E4E
Education for Engineering

National Curriculum Review

The E4E submission to the Department for Education call for evidence to the National Curriculum Review

April 2011

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Education for Engineering (E4E)

1. Education for Engineering (E4E) is the mechanism by which the engineering profession offers coordinated and clear advice on education to UK Government and the devolved Assemblies. It deals with all aspects of learning that underpin engineering. E4E represents the collective views on education and training policy of 36 Professional Engineering Institutions, the Engineering Council, EngineeringUK and the Royal Academy of Engineering.

2. E4E members support a balanced and broad general curriculum to at least age 16. Specialisation, including in vocational areas, is not encouraged pre-16.

3. A full list of E4E members is available from: http://www.educationforengineering.org.uk/membership/default.htm

4. We trust that, in assessing submissions, the Department will ascribe appropriate weight to E4E's response in view of the wide range of contributing professional engineering institutions and organisations.

Key Messages to the National Curriculum Review

5. Our response is restricted to commenting on mathematics, science, art & design, design & technology and computing (ICT). However we wish to emphasise that humanities, the performing arts and additional language(s) are also viewed as very important components of a sound 21stC general education for all pupils and for those that eventually progress into professional engineering & technology.

    - It is vital that the National Curriculum continues to include a blend of theoretical and practical learning within a general education curriculum. The revised National Curriculum must continue to include practical general subjects if young people are to be able to access and progress in professional engineering and technician roles.

    - The carefully constructed thematic approach used so successfully in Primary settings could, in our view, be usefully extended to Key Stage 3.

    - The review should consider moving to a progression system based on stage (level achieved) rather than age.

    - Alignment with vocational and occupational qualifications must be treated with the same degree of importance as alignment with level 2 and 3 general qualifications.

    - E4E believes that Design & Technology (D&T) is a vital aspect of a balanced general education for all pupils (whether on their way to engineering or not) to at least Key Stage 3 and hopefully beyond it. It is notable that many of the countries that have followed the UK lead in D&T are those countries which, regarding their success in PISA, TIMSS and so forth, we are now aiming to emulate.

    - A working definition of Technology (the T in STEM) has recently been developed. Notably, the 'T' areas are of particular economic importance to the UK. This leads us to suggest that, at all Key Stages but particularly at Key Stage 4, the review should explore opportunities to re-establish the linkages of D&T and Computing.

    - The review should take the opportunity to modernise the entire ICT curriculum and re-establish Computing as a subject.

6. This National Curriculum may become a curriculum for only a portion of students, rather than the whole maintained school cohort. E4E sees this change as an extremely retrograde step but, as it is already the case, the review needs to ask: who will the new National Curriculum be for?

The key strengths of the current National Curriculum

7. Education for Engineering believes the key strengths of the National Curriculum include:

    - The National Curriculum is seen as an important element of the school curriculum but not as the entire formal curriculum
    - It establishes an entitlement
    - It establishes standards
    - It promotes continuity and coherence
    - It promotes public understanding and confidence (transparency)
    - It is broad and balanced for all at Keys Stages 1-3
    - It enables mobility between schools
    - It enables progression
    - It strives for equity of access
    - Not all subjects are readily reducible to a fixed body of knowledge or to other dimensions of one-size-fits-all and the National Curriculum on the whole, does not try to do this
    - It aims to encourage curriculum innovation – such as local curriculum design.

    - **It includes a blend of theoretical and practical learning within a general education curriculum**

8. "[UK] Engineering, with approximately 0.5 million professional engineers, brings technology, products and services to market and in doing so directly contributes (through SET-intensive sectors) approximately £250 billion, 27% of the total UK GDP (2002). In 2006 engineering services directly contributed £3.2bn in exports to the Balance of Payments." (HoC IUSS Committee 2009:9-10)[i]

9. "Are students well prepared for future challenges? Can they analyse, reason and communicate effectively? Do they have the capacity to continue learning throughout life?" (PISA)[ii].

