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Curriculum for Excellence Science: Vision or Confusion?

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ABSTRACT

Policy studies in science education do not have a particularly high profile. For science teachers, policy lurks in the background, somewhat disconnected from their normal classroom practice; for many, it is simply taken-for-granted. This paper analyses policy documents which have emerged from Curriculum for Excellence (*CfE*) that impact on science education. It does so through the prism of Roberts' (2007) *visions* and *image* of science curricula to ask (i) how the stated rationale or *vision* for the science curriculum is reflected in the published experiences and outcomes (E&Os); (ii) what policy *image* of science education do these E&Os portray; and (iii) how well do these fit with teachers' current experiences and (evolving?) classroom practices. We argue that there is a disconnection between the stated purposes of Scottish science education and the published E&Os. Pupils' development towards functional scientific literacy cannot be achieved if there is confusion as to the purpose(s) of education in science. Greater clarification as to what the priorities are and should be for Scottish science education is required in order that significant change takes place.

INTRODUCTION

According to the mantra, Curriculum for Excellence (*CfE*) aims to develop Scottish young people as responsible citizens, confident individuals, successful learners and effective contributors. It is claimed that the curriculum has been designed to transform education in Scotland, leading to better outcomes for all children and young people (Scottish Government, 2009, p.4). Learning and Teaching Scotland (now part of Education Scotland) proclaimed on their website that *CfE* was the 'biggest reform of education in a generation' (LTS, 2006, p.3). Furthermore, Government believes that teachers need more 'freedom to teach in innovative and creative ways' (Scottish Executive, 2006, p.16) and that *CfE* provides a 'streamlined' curriculum for young people aged 3-18. The new curriculum represents a response to the findings from the 2002 National Debate on Education in Scotland to provide more freedom for teachers; greater choice and opportunity for pupils; and a single coherent curriculum for all young people aged 3-18 (LTS, 2007).

Judging by the rhetoric, one might be forgiven for thinking that the *CfE* reforms are universally accepted. However, the new curriculum is not without criticism. For example, in terms of how the policy translates into practice, Priestley (2010) has suggested that *CfE* suffers from a number of weaknesses. These emerge from a vagueness of specification in pedagogical terms, combined with the specification of the curriculum as outcomes, sequenced into levels. Also, that there is a comparative lack of content specification within the new curriculum compared to its predecessor. While he suggests that none of these issues are insurmountable for schools, since the general directions set by *CfE* are constructive and flexible, he correctly suggests (in our view) that, to overcome them, schools require a certain level of capacity and assumes a curricular vision which is shared amongst curriculum designers and those tasked with development within schools, as well as an awareness of the shortcomings of the new curriculum.

Priestley (2010) argues that there is a paucity of curriculum theory across policymaking, practitioner and academic communities, and that this has led to a lack of the capacity required to deal with the issues thrown up when attempts are made to translate policy into practice. This is manifest at a number of levels, he argues. At the macro level, an atheoretical perspective can lead to curriculum policy that lacks coherence, to a mix-and-match approach that combines different models, potentially creating difficult tensions for those charged with enacting policy. Priestley & Humes (2010) further explore the lack of coherence in CfE policy, seeing it as

> inherently not a process curriculum, but rather a mastery curriculum, an expression of vaguely defined content articulated as objectives. It is our belief that these contradictions will ultimately water down the impact of the new curriculum, meaning that the espoused vision of changes to teaching will be rendered difficult in many schools and that the maintenance of the status quo will be a likely outcome in many cases (Priestley and Humes, 2010, p. 355).

Priestley himself states that “at the meso and micro levels of curriculum enactment, an atheoretical perspective potentially denies local policymakers and practitioners the conceptual tools to make sense of policy, and to reconcile it with local needs and contingencies in a manner that is educational” (Priestley, 2010, p. 24). All of these issues lead to two important questions: *Do all schools, both primary and secondary, have the required levels of capacity?* And, *is there a shared vision amongst policy makers and school based curriculum developers?* In Priestley’s view, the answer to the first question is that capacity is indeed limited for school-based curriculum development. Many have argued that the educational workforce has, over the years, been allowed to drift into a position of rather unquestioning complacency. This has been in part due to the increased influence of managerialism, but it also relates directly to the reform tradition and a culture which values recall, grades and separate sciences. However, it is the second question which this paper addresses: we seek to assess the extent to which the stated science rationale has been translated into curricular experiences and outcomes which *can* be taken forward by teachers over the next few years as implementation gathers momentum. The paper is divided into four sections. The first places the *CfE* reforms in context and defines the terms ‘policy vision’ and ‘policy image’. The second focuses specifically on the science rationale as the curricular vision and the *CfE* science experience and outcome documents which delineate the policy image of the new curriculum. The third, analyses the extent to which the *CfE* science documentation achieves its stated aims by comparing it with the theoretical framework outlined by Douglas Roberts (Roberts, 2007a and 2007b; 2011). The fourth section looks critically at factors affecting the implementation of the *CfE* curriculum from a practitioner’s perspective.

