematics do not consist of disparate material but rather of interlocking conceptual artefacts. To develop an understanding of these artefacts, and to act intelligently with them, requires a teacher to help learners build connections between them from the beginning of a programme of learning, not trying to force them together towards the end.

On balance the evidence does suggest that in science and mathematics at least there is a problem with students developing a thorough and synoptic understanding of the subjects that they are studying and that this is associated with the way that qualifications in these areas have been modularized. This approach to assessment does not appear to make science and mathematics more attractive as subjects to be studied post-16; it has not resulted in any greater breadth of study; it may have had an impact on other forms of valuable learning experience; it has increased examination cost; and it appears to have had a detrimental impact on the quality of teaching and learning, as far as can be judged on the basis of the available evidence.

Discussion

There have always been concerns over the costs of adopting a modular approach. For example, Warwick (1987) urged some caution:

> The curriculum may be developed through modules; it can also become hopelessly atomised or fragmented in the process (p. 16).

Other commentators have been more apocalyptic in their condemnation:

> Modularisation has been in the vanguard, first in the universities, more latterly at secondary level. The effect has been disastrous: here as elsewhere, choice has become depressingly fetishised; knowledge, and with it learning, have been fragmented and commodified; academics, like others, have been de-professionalised; and students, like the rest of us, have been transformed into clients and customers. (Brecher, 2005, p. 72)

Other papers in this special issue reflect such concerns, indicating the costs of a unitized and/or modular approach in terms of a mechanical and instrumental approach to teaching and learning. There is of course a danger in developing a critique of modularization of both throwing the baby out with the bathwater and of over-romanticizing the past as some golden age where teachers did not teach to the test, and learners did not learn to pass an exam but simply struggled to understand. These are both myths (see Van Rooy, 1997 and Black, 2004 for further discussion). Nonetheless, the evidence reviewed does suggest that the benefits thought likely to occur as a result of shifting to modular qualification design in science A-levels have been bought at some cost. In particular, the shift to modular qualification designs, combined with other reforms of the education system, has led to a decline in the ability of GCE A-level teachers to help their students to develop a coherent understanding of the science subjects that they are studying. This in turn has led to a diminution of trust in the qualification among higher education tutors and admission staff, who remain the most significant end users of these qualifications.

Given the problems associated with the particular model of modularity developed during the 1990s and coming to fruition in the Curriculum 2000 development, how are we to explain the journey down this particular reform pathway with the apparent eventual support of all the major actors involved: teachers and their managers; policy makers; awarding bodies; and learners and their carers?

We hypothesize that this is the result of a very high level of path dependency, as defined in its narrow sense[4] by Levi (1997):

> Path dependence has to mean, if it is to mean anything, that once a country or region has started down a track, the costs of reversal are very high. There will be other choice points, but the entrenchments of certain institutional arrangements obstruct an easy reversal of the initial choice. Perhaps the better metaphor is a tree, rather than a path. From the same trunk, there are many different branches and smaller branches. Although it is possible to clamber from one to the other—and essential if the chosen branch dies—the branch on which a climber begins is the one she tends to follow (p. 28).

Closely linked to this concept of path dependence is the idea of an increasing returns process where 'the probability of further steps along the same path increases with each move down that path' (Pierson, 2000, p. 252). Increasing returns from movement along a particular path result from increasing relative benefits over time from a particular activity compared to other possible alternatives. As time progresses, the cost of exit from a particular strategy will, therefore, rise as a result of an essentially positive feedback process.

The initial arguments in favour of a shift to modular qualification designs in upper secondary science were made for a variety of complex reasons: for example, to permit exploration of alternative learning opportunities (academic and vocational) and to provide the opportunity to construct a more personally meaningful curriculum. But an argument in favour of using a modular approach to increase extrinsic motivation in order to force young people to work harder and so raise their attainment and 'employability' came to the fore.

> By the succession of examinations students are motivated to work throughout the whole of their course. The modular approach develops the practice of disciplined sustained work practices. Students are encouraged by success in early examinations to continue their efforts for the next stage. (Dearing, 1995, p. 4)

> Where there is a final exam after two years there is often the idea that the first year is some kind of party for students where they are resting from their GCSE exertions, and thinking about getting around to what will lay ahead in the second year of A-levels, coupled with 'You didn't tell me' when they all do badly in the end of first year exams and get the short sharp shock they need to get on with it next year, (Stobart, 1995, p. 10)

This meant that modular developments in teaching and learning in the 16–19 phase were inextricably linked to a modular assessment strategy; examining learning at the end of a module was seen as a key mechanism for increasing extrinsic motivation and thereby raising attainment. Thus in the reform of A-level science qualifications, modularization referred to a system that encompassed not only how the curriculum is divided into modules but also how the assessment regime is unitized, with each

module of study being assessed individually with credits (marks) for each module building up to produce a grade for a final overall qualification.