10. "For Britain, being better than our global competitors in the long term demands a generation of problem-solving, academically minded young people who are ready to use their hands and brains. But depending on the forthcoming curriculum review, Britain risks being a less inventive place. To our economic detriment, design and technology is under threat... We require inventive ideas and inventive people...if we are to rebalance the economy through technology and exports." (James Dyson in *The Times* 05/04/2011)

The key things that should be done to improve the National Curriculum

11. Education for Engineering believes that reviewing possible improvements to the current National Curriculum should include consideration of the following pointsIt is important to consider what the key 21stC learning needs are to ensure that all children are able to make a valuable contribution to society by the time they become adults.

12. **It is vital that the National Curriculum continues to include a blend of theoretical and practical learning within a general education curriculum.**

13. Practical education is a way of learning that should occur across the curriculum – learning through doing (preferably in authentic contexts). Practical education is particularly emphasised in a range of existing general subjects in schools (such as Design & Technology, Computing, Art & Design and Science) and involves head, body and critical reflection. It is not a low-skilled activity and neither should it be aligned only to the traditional crafts and trades. Learning-through-doing is appropriate at all levels and should be an element of a broad and balanced education for every young person. In recent years there has been a reduction in the amount of practical learning in the curriculum. Yet it is a vital aspect of formative learning for those who wish to pursue engineering and technology.

14. The National Curriculum should ensure and make explicit that it encourages curriculum innovation. For example, mandatory Programmes of Study may not be appropriate for all subjects. Greater diversity would allow more room to explore learning.

15. The review should consider moving to a progression system based on stage (level achieved) rather than age (whilst being wary of taking examinations too early).

The key ways in which the National Curriculum can be slimmed down

16. Education for Engineering believes that reviewing slimming of the National Curriculum should involve considering the following points:

17. Worthwhile study of a subject or discipline does not necessarily require taking a qualification in it or even being formally assessed in it. However, the policing of statutory requirements (apart from Ofsted inspections) and schools performance tables is predicated on the more easily quantifiable measures – qualifications, grades, test results and so forth. Any urge to 'quantify and measure everything' should be resisted.

18. Most teachers appear to regard the subject curriculum, at both primary and secondary phases, as manageable - although specialists in subjects with periodic high-stakes assessments may feel more pressure from their Programme of Study.

19. The additional requirements at some Key Stages (such as PSHE, PLTs) may tip the balance too far but they are important aspects of learner development. A possible solution would be to require and monitor but integrate them into the broader curriculum where possible and appropriate.

20. The carefully constructed thematic approach used so successfully in Primary settings could, in our view, be usefully extended to Key Stage 3.

21. There were originally 9 subjects (10 in Wales) in the National Curriculum at KS1-3 and 10 (11 in Wales) at KS4. Technology originally combined D&T (formerly CDT, textiles and food technology) and IT/Computer Studies. (*Technology in the National Curriculum* 1990 HMSO & the WO).

22. The review should consider revitalising the D&T and Computing relationship.

Lesson Time

23. E4E does not believe that the proportion or amount of lesson time should be specified *in any way* in the National Curriculum; e.g. for particular subjects and/or within particular key stages.

24. Schools should be free to decide upon curriculum time to support the needs of their pupils and the ways in which they decide to teach the Programme of Study.

25. 'Lesson time' does not necessarily equate to learning achieved and it is the latter that matters.

26. If the government were to legislate on time, how could that be transparently and fairly policed? It seems unlikely that policing could take into account private study / homework / non-formal learning / family learning / private coaching.

General Comments on the Curriculum Review

27. As third sector organisations we are chiefly concerned with ensuring fair access to, and progression in, the engineering profession, as well as maintaining quality standards and further learning opportunities at all levels so that individuals may be proud of what they achieve, employers confident in their engineer workforce and the public confident in the professionalism of engineers.

28. We are also very aware of the social and economic need to raise the skills levels of the current and future workforce (particularly in our sectors from level 2 to levels 3 and 4) and we are committed to helping to increase the number of registered Engineering and ICT Technicians, as well as to supporting their further progression.

29. Employers of engineers are looking for a blend of theoretical and practical technical skills - often multidisciplinary - as well as personal attributes such as ethical disposition, autonomy and commitment to continuing learning. This is the case at post-graduate, intermediate and technician level. There is a substantial shortage of technicians in the UK (UKCES, various reports). In addition pressure from

international competitors continues to grow - for example China is now training technicians apace.[iii]

30. The revised National Curriculum must therefore continue to include practical general subjects if young people are to be able to access and progress in professional engineering and technician roles.