A TIME OF CHANGE AND CONTINUING CONCERNS ABOUT SCIENCE

Since the turn of the 21st Century, Scottish education has undergone significant structural and curricular change. First, under the auspices of *Higher Still,* all curricular areas including the sciences underwent revision, updating and re-structuring with the introduction of a new suite of National Qualifications which introduced three new levels (Access 3, Intermediate One, and Intermediate Two) in all subject specialisms. In addition, the Higher syllabuses were updated and a new Advanced Higher level introduced to replace Certificate of Sixth Year Studies courses. Second, the implementation of *CfE* has required a further major revision across all subject areas with the sciences attempting significant change. In addition to this, the structure of the exam system is set to change with the phasing out of Standard Grade, Intermediate One and Intermediate Two and replacing them with the new National level 4 and 5 courses - session 2013-14 being scheduled as a dual run of National 4 & 5 with the last of the Standard and Intermediate awards. This level of curriculum innovation is all the more remarkable when considered in terms of the timescales involved. The *Higher Still* changes only took effect in the year 2000 and *CfE* in 2010. At best, such a sequence of change might be described as excessive given the workloads involved while at the same time teachers are expected to deliver the extant curriculum as best they can for their immediate pupil cohorts. Politically however, it could be argued that such change is a necessary response to the outcomes of the National Debate on Education held between 2002 and 2003.

Against this backdrop, a number of national and international research studies into the relevance of science education to young people have shown that present forms of science education within the United Kingdom (Jenkins & Nelson, 2005; Jenkins, 2006; Farmer *et al*. 2006) and in Europe (Sjøberg & Schreiner, 2006; Sjøberg & Schreiner, 2007; Matthews, 2007) are becoming unpopular and are increasingly turning pupils off studying science.

Two reports directly express concerns for science education in schools. The first report stems from the Proceedings of the Linnaeus Tercentenary Symposium on Promoting Scientific Literacy: Science Education Research in Transaction, held at Uppsala University, Sweden in 2007, where internationally renowned Science education researchers expressed their concerns by issuing a statement, the flavour of which is reproduced here in abridged form.

> Attitudinal data from many sources indicate that it is common for many school students to find little of interest in their studies of science and to quite often express an active dislike of it. In comparison with a number of other subjects, too many students experience science education as an experience dominated by the transmission of facts, as involving content of little relevance, and as more difficult than other school subjects… Science education has often overemphasized the learning of a store of established scientific knowledge at the expense of giving students confidence in, or knowledge of, the scientific procedures whereby scientific knowledge is obtained. Science education researchers have thus given increased attention to how various aspects of the Nature of Science can be taught, but school science curricula remain too loaded with content knowledge for these aspects to be sufficiently well-emphasised by teachers…There is little flavour in school science of the importance that creativity, ingenuity, intuition or persistence have played in the scientific enterprise. Nor is there any real sense of any meaningful exploration of issues that relate ethical and personal accountability to modern scientific activity… Curricula and assessment need to support teachers being able to share the excitement of the human dramas that lie behind the topics in school science with their students… Reforms of science education that continue to frame scientific literacy in terms of a narrow homogeneous body of knowledge, skills and dispositions, fail to acknowledge the different ethnic and cultural backgrounds of students. Such science education stands in strong contrast to the popular media. It omits a discussion of the reciprocal interactions between science and world views and between values and science, that the media regularly recognises as important to the public interest (Linder, Östman & Wickman, 2007, p. 7-8).

The second report emerged from two seminars sponsored by the Nuffield Foundation which involved invited participants from nine European countries in discussions about why fewer young people seem to be interested in science and technical subjects. The resulting report entitled *Science Education in Europe: Critical Reflections* made seven recommendations, three of which stand out as focusing on the issue at hand (Osborne & Dillon, 2008). The first recommendation deals with the competing goals of science education: “The primary goal of science education across the EU should be to educate students both about the major explanations of the material world that science offers and about the way science works. Science courses whose basic aim is to provide a foundational education for future scientists and engineers should be optional” (p. 8).

The second deals with low student motivation to learning science and the seeming gender inequity in science education: “More attempts at innovative curricula and ways of organising the teaching of science that address the issue of low student motivation are required. These innovations need to be evaluated. In particular, a physical science curriculum that specifically focuses on developing an understanding of science in contexts that are known to interest girls should be developed and trialled within the EU” (p. 8).

However, the sixth recommendation speaks of the need for more research into the development of assessments to meet the needs of assessing scientific literacy, recognising the fact that assessment practices have a tendency to drive practice: “EU governments should invest significantly in research and development in assessment in science education.

The aim should be to develop items and methods that assess the skills, knowledge and competencies expected of a scientifically literate citizen" (p. 9).

