

Curriculum for Excellence: Feedback on the draft science experiences and outcomes

An Institute of Physics response

A full list of the Institute's responses and submissions to consultations can be found at <http://www.iop.org>

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IOP Institute of Physics

Dear Sir/Madam

Feedback on the draft science experiences and outcomes

The Institute of Physics is a scientific membership organisation devoted to increasing the understanding and application of physics. It has an extensive worldwide membership (currently over 34,000, 2,500 in Scotland) and is a leading communicator of physics with all audiences from specialists through government to the general public. The Institute of Physics represents its members in Scotland through an active volunteer network and two members of staff based in Scotland

We welcome the opportunity to engage in the consultation process and would offer the following feedback based on responses from physics teachers and others.

Curriculum for Excellence

We are fully supportive of the aspirations for Scotland's learners as embedded in the guiding principles of a Curriculum for Excellence. However, we do not believe that the proposed learning outcomes and experiences for science will enable these aspirations to be met.

Draft outcomes for Science

Whilst we have numerous concerns about many of the individual learning outcomes and experiences in this response we want to highlight three overarching problems:

1) There appears to be no underpinning rationale for the inclusion of individual outcome statements. Such a rationale, offering teachers a narrative, which charts the progression of key concepts, is surely the starting point on which to build up a programme for learning. Without the direction provided by an underpinning rationale, what emerges, and indeed what has emerged, is an unsupported selection of outcome statements, seemingly randomly chosen and offering an unconnected set of learning experiences.

2) The style in which statements have been written is prescriptive in methodology and experiences but devoid of any suggestion of the depth and detail of associated key science ideas. Faced with these outcomes, experienced teachers will most likely be able to recognise the associated conceptual challenges and build them into a teaching sequence, effectively filling in the missing gaps between outcomes. Teachers with less experience are unlikely to see beyond the limitations of the outcomes and will limit their teaching only to the outcomes, thereby offering learners a set of unconnected learning experiences.

3) The outcomes do not give sufficient prominence to skills and perhaps as a result it is difficult to see where these will be developed in the curriculum.

Strategies for development

We suggest that the narrative that underpins the science curriculum needs to be made explicit and that, once this is complete, the existing learning outcomes and experiences should be audited against this narrative to ensure that the outcomes represent the significant steps in progression and that the experiences contribute to this process.

We recognise that this approach would cause a significant delay in the implementation of a CfE but we believe that the absence of this narrative poses a very significant risk to the health of science education in Scotland. We believe that a radical approach to the next stage of the implementation would reflect the spirit of consultation that has been a feature of CfE and would be supported by teachers and other stakeholders in the science community.

In addition we believe there must be a full programme of CPD for teachers, which focuses not on the outcomes themselves, but on the narrative which underpins them. Teachers deserve to understand why these outcomes are included and why they are important.

We would welcome the opportunity to contribute to the development of the narrative and the accompanying CPD. The Institute of Physics has developed a series of CDRoms intended to support the professional development of teachers of 11-14 year olds which we believe could be very helpful in exemplifying the learning outcomes and experiences in physics. We would be very happy to supply copies of the CDs to help support further work on the learning outcomes and experiences.

Our responses to the consultation questionnaire are attached. In addition, we have included an annex with a more detailed commentary on specific issues relating to physics in the science experiences and outcomes.

If you need any further information on the points raised, please do not hesitate to contact me.

Yours faithfully



Professor Peter Main
Director, Education and Science

Curriculum for Excellence: Response to the consultation on the draft science experiences and outcomes

Q1. The draft science experiences and outcomes are clearly worded. To what extent do you agree or disagree with this statement?

Strong disagreement

As written, the outcomes do not express clearly the depth or detail of learning that is expected from students. In addition there is insufficient attention paid to the development of skills in and through science.

This absence of clarity will inevitably lead to a haphazard variation in learning/teaching experiences as considerable interpretation will be required by individual teachers. In turn this will make it difficult for staff to develop indicators for both children and themselves to establish that an outcome has been achieved.