31. A National Curriculum should be mandatory for all, other than in exceptional and well-evidenced circumstances. The fact that the National curriculum will not be mandatory in Academies or Free Schools is a substantial change and must be taken on board in the review. This National Curriculum may become a curriculum for only a portion of students, rather than the whole maintained school cohort. E4E sees this change as an extremely retrograde step but, as it is already the case, the review needs to ask: who will the new National Curriculum be for?

E4E response regarding mathematics and science

Mathematics

32. Education for Engineering does not comment in detail on the essential knowledge that all pupils should be taught in mathematics at key stages 1-4. However, there are some over-arching design principles we wish to emphasise:

33. In general terms, engineering requires well-honed mathematics capability, with very secure understanding of basic principles.

34. It is important that there is coherence across the subjects within the mathematics curriculum and that the connections between subjects are explicitly made. The teaching of a series of disconnected topics can lead to rote-learning which in turn can lead to a lack of fluency in mathematics. The curriculum should therefore provide sufficient information to enable teachers to see a *big picture of mathematics* rather than provide a list of disconnected topics.

35. As well as building on learning at KS 1-3, the Programme of Study at KS4 must underpin smooth transition to AS/A level mathematics and to other level 2 and 3 mathematics study. This applies particularly to freestanding mathematics and mathematics for engineering[iv] but also, and importantly, to level 2 and 3 vocationally related and occupational qualifications of a technical nature (T and E in STEM).

36. **Alignment with vocational and occupational qualifications must be treated with the same degree of importance as alignment with level 2 and 3 general qualifications.**

37. In the English FE & Skills sector alone, around 182,000 VRQ and NVQ qualifications are achieved per year in technology and engineering at level 2 and some 125,000 at level 3[v]. The latter can be contextualised in terms of around 82,000 achievements in mathematics and further mathematics A level in 2010 (England)[vi].

38. As with all subjects, assessment of mathematics should be designed integrally within the process of designing the Programmes of Study.

39. We agree with Alison Wolf's report that the vast majority of learners should achieve a level 2 in mathematics by the age of 19. We also expect that continuing with some mathematics – whether through formal or non-formal learning - will become increasingly important for most learners post-16. These matters require consideration in designing Key stages 1-4.

40. The contribution of mathematics to other subjects, at all Key Stages, should be considered in designing the curriculum, including its importance within subjects to be considered in the second phase of the curriculum review. Aspects of mathematics could be made more explicit in, for example, design & technology, computing and geography. Further, application of mathematics to everyday experience may, if well designed and taught, lead to increased interest and therefore to a greater motivation to learn.

41. We have concerns that the high stakes nature of assessment of mathematics leads to rote-learning, teaching to the test and exam-cramming rather than ensuring proper understanding of mathematical principles. Assessments should be designed

specifically to test understanding rather than simply recall, as has been undertaken with the *OCR Level 3 Mathematics for Engineering* certificate.

42. It seems likely that statistics, probability and risk are going to grow in importance as areas in which all learners should have some grounding. These vital areas of mathematics will be increasingly needed to understand how complex societies work in the 21st Century.

43. We believe that the development of the mathematics curriculum is critical for the nation. We ask therefore that an expert group of mathematicians such as ACME (Advisory Committee on Mathematics Education) is involved in the design of the curriculum and have opportunity to review the curriculum on a frequent basis during its development. E4E is ready to support ACME if it is asked to undertake any further work in developing the mathematics curriculum.

Programme of Study - year by year basis or for each key stage?

44. Education for Engineering is uncertain about whether the Programme of Study for mathematics should be set out on a year by year basis or as it currently is, for each key stage.

45. In the current system same-age cohorts generally follow the same Programme of Study. A year-on-year Programme of Study might restrict those who learn more quickly or slowly. In an age-restricted cohort, Key Stage Programmes of Study allow for more flexibility.

46. However, if the cohort was not age-restricted then an individual-based year on year programme of study could be very useful in encouraging stretch for some and allowing space for consolidation of learning for those who take longer to develop their understanding.

47. Designed or used badly, a year-by-year Programme of Study may lead to 'box-ticking' rather than ensuring embedded understanding.