One can see from both of these reports that the theme is consistent, that science education as currently practised fails to inspire and engage young people and that the taught sciences are in danger of becoming marginalised. It is clear from these concerns, and from a growing body of published research, that there is a need for reinvigoration in science education.

With respect to Scottish science education, the picture is rather mixed, with many arguing that it is still backward looking and conservative - with regard to what is taught, how it is taught, the activities pursued in school laboratories, the examination formats imposed, and the attainment measures used to drive accountability. For example:

- With respect to *content*, the Higher Still science subject revisions certainly reorganised material but little was removed to make way for new ideas;

- The Advanced Higher science revisions have done little to help teachers deal with controversial issues, particularly with regard to the handling of discussions by pupils. HMIE themselves say, for example, that "Across all sectors, the use of debates and class discussions to help children and young people develop informed, ethical views of topical issues in science is not a common enough feature of learners' experiences in the sciences" (Education Scotland, 2012, p.24);

- *Pedagogy* throughout the sciences, at all levels, has remained largely transmissive;

- *Practical*, investigative work has become largely routine and formulaic. To quote the Inspectorate again: "At times, practical work in all sectors is still too prescriptive and teacher-led thereby not allowing the development of learners' creativity and inquiry skills. In such cases learners are not given enough responsibility to plan practical work and to select equipment and resources that they will need" and that: "There is scope for children to be engaged further in such fruitful investigative work as this is not a consistent enough feature of learning in the sciences across primary schools" (p.24);

- *Examination* formats have seen structural changes which emphasise more recall at the expense of problem solving. The annual STACS analyses of attainment data for schools handled by local authorities (Standard Tables and Charts Software) pressurise teachers to get improvements in pupil attainment, not to better their learning. The two are not synonymous and, while it is true that attainment figures have been slowly rising in all of the sciences (and they remain popular as subject choices for upper secondary), there remain concerns about the depth of the learning which is taking place. HMIE (2012) states: "Children and young people are not often enough experiencing sufficient depth in their learning across all key areas in the sciences" (p.43).

In this regard, while the Scottish reforms under the auspices of *CfE* are, on paper, in step with the current reform climate across Europe and have the potential to address acknowledged weaknesses, the content updating has done little to re-dress the balance. The E&Os bear a striking resemblance to 5-14 content; no real 'de-cluttering' has taken place; and teaching methods seem stuck in a groove. In terms of enacted changes in practice, the *CfE* Science reforms seem far from radical.

DEFINING TERMS: POLICY VISION AND POLICY IMAGE

Any school curriculum is, at least in part, a reflection of political and professional debate; some of it results from tradition and habit and the remnants of previous thinking. However, policy studies in science education research do not enjoy a high profile (Fensham, 2009; Roberts, 2011). For science teachers, policy lurks in the background, somewhat disconnected from most teachers' classroom practice; for very many it is simply taken-for-granted. Where policy does speak to them is through required sets of learning outcomes;

‘the’ syllabus, or an approved textbook. The reasoning behind the decision-making processes that went into determining the policy, particularly intended shifts of emphases, are often far removed from teachers’ day-to-day experiences and contemplations. Its implementation, on the other hand, relies heavily on their ability to interpret and enact the policy.

How one defines the terms ‘vision’ and ‘image’ in the policy context is important, both of these being sometimes used in relation to an innovation or new development. It is difficult to escape the business view of a ‘vision’ - a statement which provides a clear orientation to a commercial enterprise; what it is and why, conveying what success will be in the future (Müller-Stewens & Lechner, 2005; Grant, 2002). *The Coca-Cola Company’s* vision is typical:

> The world is changing all around us. To continue to thrive as a business over the next ten years and beyond, *we must look ahead*, understand the trends and forces that will shape our business in the future and move swiftly to *prepare for what's to come*. *We must get ready for tomorrow today*. That's what our 2020 Vision is all about. It creates a *long-term destination* for our business and provides us with a *"Roadmap"* for winning together with our bottling partners. [Emphases added]
> Available at http://www.coca-colacompany.com/our-company/mission-vision-values

Extending this to the educational context, substituting curriculum for commercial enterprise, one might suggest that a ‘good’ policy vision should not be narrow in focus, but should be directed towards all users of the curriculum, thereby reducing its complexity and making the processing and classification of observations of the policy environment much clearer, so that a correct orientation and order can be established. The vision should also motivate the users of the curriculum into action and should be based on the long-term view of the educational enterprise, hence providing a basis for future stability, continuity and direction. The term ‘policy image’ can be defined as an official projection, typically through a policy document of what that policy will look like *in practice.*

Even if one only partly accepts these rudimentary descriptions, then it follows that a vision must be clear and unambiguous. Roberts (2011) suggests that a policy vision orients the plan in broad and general terms - *more like this than like that* - so the policy vision acts as a pointer rather than a pigeon-hole for classifying definitions. However, it is the companion meanings which provide the substance and scope of the vision. For Roberts, a policy image differs from a vision since the image serves as the starting point and conceptual ‘glue’ that holds together the long process of systemic reform in education where he suggests, citing Walker 1971, p. 51, that the policy image is an “entity or class of entities that is desirable” in the platform expressed by the curriculum (Roberts 2011, p.12). What happens to a policy image in practice, Roberts suggests, is dependent on the ‘tradition’ of the educational system into which the policy is being implemented.