Q2. The expectations of the draft science experiences and outcomes at each level are suitably challenging. To what extent do you agree or disagree with this statement?

Strong disagreement

As has been highlighted, the lack of clarity about the detail and depth make it impossible to make a judgement about the demands of the experiences and outcomes.

Q3 Overall, the draft science experiences and outcomes provide a good basis for planning how children and young people will progress in their learning in science. To what extent do you agree or disagree with this statement?

Strong disagreement

We believe that insufficient attention has been paid to the progression. As a result it is difficult to see the connections between learning experiences. As a result there is a considerable amount of work left to teachers in working out what teaching and learning is required to help students move from one learning experience to another. For example, it is difficult to see what progression in the understanding of forces is expected in the following sequence:

Early	First	Second
Through everyday play with toys and from other experiences I can describe the effects of simple forces. SCN 007L	Using my results from investigations with toys or other objects, I can explore links between how far things move and the force applied. SCN 109L	By carrying out investigations into friction I can explain how it affects movement, and can use my understanding of friction to design or improve a product. SCN 222L

We believe that it is essential to provide an overview or teaching narrative to help teachers make the connections between the different learning experiences.

It is also unfortunate that there are no details of what happens beyond these experiences and outcomes.

Q4 The draft science experiences and outcomes provide opportunities to promote good teaching approaches and deep learning. To what extent do you agree or disagree with this statement?

Agree

The outcomes are general enough that experienced teachers may be able to use the proposed context to develop rich and diverse learning experiences and feedback from teachers suggest that they are enthusiastic to adopt more varied approaches to learning.

However, it is important to note that for this development to take place teachers will need to be given time and in many cases professional development.

Q5 The draft science experiences and outcomes provide opportunities for effective links with other areas of the curriculum. To what extent do you agree or disagree with this statement?

Disagree

Whilst we recognise the value of linking different areas of the curriculum we have some concern that if this aspect is over-emphasised much of the recent progress in primary science will be lost as science becomes too diluted.

A number of the secondary teachers responded that they did not believe that they had sufficient time to work with colleagues in other subjects to plan these links. We would particularly welcome more explicit linkage between maths and science in the experiences and outcomes and support for joint planning of the curriculum.

Q6 Taken together, the draft science experiences and outcomes provide opportunities for development of the four capacities (successful learners, confident individuals, responsible citizens, effective contributors). To what extent do you agree or disagree with this statement?

Disagree

We are concerned that the outcomes as presented do not contain sufficient detail to enable the strategic development of these capacities in the learners.

Q7 The draft science experiences and outcomes provide opportunities for children and young people to develop an understanding of how their learning will help them in their future lives. To what extent do you agree or disagree with this statement?

Don't know

This question provoked a range of responses from the teachers we consulted. Some respondents felt that it would be possible to work with the framework to provide these opportunities but others were less confident, noting that, particularly in the context of

science, it is very difficult to help children plan for a life in a world that will be very different to the one we are in at present.

Q8 What do you see as the main strengths of the draft science experiences and outcomes?

The outcomes are general enough that experienced teachers may be able to use the proposed context to develop rich and diverse learning experiences.

Q9 What professional development may be needed to help the implementation of the draft science experiences and outcomes?

We believe that high quality professional development is essential if the aims of CfE are to be realised.

The professional development should enable teachers to have a sustained engagement with the implications of these outcomes and experiences for their own teaching. In particular, the professional development should focus on the outcomes themselves, but on the narrative which underpins them. Teachers deserve to understand why these outcomes are included and why they are important.

Q10 In what ways could the draft science experiences and outcomes be developed further?

We suggest that the learning journey that underpins the science curriculum needs to be made explicit through a narrative that highlights the conceptual leaps required of learners. The narrative should also make it explicit how the experiences contribute to the learning process.