48. Some schools have a two-year Key Stage 3 and this needs taking into account.

49. The Raising of Participation Age must be taken into account when considering, in particular, Key Stage 4.

Science

50. Education for Engineering does not comment in detail at this stage on the essential knowledge that all pupils should be taught in science at key stages 1-4. However, there are some over-arching design principles we wish to emphasise:

51. **The Science curriculum should be a blend of theoretical work and practical investigation. This includes laboratory and field work.**

52. UK business is concerned about the lack of problem-solving and critical thinking skills of the work-force. The Royal Academy of Engineering's report 'Engineering Graduates for Industry' emphasises the need for *experience-led learning* to develop these important attributes in graduates[vii]. This is open ended, investigative learning based on the constructivist principles[viii]. The science curriculum should also reflect this important form of learning for children.

53. Professional engineers and technicians are committed to undertake their activities in a way that contributes to sustainable development[ix]. This leads us to support the concepts that Practical Action has suggested to be considered in the review.

54. As well as building on learning at KS 1-3, the Programme of Study at KS4 must underpin smooth transition to AS/A level sciences and to other level 2 and 3 science study, particularly to level 2 and 3 vocationally related and occupational qualifications of a technical nature (T and E in STEM). Alignment with vocational and occupation qualifications must be treated with the same degree of importance as alignment with level 2 and 3 general qualifications. In the English FE & Skills sector alone, around 182,000 VRQ and NVQ qualifications are achieved per year in technology and engineering at level 2 and over 125,000 at level 3[x]. The latter can be contextualised in terms of around 120,000 achievements in A level chemistry, physics and biology in 2010 (England)[xi].

55. As with all subjects, assessment of science should be designed integrally within the process of designing the Programmes of Study.

56. The contribution of science to other subjects, at all Key Stages, should be considered in designing the curriculum, including its importance within subjects to be considered in the second phase of the curriculum review. Aspects of science could be made more explicit in, for example, design & technology, computing, art & design and humanities. With regard to D&T, physics is important for systems & control, physics and materials science is important in product design and chemistry is important in textile technology.

57. E4E will consult with SCORE on development of the science curriculum. We support the views of the Institute of Physics, a member institution of E4E, with regard to physics in the science curriculum

Programme of Study - year by year basis or for each key stage?

58. Education for Engineering is uncertain about whether the Programme of Study for science should be set out on a year by year basis or as it currently is, for each key stage.

59. See comments under mathematics.

Separate Programmes of Study for biology, chemistry and physics

60. E4E does not believe that, at Key Stages 1 and 2 the Programme(s) of Study for science should identify separate requirements for biology, chemistry and physics and is unsure whether this should be introduced at Key Stages 3 and 4.

61. Integrated KS1-2 science seems to be successful. It should be afforded stability.

62. Whilst it seems intuitively useful to identify separate requirements at KS3 and KS4, appreciation of common elements may be lost (or repeated in confusing guises). Whilst separate sciences will be appropriate for some learners, all learners should not be statutorily required to study science this way.

63. Longitudinal data are required from the learner progression records before a judgement should be made about moving further towards separate Programme of Study, at KS3 and KS4.

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E4E response regarding other subjects currently in the National Curriculum

Art and Design

64. Education for Engineering believes that Art & Design should continue to be a National Curriculum subject at Key Stages 1-3.

65. In preparing young people for careers in engineering and technology (E4E's area of interest), Design and Technology, Art and Design and Computing are particularly useful (as well as mathematics and science). This review should offer an opportunity to reconsider interconnections between subjects. We believe that Art & Design, Design & Technology and Computing (as differentiated from ICT[xii]) are, or should be, intimately interconnected.

66. Teaching science and mathematics in pure form does not instil the ability to design. Design is about the application of understanding drawn from mathematics and science (as well as humanities and other areas) to create something new – that answers a defined need. All professional engineers and technicians must be able to contribute to the design of products, processes, systems or services. A good designer will need training in the techniques of design. Much of this is more akin to the way we teach art & design and/or design and technology rather than science. An engineer with this aptitude and capability is invaluable. If design were to be a strong part of the school vocabulary for 'STEM' students it would make better (more creative) engineers.

Should Art and Design be a compulsory subject for pupils to study, but with the content determined locally by schools and colleges?