Fensham (2009) has drawn attention to two differing traditions in terms of the amount of specification and control assumed by the education authority advancing the image. In the ‘Anglo-American tradition’ the policy image is translated into guidelines which are subsequently transposed into instructional materials which teachers use with sample examinations. These lead to teacher actions which direct pupils learning which, in turn, terminate with assessments of the learning process. In the ‘Germanic tradition’ the policy image is transmitted directly to teachers with elaboration in a sample examination or a set of standards, but the development of materials is entrusted to the professional expertise of the teacher. Until 2010, the prevalent reform tradition in Scotland was the Anglo-American tradition but the *CfE* reforms espouse a model that is more attuned to the Germanic tradition.

It remains to be seen how this Germanic reform tradition of CfE will impact on the implementation process, particularly considering that the majority of Scottish teachers are used to the Anglo-American tradition of curricular reform. However, tensions are beginning to emerge between what teachers expect to receive centrally, in terms of curricular guidance and exemplification of assessments designed to measure pupil progress as they move through the different stages of the new curriculum. For example, there is anecdotal evidence that teachers are less than enthusiastic about the 'poor' quality of materials which currently populate the National Assessment Resources (NARs). One string of comments to the *Times Educational Supplement Scotland* website on the subject of (mathematics) NARs gives a flavour of many teachers' (perhaps not all) frustrations on this single aspect.

> What a farce it is. Why do we put up with this cr*p? Why aren't heads rolling? I'm looking for maths assessments for first level. They're there, on the NAR, but you have to open each question, one at a time. There are dozens of them. You can't even read them first, you have to open each one to see what's in it. Bit like a Kinder Surprise with no consolation chocolate. None of them are even CfE coded. But there's a handy-dandy basket to put them in, except that the basket's not big enough to put them all in. Oh dear, never mind, there's a gizmo here for making up your own assessment---be still my beating heart!! -- but wait.... oh no..... it works on a similar 1980s-style interface to GLOW. Teacher X
>
> Am so with you on all of this AND the last time I downloaded something from NAR it had a virus in it! The NARs for other things are equally irritating as they consist of what appears to be the cyber-equivalent of a competition as to who is the most CfE-compliant teacher (no offence intended to any of the ~~mad~~ enthusiastic contributors. Pages and pages and pages of photos, transcripts of conversations with children, pictures of their artwork, mindmaps, blow-by-blow descriptions of every tiny thing that happened during it, multiple new documents which have to be opened up, only to discover that the actual learning covered amounts to perhaps an hour of teaching at the most. So, huge amounts of work on the part of the teachers who contributed to this for very little useable/accessible material. It takes hours to search through for anything as it is poorly indexed etc… and quite frankly some of the ways in which outcomes are linked to learning experiences are spurious/clutching at straws. These NARs must have taken weeks to put together and instead of making me feel reassured, I now feel completely hopeless as I've got no chance of putting together this much evidence in a day/week, never mind for each lesson. To be very honest, I'd much rather spend my time teaching/putting together useful resources! Teacher Y
>
> I attended a Numeracy event where we had to assess some materials from the NARS. We were astounded to find that although the materials are quality assured prior to being uploaded, the quality ranges from unusable to 'kite-marked'. When I asked why the poor materials had not been removed, I was told that it was up to the teacher to decide how to modify/adapt the NARS to suit the class in front of them and that even with poor quality resource, there may be some glimmer of gold in there that a teacher could exploit. So, what we have in essence is a pool of assessments, poorly linked, with no real indication of validity or quality that we have to search, analyse and quality assure prior to giving to our classes. Teacher Z
> (TES forum: Seen the NARs recently? Sep 2011,
> www.tes.co.uk/forums/p/520533/7015129.aspx#7015129).

Admittedly these comments are not generalizable but they clearly show that teachers are not happy with the quality of the materials they are expected to work with. The last comment is particularly worrying in terms of resource management, time and teacher workload. With regard to the consequences of an attempted reform which adheres to target specification and an essentially behavioural orientation to what should be required of teachers, we seem to have been here before with 5 - 14 (see Bryce, 1992; 1993; 1996).

DIFFERING VISIONS OF SCIENCE EDUCATION

It has been national policy in Scotland since 1947 for the secondary education of all Scottish pupils to include science.

> To justify such a policy we do not point to the technological needs of the country, nor do we lay the primary emphasis on that exactitude of observation, measurement and thought which is the characteristic virtue of the trained scientist. Science claims this place in the education of every boy and girl because of its immense cultural significance. It is far more than a subject or group of subjects; it is a whole vast world of human thought, feeling and endeavour (Advisory Council on Education in Scotland, 1947.