This link to assessment is not a necessary part of a modular strategy:

> I want to … [define] … modularization as a way of organising a flexible curriculum into small blocks of learning which can be combined together in different ways. (Young, 1998, p. 80)

In the early stages of the development of modular curricula a rather sharp distinction was drawn between a modular approach that divided the curriculum into relatively short learning experiences encouraging a gradual and staged approach to achievement, which was seen as characteristic of the academic track, and unitization of assessment which was seen as more characteristic of the vocational pathways (Hodgson & Spours, 1997, p. 106).

The argument in this paper is that this distinction between a modular approach and a unitized approach to assessment began to break down and was not the one adopted during the process of the unitization of GCE A-level science subjects during the Curriculum 2000 initiative. Increasingly, then, an A-level module was seen as both a unit of delivery and a unit of assessment (Raffe, 1994). If an alternative vision had been adopted the modularization process might have proceeded down a very different pathway with potentially better educational outcomes.

Conclusion

The argument developed in this paper is that due to an essentially contingent set of circumstances, modularization of science A-levels occurred along a pathway that linked curriculum planning with assessment. There were some genuine educational aspirations associated with the initial experimentation with a modular qualification design for science A-levels, but these aspirations do not seem to have come to fruition. Rather, increasing returns to key actors have driven the modularization bandwagon down a pathway that has produced educational disadvantages for teachers and learners.

Nonetheless, the evidence does suggest that the returns to following this particular approach to designing and assessing a modular qualification increased very rapidly linked with:

- a growing accountability and target-driven culture within the institutional logic of the education system that employs examination attainment, as a key performance management tool;
- a further increase in an instrumental rationality among learners and their carers, that linked the pursuit of improved examination grades to increase the probability of progression to higher education with the ultimate outcome of improved labour market status;
- a 'desire' to manage the reputation of their organizations, in the case of educational managers, to compete more effectively in the educational market-place;
- the need for examination boards to compete in an increasingly commercialized qualifications market-place;

- the political necessity for policy–makers to demonstrate that reforms were producing improved examination results (though an increase in participation rates did not result from this strategy—see Hayward *et al.* 2004, 2005, 2006; Hayward, 2005).

A modular assessment process provided all these groups with affordances that enabled them to satisfy their respective objectives, thereby increasing inexorably over time the cost of opting for an alternative qualification structure. All of this has been bought, however, at a considerable cost, both financial and educational, in particular the ongoing impact on the quality of teaching and learning. This should remind us in a rather stark way that the apparently technical and neutral processes of dividing up a qualification into modules, because it 'embodies both assumptions about knowledge and pedagogy and what we mean by education' (Young, 2003, p. 236) can produce undesirable outcomes.

The modular genie is clearly out of the bottle and it will be difficult, because of path dependency, to force it back in. However, it may not be desirable to do so if alternative conceptions of modular science programmes could rectify the weaknesses identified above. This is not a new idea. Dobson (1994) criticized proposals for modularization of A-level courses and suggested that an intelligent modular course would begin with an analysis of the educational aims of learning a subject like physics or maths, the educational advantages that might be gained from a modular scheme and the recognition that end-of-module tests accordingly have a different function from a terminal examination. Unfortunately, this more thoughtful discussion about the nature of scientific knowledge, and the process of its acquisition by those in upper secondary education, is one that we are not having in the UK as we move into yet another iteration of GCE A-level reform. This current reform does involve a reduction in the number of modules within the qualifications in order to reduce assessment burden coupled with the intention of employing more synoptic and holistic approaches to assessment. While this may be a step in the right direction, as a policy it still runs the potential risk of undermining the learner's development of a coherent understanding of science, resulting in a qualification that potentially remains unfit for purpose.

Notes

1. There are differences between countries as to what is to count as the senior secondary cycle of schooling, but typically this term covers the education of 14–19-year-olds.
2. Data on the Wessex scheme were obtained by analysis of unpublished documents and an interview with a developer of the scheme. We are grateful to him for providing access to this information and for his time.
3. Business and Technical Education Council.
4. A broader definition is provided by, for example, Sewell (1996) who suggests that path dependence means 'that what happened at an earlier point in time will affect the possible outcomes of a sequence of events occurring at a later point in time' (pp. 262–263). As Pierson (2000) points out, such a usage may only entail the idea that 'history matters'.

Notes on contributors

Dr Geoff Hayward is a lecturer in education at the University of Oxford, director of the Nuffield 14–19 Review and Associate Director of the ESRC research centre on Skills, Knowledge and Organizational Performance. His research interests include qualification and curriculum design, vocational education and training, and professional learning.

Dr Jane McNicholl is a lecturer in education at the University of Oxford. Her research interests include science teachers' professional knowledge and the role of school subject departments as learning environments.

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