67. The review asks whether Art and Design could be a compulsory subject, but with the content of what is taught being determined by schools and colleges. E4E is unsure whether this model would be appropriate for Art & Design.

68. The idea of a compulsory subject with content being locally determined is very attractive. If allied subjects were also compulsory and locally determined curriculum innovation might have room to flourish.

69. Our response [in earlier question] only applies to statutory Programme of Study rather than locally determined because at this juncture we cannot be sure which other subjects might no longer be statutory, statutory with Programme of Study or statutory without Programme of Study. The history of educational reform has shown that non-statutory subjects usually soon fade away – although history doesn't necessarily always repeat itself. The fact that D&T has remained very popular so far at GCSE despite non-statutory Programme of Study at KS4 may be an example of things working otherwise where a subject is highly valued for other reasons. However it is worth noting that numbers of pupils taking D&T are falling.

70. Art & Design seems to fall into the same category – with particularly high participation in design subjects in post-16 qualifications in the FE & skills sector[xiii].

71. The system of accountability or performance measures require 'fixed things' to measure if a purpose is to compare measures. Direct comparison isn't a necessity of course. However, we are concerned that little attention may be afforded by schools to those subjects that do not contribute to accountability measures.

72. There is a very real risk that high-cost general curriculum practical subjects such as Art & Design, D&T and Computing could be sidelined if they do not contribute to accountability measures because their facilities and resources are more expensive to run than those of theoretical subjects. Consideration should be given to creating a mechanism that encourages schools to allocate funding in accordance with subject costs.

Option of non-statutory programme of study, to be used by schools as guidance

73. E4E is unsure as to whether non-statutory Programme of Study could be useful as guidance where certain key stages of subjects are not part of the National Curriculum.

74. In principle, Programme of Study as guidance would be useful in encouraging some cohesion within the system if a subject is not part of the National Curriculum at certain Key stages. However, Key Stage 4 (where we believe Art & Design need not be included in the National Curriculum) is well covered by examination board specifications, support and so forth and additional guidance seems unnecessary.

Design and Technology

75. Education for Engineering believes that Design and Technology should continue to be a National Curriculum subject at Key Stages 1-3.

76. E4E members were undecided about whether or not to also select the Key Stage 4 box. There was a strong view in favour of doing so. However, we decided to err on the side of being realistic about likely outcomes. We want to emphasise, however, that members highly value the contribution that D&T makes at Key Stage 4. Please also see our comments below about D&T and Computing – 'Technology' (the T in STEM).

77. In preparing young people for careers in engineering and technology (E4E's area of interest), Design and Technology, Art and Design and Computing are particularly useful (as well as mathematics and science). This review should offer an opportunity to reconsider interconnections between subjects. We believe that Art & Design, Design & Technology and Computing (as differentiated from ICT[xiv]) are, or should be, intimately interconnected.

78. The primary purpose of education in school is to ensure all children are able to make a valuable contribution to society by the time they become adults. Additionally, UK businesses will only thrive in the global economy through continual innovation, which depends on the plentiful supply of highly skilled and well educated individuals.

79. Progression to a career in engineering requires Mathematics and English and, often but not always, sciences as a core of pre-16 study. Design and Technology and

Computing are also seen as important components and all professional engineers and technicians must be able to contribute to the design of products, processes, systems or services. Design capability is therefore crucial in all professional engineering & technology fields and at all role levels.

80. Teaching science and mathematics in pure form does not instil the ability to design. Design is about the application of understanding drawn from mathematics and science (as well as humanities and other areas) to create something new – that answers a defined need. All professional engineers and technicians must be able to contribute to the design of products, processes, systems or services. A good designer will need training in the techniques of design. Much of this is more akin to the way we teach art & design and/or design and technology rather than science. An engineer with this aptitude and capability is invaluable. If design were to be a strong part of the school vocabulary for 'STEM' students it would make better (more creative) engineers.

81. D&T A-levels are listed as *essential or useful* for entry to engineering and technology-related degrees in most universities, including the Russell Group[xv]. Similarly, lack of the study of art & design, design & technology and/or computing at Key Stage 4 could severely limit the numbers progressing to product/industrial design and media technologies[xvi].