However, as the above quote suggests there is an inherent duality which exists in the nature of science education; the tension between the need to educate the next generation of scientists as opposed to teaching science for citizenship. Layton (1972) characterised this tension as 'internal/external'. It is not our intention to review the arguments which lie at the heart of this tension, but one must recognise the existence of the tension and that any new science curriculum will be viewed by the extent to which it leans towards one position or the other. It is also important to note that *both* science education for specialisation or as a generalist education claim the development of scientific literacy as a major aim. *How* one defines scientific literacy depends on how you view the purpose of science education.

Roberts (2007a) suggests that the science education landscape is characterised by two *competing visions* of the purpose for learning school science. He suggests that these lie at the heart of the concerns that many prominent science educators have for the future of school science. Vision I relates to the discipline of science itself - the products, processes and characteristics of the scientific enterprise. Vision II relates to the situations in which science demonstrably plays a role in human affairs - including but not limited to scientific thinking and activity. Vision I is generally favoured by academic scientists since it is the organisational generator for the practice of orienting school science. Its main purpose is to develop the pool of future scientists. Vision II is favoured by others (and to be fair some academic scientists) since it is the organisational generator for the practice of orienting school science towards having students engage with a variety of science-related situations that confront the general public. The difference between these two visions is that Vision I leans towards curricula which are content heavy (crammed with canonical science, full of practical techniques and laboratory based experiences), while Vision II is based on the relevance of science to students' everyday lives (where, thereby, topics and issues will inevitably change or evolve with the passage of time). Vision I is scientists' science; Vision II is the interesting, often controversial, science which is in the public domain.

While the goal of developing students as scientifically literate citizens links these two visions of science education, Roberts (2011) suggests that the term scientific literacy "is used by science educators to characterise the very long term outcome of school science programs associated with both visions" (p. 12). He further suggests that a vision provides professional educators, policy makers and the general public with an answer to the question of what a scientifically literate person should know and be able to do, thus these visions orient the curriculum.

However, scientific literacy is a concept which is mired in debate, with some dismissing it as an ill-defined concept with little utility and whose pursuit is ultimately futile (Shamos, 1995), and others seeing its development as the ultimate goal of science education and, as such, worthwhile (Bybee, 1997; Miller, 1983; Miller, 1998). Regardless of how one defines the term, Roberts suggests that "everyone agrees that students can't become scientifically literate without knowing some science, and everyone agrees that the concept needs to include some other types of understanding about science" (Roberts 2007b, p.11). Thus Roberts (2011) suggests that most definitions fit neatly into science curricula which are either Vision I-like or Vision II-like.

Dillon (2009) on the other hand, suggests that Vision I and Vision II are underpinned by different philosophies and, at their most extreme, reflect competing interests that have influenced and continue to influence the content of the science curriculum and, as such, questions whether there can ever be a balance between Vision I and Vision II. Particularly since he suggests that there are a number of cases where scientists have defeated proposals to implement science curricula which are more Vision II-like in their approach to scientific literacy. Also noting this phenomenon, Roberts (2007a) suggests that the retreat from a Vision II to Vision I-like curricula occurs as a result of power politics within curriculum committees (p. 771). Dillon (2009) further suggests that when words turn into action, the philosophical chasm that exists between Vision I and Vision II becomes a barrier to the major shift required in the culture of science education.

The CfE Science policy vision

In March 2006, the curriculum review group published *CfE Progress and Proposals*. In appendix 2, they set out the Science rationale, Science 3 to 15. Contained within this rationale, the review group define the two main aims of Science Education as being to enable young people to develop as scientifically literate citizens, able to hold and defend informed views on social, moral, ethical, economic and environmental issues related to science; and prepare them for further, more specialised, learning by developing their secure understanding of the 'big ideas' and concepts of science (Scottish Executive Education Department, 2006, p. 30).

This rationale places the main emphasis of science education on the development of pupils as scientifically literate citizens, with the production of science specialists as a secondary aim. Interestingly, the review group neither defined what scientific literacy is or what a scientifically literate person should be capable of doing, nor what should be taught in order to develop pupils' scientific literacy.

However, the E&Os (the instrument through which the policy image is projected) outlines the range and type of curricular content, and yields some clues which allow us to infer the curriculum planners' intent. It is important to note at this point that the science E&Os have been criticised by many science teachers as being vague (a trend which seems widespread concerning most *CfE* documents) and so wide-ranging that their interpretation by different interested groups leads to differing emphases. Thus there is a danger that consistency of pupil experience within Scottish science education could be compromised, depending on how individual schools choose to interpret and subsequently implement the new curriculum. If science teachers are expected to develop their pupils' scientific literacy, they require a definition of what scientific literacy is in the Scottish context. In addition, the components of scientific literacy need delineating before the developmental process can begin. Furthermore, science teachers must also decide which pedagogical approaches could be used at the different stages of education in order to facilitate the development of scientific literacy amongst all pupils. However, while these concerns are germane, they lie beyond the scope of this paper.