Once this narrative is complete, the draft learning outcomes and experiences should be audited against it to ensure that the outcomes represent the significant steps in progression and that the experiences contribute to this process. In addition, further thought needs to be given to how skills are developed.

There also needs to be more guidance about the depth of the learning experiences and there should be more work on the place of contemporary science issues within the outcomes and experiences.

Q11 Do you have any further comments?

Many teachers cited a number of other factors they believe might hinder successful implementation of the proposals, namely, a lack of provision of:

- sufficient modern high quality laboratory accommodation
- high quality science technician support for teachers in secondary schools
- adequate and continuing funding for new equipment and resources

Curriculum for Excellence: Further detailed commentary on the draft science experiences and outcomes

Within each topic, the science outcomes are organized into 'lines of progression' but in many cases it is hard to see the progression of core ideas or concepts and thinking essential to learning in science.

In discussions with teachers it is clear that this is a cause for concern, in that to teach some science concepts, some 'gaps' in the statements will need to be filled to enable clear scaffolding of ideas, or earlier preparatory learning experiences inserted into learning and teaching programmes. The lack of detailed advice is likely to lead to widely different experiences for children.

Planet Earth

Under the subheading for astronomy, we note that currently many pupils study the seasons, time (year, day, month) and relate these to the motion of the earth (and the moon for phases of the moon). We suggest that the early and level 1 outcomes be re-written to include this.

Energy in the Environment

On reading the outcome statements the impression is one of sparseness and a lack of detail. Energy is a difficult idea to teach and as such more guidance is required to make it explicit what learning is important.

It is not clear why a distinction has been made between energy transfer, energy sources and energy in food, although we agree that the role of energy in the diet is a useful starting point and that it is appropriate to move on to the costs of energy in the home, in transport and in lighting. The important idea of fuels being a repository or source of energy, and other things being 'energy stores'; the ideas that machines or appliances can be used to 'move energy around' isn't clearly articulated through the outcomes.

The difference between physical changes we can observe (like a book on a shelf, or an impact between a bat and ball) and tracking changes in the amounts of energy in energy stores associated with real objects needs to be more clearly explored in the outcomes. This will help children to recognize how the use of abstract concept 'energy' can be a useful means of understanding the world.

Children need to be able to recognize when to use energy to understand process and when it is more appropriate to use forces. Energy can be useful in telling us what cannot happen but it is rarely useful in telling us why something has happened.

I can investigate the burning of different foods. Using my results I can conclude which foods release the most energy and can evaluate my method.

SCN 218G

We are concerned about the safety implications of burning food in primary schools.

We support the inclusion of renewable and non-renewable energy sources within the primary science curriculum.

Electricity

Reading horizontally across the outcomes it is clear that there are two key themes running through these 'electricity' outcomes. Across the top is a theme of circuits and circuit competence leading eventually to calculations involving more complex series and parallel circuits. The lower theme seems to be associated with electrical safety and domestic appliances.

Again there is far more missing than is written. For example, in order that outcome SCN 220J, is achieved, preliminary work relating to the nature of a complete circuit is required, as is the concept of a switch. For outcome SCN 417J, there is an implied need for understanding of circuit symbols and the ability to construct a circuit from a formal circuit diagram. Aligned to this is the inverse skill of drawing the correct circuit diagram from a real circuit. Knowing how to use and read a digital multimeter is also hidden within the outcome. We are concerned that not all teachers will recognise these hidden key steps in conceptual development if they are not made explicit.

The outcomes appear to highlight only some of the key learning activities and ideas that a learner would require in their journey through electricity. Other 'missing' experiences, such as the skills relating to circuit diagrams, have been referred to in the above paragraph. One wonders why the writing team has chosen to omit some key outcomes but include others. Decluttering cannot be the rationale as the missing outcomes are critical stages in the whole learning journey. They will need to be covered even if they are not stated.