82. **E4E believes that D&T is a vital aspect of a balanced general education for all pupils** (whether on their way to engineering or not) to at least Key Stage 3 and hopefully beyond it. This reflects a consistent view from the engineering profession - over ten years ago the Engineering Council[xvii] wrote:

> "The Engineering Council believes that all those concerned with curriculum policy should understand the importance of design and technology. Decisions are due to be taken about the future nature of the curriculum at national level. These offer welcome possibilities, but it is crucial that the role of design and technology is understood and built upon. … design and technology is about far more than career preparation. More than any other area of the curriculum, it is about capability for all."

83. Alison Wolf (DfE 2011:107[xviii]) identified the special and important place of D&T in the National Curriculum:

> "English education has always been unusual in its incorporation of a wide range of options: the inclusion of Design and Technology in the National Curriculum is one manifestation of this. The value of practical skills as part of a rounded education; the potential to sample different material as a form of orientation; and the opportunity for young people to excel on a variety of dimensions are all important and should be encouraged."

Technology (the T in STEM)

84. A working definition of Technology (the T in STEM) has recently been developed (BIS/ Royal Academy of Engineering 2010:35[xix]).

> "'Technology' is not a discipline per se but a working definition was evolved for this project. The National Curriculum for England and Wales (1990; 1995) National Curriculum foundation subject of 'Technology' included Design & Technology and IT/ICT [now termed Computing]. So for the purposes of this project, (core) Technology was taken to include:
>
> * IT/ICT practitioner qualifications [Computing]
> * Electronics / systems & control
> * Music technology
> * Production technology and technical theatre (light; sound; media)
> * 3-D design
> * CAD/CAM
> * Interactive media
> * Design & Technology GCSEs and GCEs
> * IT/ICT GCSEs and GCEs
>
> Technology-*related* areas were taken to include IT/ICT user qualifications – although all need to be fluent users of IT/ICT; and general Art & Design – because a general Art & Design grounding is necessary to progress to, for example, 3-D/industrial design."

85. Notably, the 'T' areas are of particular economic importance to the UK. This leads us to suggest that, at all Key Stages but particularly at Key Stage 4, the review should explore opportunities to re-establish the linkages of D&T and Computing (see, for example: BCS, The Chartered Institute for IT in association with the Computing At School (CAS) group consultation response to the Royal Society's call for evidence - Computing in Schools. 2010:20[xx])

86. Demonstrating the value of allowing curriculum innovation time to succeed, an Ofsted thematic review of D&T (March 2011) has highlighted major improvements in teaching and achievement in design and technology (D&T) at both primary and secondary school level, with 72% of primary and 60% of secondary schools now teaching good or outstanding D&T. However, over the twenty years of the current National Curriculum D&T teachers have not enjoyed anything like the same levels of centrally funded CPD support as Mathematics and Science – this despite the fast-changing nature of technology. Hence Ofsted (2011:4[xxi]) emphasise:

> "a considerable challenge facing schools is the modernisation of the D&T curriculum so that it keeps pace with technological developments … Tackling this issue, particularly in secondary schools, is fundamental to the improvements that need to be made and essential if pupils are to become confident and capable members of a technologically advanced society. … Many teachers were not keeping pace with technological developments or expanding upon their initial training sufficiently to enable them to teach the technically demanding aspects of the curriculum."

87. Restoration of closer relationship with Computing might help as scarce resources could (through D&TA and CAS), be directed towards shared CPD provision. As Computing and D&T involve programming and control systems, such an approach might also support enhancing (and/or making more explicit) the mathematics and science (particularly physics) elements of both subjects.

Should Design and Technology be a compulsory subject for pupils to study, but with the content determined locally by schools and colleges?

88. E4E is unsure whether this model would be appropriate for Design and Technology. Again, the idea of a compulsory subject with content being locally determined is very attractive. If allied subjects were also compulsory and locally determined curriculum innovation might have room to flourish.

89. However, we are not proposing this for D&T because we feel it is crucial that D&T continues to build on its improvement record and that all D&T experiences are 'modernised' (Ofsted 2011). Whilst possibly encouraging the best to flourish, locally devised might permit backwards slippage of the mediocre.