The CfE Science policy image

The experiences and outcomes for science are categorised under three major themes of science: The Physical World dealing with topics and concepts broadly thought of as Physics; The Material World dealing with topics and concepts generally considered as Chemistry; and The Living World dealing with topics and concepts which most would consider to be Biology. In addition, there are two themes which cut across the science curriculum, the Process of scientific enquiry and Topical science. The Process of scientific enquiry relates to experimental design and the methods and techniques used by scientists to observe and measure the world. The Topical science strand involves the use of socio-scientific discussion of issues such as global warming and climate change; pollution and environmental damage; the therapeutic use of cells, relating to embryonic stem cell research; as well as ethical discussions which emerge from the use of controversial biological procedures such as in vitro fertilisation (IVF) and pre-implantation genetic screening (PIGS). Each of the three sciences is represented within the new science E&Os, both in terms of content knowledge and conceptual detail as well as socio-scientific discussion.

On closer inspection of the E&Os it becomes clear that the image they portray is one which is content and process heavy, with little scope for socio-scientific discussion. As Table 1 shows there are 69 E&Os; 33 at CfE level 3 and 36 at level 4 covering the areas of the living world, the material world, the physical world, scientific enquiry and topical science.

Table 1: *Breakdown of the CfE Science curriculum Experiences and Outcomes (E&Os).*

Curricular Component	**Level 3** E&Os (n=32)	**Level 4** E&Os (n=37)
*Content Knowledge.	12	11
Experimental Inquiry Skills.	15	16
Inquiry Skills (not practical).	2	5
*Socio-scientific discussion.	3	5

Note: *E&O SCH 3.05b contributes to content knowledge and socio-scientific discussion and could potentially be counted in both components

Further scrutiny of the E&Os indicate that there are more level 4 than level 3 E&Os; both levels 3 and 4 contain more Experimental Inquiry Skills orientated E&Os; and that socio-scientific discussion and inquiry skills not related to experimental work are relatively under-represented. In addition, of the E&Os which deal directly with socio-scientific discussion, most are at level 4 than level 3 and the context of these discussions are overwhelmingly biological in nature. We are tempted to conclude that the planners consider that only older and brighter secondary pupils should be required to participate in the kind of teaching which develops scientific literacy and thus achieve them. In our view this is quite wrong. Regarding content overall, it is actually rather difficult to discern 'the big ideas' in science which should be apparent from a reading of the E&Os. Following the publication of the rationale for CfE Science, these have not been prominent in the literature associated with the attempted reform.

It is apparent also from the E&Os that the curriculum planners see scientific literacy from a system point of view. This suggests that their justification for arguing for increased scientific literacy is policy-centred rather than pupil-centred. They justify the goal of developing scientific literacy from an all-inclusive collection of economic, utilitarian, citizenship and cultural literacy arguments. In this way the new science curriculum can incorporate many possibilities that accommodate all pupils regardless of their ability, interest, or future plans for their careers. However, it does not necessarily provide every pupil with the same exposure to scientific literacy.

It might be argued in one sense that the guidance permits scientific literacy to permeate throughout the whole science curriculum, allowing for a rich and comprehensive policy which accommodates variation in the degree of development of scientific literacy by pupils with differing abilities, motivation and future plans. In another sense, one wonders if the curriculum planners know what they intend to achieve. If they do, they have not clearly set forth their vision. Since they have failed to articulate what they envisage scientific literacy to be or how best to develop scientific literacy within pupils, there is a lack of direction from the centre which is a potential weakness in the new curriculum. Different groups of science teachers are left to interpret what all of these interpretations mean in terms of practice. It is difficult to avoid the conclusion that this will lead to inconsistency of practice nationally and possibly even a failure to achieve the stated aim of scientific literacy.

In addition to differences in interpretation, there is an inconsistency in the advice given to science teachers. When the E&Os were published, another document accompanied them called *Curriculum for Excellence Science: Principles and Practice* which states that:

> …children and young people participating in the experiences and outcomes in the sciences will:
>
> - develop a curiosity and understanding of their environment and their place in the living, material and physical world
> - demonstrate a secure knowledge and understanding of the big ideas and concepts of the sciences
> - develop skills for learning, life and work
> - develop skills of scientific inquiry and investigation using practical techniques
> - develop skills in the accurate use of scientific language, formulae and equations
> - recognise the role of creativity and inventiveness in the development of the sciences
> - apply safety measures and take necessary actions to control risk and hazards
> - recognise the impact the sciences make on their lives, the lives of others, the environment and on society
> - develop an understanding of the Earth's resources and the need for responsible use of them
> - express opinions and make decisions on social, moral, ethical, economic and environmental issues based upon sound understanding
> - develop as scientifically literate citizens with a lifelong interest in the sciences
> - establish the foundation for more advanced learning and, for some, future careers in the sciences and the technologies" (LTS, 2009a, p.1).