At level three, it appears to us that a critical step could be inserted into what might be seen as the vacant slot. Learners will enquire about the nature of electricity and electric current. Here is an opportunity to introduce the role of modelling in science. There is no shortage of excellent animated software which helps to present models of electrons in circuits. The misconceptions that electric charge is supplied by a battery and that current is 'used up' need to find a place to be expressed and challenged. We think this belongs at the third level and should be inserted. The outcome and experience statement might read something like: 'I have considered ways in which models help me to think about electric current and can explain the strengths and limitations of a model.'

Currently occupying the third level is outcome SCN 312J. We must express a serious concern over this outcome. Children should not be encouraged to find faults in electrical appliances nor suggest corrections. Such work is not only dangerous at 230V but will encourage such tampering in a domestic context, something which is no longer legal. Most plugs are ready sealed and so replacing loose wires is a thing of the past. The outcome might have featured in a school programme in 1960-1990 but at 2008 it is inappropriate and dangerous.

If it is important to continue the electricity theme into the domestic sphere, then we suggest that the outcomes should explore the whole issue of power stations, energy and electricity and the cost of domestic energy. Even electric motors could find a useful place in a domestic story. An alternative outcome which might fit here could be: 'I have used real life data from appliances and electricity bills to calculate the cost of energy supplied through electricity.'

We consider that the use of magnets as an example of forces that show 'action at a distance' is an important teaching point for Forces that this should be clearly indicated in the outcomes.

The gap between the level 1 outcome on Magnets (SCN 110L), and the level 4 outcome (SCN 424 L) seems a long time between children's introduction to and subsequent exploration of magnetic effects.

I can use my knowledge of the different ways in which energy is transferred between hot and cold objects to design an energy-efficient building.

SCN 309F

We are concerned that this statement mixes pedagogical strategies and content in a way that could limit teaching approaches and is therefore limits flexibility. We suggest that this mixing should be avoided.

At level four there appears static electricity in outcome SCN 420J. This is puzzling. An understanding of electric charge and charged particles must be based on an appreciation of electrons and atomic structure in some simplified model. Without such a model the whole static electricity story can be no more than some experiences with rubbed balloons and paper and comb fun. If it is to be there then it must be supported by appropriate electron modelling stories at level three. Might it be replaced with a level 4 outcome which continues the theme of domestic electricity – perhaps something about power stations, generators, transformers or motors?

Elements of the electricity outcomes which could relate to other learning environments include:

SCN006J, Creating a display: outdoor displays /advertising hoardings/ posters in corridors/ art and design/language

SCN 220J, Designing a game or model: visit to toy shop to look at games/art and design/technology

SCN 221J, conductors and insulators: classification (e.g. in biology), use of materials / technology.

SCN 418J, problems using relationship: mathematics (graphs/equations/calculators)

Forces and Motion

The initial impression on reading the outcome statements within Forces and Motion is of sparseness and lack of detail. The need for children to explore forces and develop an understanding of how an abstract representation can be used to describe these forces is not clearly articulated. The lack of clear learning and teaching pathways to support the development of children's ideas around forces is a flaw in the current outcomes.

The outcomes don't offer advice to teachers on how to support young children to develop the idea of inert objects being able to exert a force. The difficulties in helping children in developing understanding of non-contact forces aren't explored in the outcomes.

A clear teacher narrative needs to be developed for this topic to offer guidance to teachers who may lack in knowledge, confidence or experience to develop a programme of work.

Cross curricular linking.

The philosophy of CFE appears to promote linking across departmental boundaries. There are several opportunities to help break down such barriers in the forces theme, e.g. forces and sport, forces and mathematics (particularly graphing to show patterns in numbers), forces and the skeletal structure, forces and vehicle design (with technological studies).

Communications

Within the section on the electromagnetic spectrum it seems peculiar not to mention radio waves, X-rays or Gamma radiation within the learning outcomes. However, this does not sit easily within the overall theme of communication but then, using that criterion, it is also not clear why there would be a learning outcome associated with the ultraviolet radiation in medicine.

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