90. There is also a very real risk that high-cost general curriculum practical subjects such as D&T could be sidelined if they do not contribute to accountability measures because their facilities and resources are more expensive to run than those of theoretical subjects. Consideration should be given to creating a mechanism that encourages schools to allocate funding in accordance with subject costs.

Option of non-statutory programme of study, to be used by schools as guidance

91. E4E is unsure as to whether non-statutory Programmes of Study could be useful as guidance where certain key stages of subjects are not part of the National Curriculum.

92. In principle, Programme of Study as guidance would be useful in encouraging some cohesion within the system if a subject is not part of the National Curriculum at certain Key stages. However, Key Stage 4 (where we believe Design & Technology need not be included in the National Curriculum) is well covered by examination board specifications, support and so forth and additional guidance seems unnecessary.

Information and Communication Technology (ICT)

93. Education for Engineering believes that **Computing** should be a National Curriculum subject at Key Stages 1-3.

94. **Our key point here is that we are not supporting the current IT/ICT curriculum as compulsory at all Key Stages.**

95. **The review should take the opportunity to modernise the entire ICT curriculum and re-establish Computing as a subject[xxii].**

96. The National Curriculum should recognise Computing as a subject in its own right. Computing should be compulsory to KS3, and should have an optional programme of study at KS4. It should be recognised in school performance measures (such as the English Baccalaureate).

97. In preparing young people for careers in engineering and technology (E4E's area of interest), Design and Technology, Art and Design and Computing are particularly useful (as well as mathematics and science). This review should offer an opportunity to reconsider interconnections between subjects. We believe that Art & Design, Design & Technology and Computing (as differentiated from ICT[xxiii]) are, or should be, intimately interconnected.

98. The 2009 Royal Society policy report *Hidden wealth: the contribution of science to service sector innovation*[xxiv] states "Computing, communications, IT, the internet, the worldwide web, massive distributed databases, large scale computer modelling and deep numerate analysis are fundamental STEM underpinnings to many areas of service innovation". Note the UK service sector accounts for over 80% of GDP.

99. The purpose of Computing education in schools is to equip every child with the basic understanding of how computer systems work and with the capabilities necessary to take their proper place in a digitally enabled, knowledge based society and economy.

100. Computing is a rigorous, intellectually rich discipline, which is different from ICT. Computing has an established body of knowledge, with a set of techniques and methods, a way of thinking and it is embedded in principles that out-live rapidly changing technologies. A well designed and properly implemented Computing curriculum also equips students with the competencies necessary to solve real world problems through the application of digital technology.

101. Every school pupil should encounter Computing because:

- General scientific, engineering, mathematical and business principles, concepts and methods can be encoded in formal languages that a human can understand and a digital computer can execute automatically
- The rigorous design and automation of different kinds of machine executable languages is unique to Computing; in particular designing and building languages capable of describing elegant, efficient solutions to hard real-world problems that affect our societal wellbeing as well as our future economic prosperity
- Computing develops a way of thinking about issues, problems and situations that uses the powers of logic, algorithm, precision and abstraction (understanding through analysis and reconstructing from the constituent parts) - it is a scientific, engineering and mathematical approach

- Computing supports economic well-being at the personal (intellectual), vocational (employability), social (stronger work force) and national (more competitive market force) levels

102. The Wolf report[xxv] points out that the current qualification equivalence system tends to undermine the quality of education delivered in school, because funding is more dependent on qualification success than educational success. Therefore, there is systemic pressure to adopt qualifications that have a higher success rate rather than support a better learning experience. ICT has been a particular victim of this process due to the availability of qualifications that are equivalent to two or more GCSE, but which do not adequately measure the ability of students to apply knowledge to solve real world problems. The existing ICT National Curriculum has made it much easier for ICT qualifications to become biased towards qualification success rather than supporting educational goals. This is because it has not included the underpinning principles of Computing at its core. Changing the National Curriculum so that future qualifications must measure the understanding of such underpinning Computing principles is one way of resolving this issue.

103. The Computing At School group has published an exemplary Computing Curriculum *Computing - a curriculum for schools*[xxvi] which outlines the subject with concepts, processes, scope and attainment targets with a statement of its importance to all pupils.

104. Computing as a school subject enables a variety of professional pathways in STEM related careers, as well as a pathway to an IT career. One of the key points that Wolf makes is the need for qualifications to lead to a professional career.