It is interesting to note that the development of pupils as scientifically literate citizens (espoused in the vision) is 11th in the list of 12 things that pupils participating in the E&Os will develop. This begs the question: *If the development of pupils' scientific literacy is the aim of the policy vision, why is the development of pupils as scientifically literate citizens so far down the list of developmental priorities?* It might be the case that these development priorities are not ranked in order of priority (which we suspect is the case) and that the relative importance of each is open to interpretation. If this is so, then one might suggest that it will lead to inconsistency in both implementation and pupils' experience of the science curriculum.

The *Principles and Practice* document suggests that *CfE* Science clearly indicates opportunities for developing those skills and attributes required to support young people's development towards scientific literacy (*which skills? what attributes?*), with a lifelong interest in science by developing scientific values and respect for living things and the environment (*what values?*); assessing risk and benefit of science applications; making informed personal decisions and choices; expressing opinions and showing respect for others' views; developing informed social, moral and ethical views of scientific, economic and environmental issues; developing self-awareness through reflecting on the impact, significance and cultural importance of science and its applications to society; demonstrating honesty in collecting and presenting scientific information/data and showing respect for evidence; being able to read and understand essential points from sources of information including media reports; discussing and debating scientific ideas and issues; reflecting critically on information included or omitted from sources/reports including consideration of limitations of data (LTS, 2009a, p. 5).

Again one is left with more questions than answers since this document attempts to outline the principles which one assumes should be adopted by science teachers in their practice but fails to clearly define what the basic elements of scientific literacy are or what skills and attributes of a scientifically literate citizen need to be developed. It also fails to provide pointers as to what scientific values are to be focused on, or which approaches should be used to successfully develop them.

From an academic perspective, these documents appear to pay no attention to the research literature regarding the development of pupils' scientific literacy, or the use of socio-scientific discussion, or how the key skills and attributes required for open discussion and critical debate of issues with environmental, moral, ethical and social dimensions should be handled in practice. Given the reasoning advanced by Priestley and Humes (2010), referred to earlier in this article, it is very tempting to generalise the argument here beyond science to other subject matters in the curriculum concerned with values and public disputation.

There is clear evidence from the science education literature that science teachers struggle to enact open, pupil centred socio-scientific discussion (Day & Bryce 2011 and 2012; Bryce & Gray 2004; Gray & Bryce 2006; Osborne et al, 2002) and in fact try to avoid it where possible. In addition, research shows that in order to develop the skills required for high quality, socio-scientific discussion, i.e. argumentation skills, communication skills, moral reasoning skills and the development of critical thinking skills, repeated exposure to socio-scientific discussion is required (Sadler, 2004a; Sadler, 2004b; Sadler & Zeidler, 2004; Sadler & Zeidler, 2005a; Sadler & Zeidler, 2005b; Sadler, et al, 2005c; Sadler et al, 2007; Osborne et al, 2004). It is also necessary given the prevailing, and strengthening, forms of anti-science biases which are pedalled so regularly in public life. These need to be challenged in the course of school education (see Bryce, 2010).

When one compares the *CfE* Science rationale (the policy vision) to the *CfE* Science E&Os (the policy image), it is difficult to escape the conclusion that the vision and image are in conflict. The *CfE* Science policy vision as set out in the rationale is vision II-like whereas the policy image is unashamedly vision I-like. This blurring of the Vision and Image will inevitably lead to a curriculum which lacks focus and could potentially become fractured since the 'Germanic leanings' of CfE place the emphasis of implementation on teachers' interpretations of policy.

IMPLICATIONS OF CfE POLICY FOR PRACTICE

More substance, less rhetoric

Most Scottish teachers recognise the rhetoric emergent from the *CfE* documentation. In terms of basic familiarisation with the documentation, the reading load is high. Between the *Building the curriculum* series (of which there are five to date), the discussion papers (of which there are four), the Literacy, Numeracy and Health & Wellbeing advice across the curriculum, Principle and Practice and Experiences and Outcomes documents, as well as the subject specific documents, Scottish teachers have to work through approximately 380 pages of documentation, while at the same time teaching and developing materials for their current pupil cohort, preparing pupils for examination and for some, undergoing inspections.

Priestley's (2010) comment that the CfE documentation is vague in that the E&Os are framed in very general terms, with the place and form that content might take being largely left to schools, provides an academic voice to most teachers' concerns about CfE. The proselytizing rhetoric is of particular concern in an era when teacher autonomy and professionalism have been deeply eroded by managerial forms of quality improvement and outcomes steering (Biesta, 2004), and especially given that these new curricula purport to re-establish teacher autonomy in curriculum making. It is difficult to avoid the conclusion that most teachers would prefer more substance and less rhetoric. The Scottish Government has belatedly recognised this by publishing summary documents designed to make the CfE documentation more accessible but again they provide little clarity either in terms of substance or pedagogy.

From a science teacher's perspective, the curriculum planners need to clearly define (i) what their intended purpose for the science curriculum is; (ii) also clearly define their intended meaning for scientific literacy; and (iii) how they intend to assess, in a valid and reliable manner, the development of scientific literacy - if indeed this is the primary goal of the new science curriculum. (We would certainly wish it to be.)

Flexibility and Choice

Flexibility and choice is a cornerstone of the *CfE* reforms both in terms of pupils' choice and the school management of the curricular model applied to CfE. How schools deliver *real* flexibility and choice to pupils within the constraints of their timetables is a major issue. One must remember that in terms of core subjects, only English and Mathematics will be compulsory subjects at secondary level with all other subjects being free choice options. In general, *CfE* Level 3 and 4 E&Os are supposed to be experienced by all pupils from S1 to S3.

In practice, because schools have been given the freedom to choose how they deliver their curriculum, some schools have chosen to keep the current model where S1 and S2 pupils experience a general education with some pupil choice in S2, moving to a free pupil choice in S2 for study in S3 to S4. Others have opted for the (preferred?) model where S1 to S3 pupils experience a general education then have a free choice of National 4/National 5 courses in S4. Some schools have even chosen to opt for a delivery of all of the Level 3 E&Os in S1 then move to free choice in S2. There are at least three major curricular models in practice (possibly more). Whichever model a school opts to implement is up to that school. Potentially this could lead to a scenario where, within one local authority, there may be schools which are geographically close but enacting different curricular models. In effect there will be no consistency within the local authority in terms of school curricular structure. What will happen when a pupil moves from one school to another where the curricular models are incompatible? If consistency of curricular model is low within a local authority, there is little hope of maintaining consistency between local authorities, thereby dramatically reducing pupil choice by default.

In addition, since science will no longer be a core subject, a larger question remains to be answered: *How will the sciences fare in terms of pupil uptake?* Evidence from England suggests that pupils *'vote with their feet'* since they perceive the sciences (particularly physics) to be more difficult than other subjects. If Scottish pupils are indeed turned off by the sciences as evidenced by the Scottish ROSE data (Farmer *et al,* 2006) and opt out of science in S3 and S4 in sufficient numbers, *how achievable will the stated aim of developing pupils as scientifically literate citizens be?* It is difficult to escape the conclusion that the reform will achieve neither the development of pupils' scientific literacy nor a satisfactory training of the next generation of scientists.

Blurred vision?

The new *CfE* science curriculum has been characterised so far in this paper as suffering from a number of policy level flaws, chief among these being the apparent disconnection between the policy vision outlined in the Science rationale and the policy image portrayed by both the *Experiences and Outcomes* and the *Principles and Practice* documents. It is important to note that the policy vision espoused by the science rationale is challenging in terms of its intention and the implementation of newer pedagogical approaches. The policy vision requires science teachers to shift the thrust of their practice towards the development of 'softer' skills where the emphases requires science teachers to develop values derived from the moral and ethical plane, as well as the use of techniques for dealing with controversial issues which require pupils to judge and decide the merits of arguments based on tentative evidence and the balance of opinion (see Day & Bryce, 2011 and 2012; Bryce & Day, in press, 2013).

This vision is a radical departure from most science teachers' current practice, where the main emphasis is around increasing specialisation with the assimilation of key concepts and the development of inquiry skill based on the objective collection of data using the scientific method. In addition, the typical science classroom discourse has been characterised as teacher-centred where pupils' views do not figure prominently, far less be clarified and integrated with their scientific learning; they are closed and authoritarian (Day & Bryce 2011; Cazden, 1988; Osborne *et al*., 2002).

This vision is juxtaposed with a policy image espoused in both the published *E&Os* and the *Principles and Practice* document which places the development of informed opinions on issues with a social, moral, ethical, economic and environmental dimension and pupils' development towards becoming scientifically literate citizens, 10th and 11th out of 12 developmental outcomes. We therefore conclude that the vision espoused by the *CfE* Science rationale is Vision II-like (literacy about science-related situations), but the image portrayed by the *E&Os* and *Principles and Practice* documents is Vision I-like (literacy within science)

It is incumbent upon those in positions of leadership within the Scottish Science education community (chiefly the Inspectorate within the new umbrella organisation, Education Scotland?) to show that leadership and to take control of the direction and orientation of CfE Science. Adhering to the PISA definition of scientific literacy, particularly in respect of specifying outcomes for the curriculum [a 'box' so easily 'ticked'], is insufficient when the real concerns are with pedagogy. We would argue that teaching for scientific literacy is qualitatively different from teaching for specialisms in science. The imperative is *how* CfE science should be taught. The present situation has many science teachers asking the question: Why should we change our practice? Our analysis indicates after all that the E&Os look very much like 'business as usual'.

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