105. A focus on Computing does not negate the importance of digital literacy and research and judgement-making skills, which should be acquired by all schoolchildren and can lead to worthwhile supplementary qualifications that support a variety of careers, but, whilst they should be compulsory, they do not need be part of the centrally prescribed National Curriculum. Similarly learning to use office productivity software is also important, but they are skills rather than part of a National Curriculum, and too often lead to uninspiring teaching because many pupils already know more than their teachers. By re-focussing the curriculum from ICT to Computing the emphasis will change to enabling pupils to develop vocationally and personally rewarding knowledge and understanding.

Supporting and recognising progress

Whether the National Curriculum should continue to specify the requirements for each of the 8 levels of achievement

106. Education for Engineering is unsure whether the National Curriculum should continue to specify the requirements for each of the 8 levels of achievement.

107. Assessment approaches and models must be reviewed in an integrated way with any review of 'content' if we are not to end up measuring the *wrong thing* and *measuring it wrongly*. It will therefore be necessary to review the levels of achievement descriptors, their purpose and the uses to which they are or may be put. They must be fit for purpose in relation to each subject (not one size fits all), useful in formative assessment and clearly progressive. However there <u>must not</u> be any sort of return to the 'digitisation' situation we had at the outset of the National Curriculum (late 1980s early 1990s) (see, for example, Richard Kimbell 1997 *Assessing Technology*, Open University Press, pp 69-72). The final arrival at holistic descriptive level statements was a relief to many and such statements appear to be fit for various purposes.

108. However, there is a further dimension – that is the uses to which records of levels of achievement may be put, such as accountability measures of schools and reporting performance at a national level. It is also worth re-emphasising that the reach of National Curriculum requirement is changing. It is possible that many schools will become Academies. While it seems likely that many schools will follow the National Curriculum, it will not be mandatory in Academies or Free Schools. We cannot, therefore, rely on National Curriculum adherence as a way of measuring, maintaining and, particularly, increasing achievement in technology-related areas in which we urgently need to compete on an international basis.

109. At the same time, funding will increasingly come directly from Government, and data from the funding system along with individual learner records, the credit accumulation system and other mechanisms can provide a rich resource for accountability purposes (as is the case with the funded FE & Skills sector).

110. The complexity of calculating and reporting 'measures' is no longer a barrier and there seems to be no reason why a number of measures (if that is one purposes of achievement descriptors) should not exist in parallel

E4E suggestion regarding the Attainment Target levels

111. It would be helpful in reducing confusion - and in encouraging understanding that there is learning to be acquired beyond the first two phases of education - if the levels had an explicit and closer relationship to the entry (1, 2, 3), level 1 and level 2 (Possibly 3 and 4 under the Raising of Participation Age) QCF levels and descriptions[xxvii].

112. The overarching QCF descriptors (as with EQF descriptors) are formulated in a similar way to the current National Curriculum statements of achievement. The QCF descriptors – particularly the overarching statement at each level – could be used as a high-level reference to which revised National Curriculum levels of achievement in all statutory subjects must comply.

International comparisons

Examples of jurisdictions that can usefully be examined to inform the new National Curriculum

113. We bring to your attention that many countries have developed design and technology (or similarly named) curricula based on the UK model, often combining (as was intended in England and Wales in 1988[xxviii]) design, technology and application of ICT. These countries include Finland[xxix], Sweden, New Zealand, the Netherlands, Australia, parts of USA, Taiwan, Germany and South Africa.

114. Developments can be traced through, for example, the International Journal of Technology and Design Education (Kluwer) and the IDATER Archive at Loughborough University[xxx].

115. See also, for example, Kimbell, R. (1997)[xxxi] and Kimbell and Perry (2001:3)[xxxii]:

> "In the UK we originated the concept of design and technology and we were the first nation to establish it as an entitlement for all children from 5-16. In doing so, we have provided a model that much of the world has followed. In S. Africa, Australia, the USA [in parts], Botswana, Israel, Singapore, New Zealand, Russia and Chile, to give but some examples, our vision of design and technology informs curriculum debate and classroom practice."

116. It is notable that many of the countries that have followed our lead are those countries which, regarding their success in PISA, TIMSS and so forth, we are now aiming to emulate.

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