Visualizing progression through the Science curriculum in order to raise standards

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Abstract

We believe that pupil progression through the content of the National Curriculum for science rests upon them gaining an understanding of four key models: energy, forces, particles, and cells. Pupil’s progression to higher levels of attainment depends upon the effective introduction and systematic development of these key models through Key Stage 3. A visual representation (The ‘Levels Mountain’) has now been developed as a tool to assist teaching and learning and so aid progression. This visualization has improved teachers’ understanding of the meaning of National Curriculum levels and has encouraged them to share these insights with their pupils. This has enabled a rise in both pupil and teacher engagement with the complex issues associated with progression through the KS3 science curriculum. The Levels Mountain approach is a highly effective tool for raising the standard of teachers’ planning and development of effective assessment for learning within the classroom within Hampshire secondary schools.

Background

The work is the outcome to date of over 5 years of action research.

In the first phase, The University of Reading / Hampshire Inspection & Advisory Service (HIAS) / Hampshire Schools Partnership was formed in 1997. The initial focus was on the teaching and learning of models and modelling in the KS3 Science curriculum to improve progression. It involved participants from 12 Hampshire and 2 Southampton schools, with support and guidance from Hampshire science inspectors and Professor John Gilbert of The University of Reading. Within a framework of regular workshops and in-school support, teachers engaged in small scale classroom based action research projects in areas that they had identified as being relevant to their school. This partnership continued for 3 years and contributed to both individual and departmental professional development. It was through
this project that the four key models (energy, forces, particles and cells) were first identified as underpinning pupil understanding and access to progression through the curriculum. (Evans and Moore, 2003; Moore and Gilbert, 1998).

In the second phase from 2000 to present the work reported here was carried out through the Cams Hill Science Consortium, a partnership between Cams Hill School, HIAS, and Prof. John Gilbert. The project funded by Cams Hill School as part of their Leading Edge Partnership currently involves 16 secondary schools and 6 primary schools from across Hampshire and East Sussex. Our work involves a coordinated programme of action research projects into models and modelling in science to improve progression.

**Introduction to the issues faced**

Through analysis of 5 year trends within data arising from national tests taken at age 11 and 14, it became apparent that pupils in the county of Hampshire were making significant progress in the numbers achieving the expected level 4+ in science at Key Stage 2 (age 11 years). However the numbers achieving the expected level 5+ at Key Stage 3 (age 14 years) were not improving at the same rate. There was also a misconception held by many secondary school teachers that levelling was not consistent across the two key stages and that it was “easier for pupils to achieve a level 5 at KS2 than at KS3”. Work carried out by P.Bunyan (1998) indicates that this is not the case. A number of year 9 (14 year old) pupils in schools across Nottinghamshire were tested on KS2 and KS3 papers in the run up to their actual national curriculum tests. The papers were marked according to the published mark scheme and it was found that just over one half achieved the same level in the KS2 and 3 papers. A further third achieved one level higher in the KS3 paper than in the KS2, with only a tenth achieving better in the KS2 paper than the KS3 paper.

Work carried out within the Hampshire Curriculum Inspection Team for science by Jill Moore and David Hardcastle (Internal Communication, 1998) also discounts the idea that it is easier to achieve level 5 at KS2 than KS3. KS2 and KS3 question papers were analysed for the type of questions that were set. Pupils tend to score better on recall questions than they do on those that require explanation, application or interpretation. For the National Tests for KS3 pupils can be entered to sit tests in one of two tiers of entry, a lower tier
covering levels 3 to 6 or a higher tier covering levels 5 to 7. It was found that there was a significantly higher percentage of marks awarded for recall on the lower tier of entry papers than on the KS2 papers from the same year. Approximately 60% of the marks on the KS2 paper were dedicated to application, explanation of interpretation style questions; with about 40% of the marks being linked with these style questions on the KS3 3 to 6 papers.

In recent years, secondary school teachers have felt under an increasing amount of pressure to focus upon test results as national, local and school targets have been set that focus upon numbers of pupils who achieve level 5 and above at KS3. This focus has encouraged teachers to become focussed upon the improving the achievement of the middle to lower achieving pupils in KS3. All Science Departments within schools in Hampshire have reshaped their Schemes of Work so as to cover the very wide breadth of content that the curriculum requires. This they did in a whole variety of approaches and with mixed success. However, what they all had in common was that they all began to test pupils regularly so as to “measure their progress”. The tests in most cases were constructed by teachers using past paper questions and marked as percentages. Pupils who had become used to working in levels and being set targets in terms of levels at KS2 were no longer receiving such information in their regular interactions with teachers in KS3. Departmental Schemes of Work, written and re-written several times in recent years - perhaps adopting different published schemes - had focussed on the content of the curriculum and WHAT pupils are taught, rather than on the progression in scientific thinking skills required and on HOW pupils are taught. These observations were made by Inspectors / Consultants and through The University of Reading ‘PGCE Schools Partnership’ for pre-service teacher training. The focus on content meant that it was difficult to see what needed to be done to raise standards.

The report Progress in Key Stage 3 Science (OFSTED 2000) identifies that as much as 10 to 15% of teaching time in Key Stage 3 science had become devoted to assessment. In general only a limited range of techniques was used and the use of the data that was generated was also limited. It concludes that “the use of so much teaching time on testing is therefore often unproductive.” (p14). It contrasts this with the work carried out by the best science departments. A common feature was the quality of the feedback provided to pupils and the “excellent” use of directed questions used by teachers to inform their knowledge of pupils’ level of understanding.
The advent of the DfES Key Stage 3 National Strategy’s science strand (DfES 2002) has provided a welcome fresh focus upon raising standards at KS3. Its implementation has helped teachers to focus on KS3 and to think about how to raise standards of teaching and learning. However, as a Consultant (MN) and County Inspector/Advisor for Science (DH) in Hampshire, we became aware that teachers were finding it difficult to sort out the key messages within the Science Strategy materials. Many were reporting of feeling deluged by the amount of materials and good ideas on offer. Teachers now found themselves faced with a bewildering array of different ways of measuring progression and differentiating materials for pupils within their classes. These included the National Curriculum Level descriptions (DFEE 1999), the differentiation offered by the QCA Schemes of Work (QCA 2000), advice within commercially published schemes of work, and now the KS3 National Science Strategy’s Yearly Teaching Objectives (DfES 2002).

Whilst all of these are valuable resources, the situation poses two problems. First, teachers were becoming concerned by the number of different approaches, there didn’t appear to be a coherent message, and that they couldn’t envisage how they could possibly put all of them into practice within the classroom. Second, pupils could not be involved in measuring their own progression through the levels of the curriculum. Although in most schools they were frequently tested, the results were rarely reported to pupils in terms of National Curriculum levels. Not only were pupils unaware of the meanings of these levels, but they also did not know what was expected of them or how they could progress towards the next level.

A way of uniting the key messages was needed that could encourage and stimulate both teachers and pupils to engage with levels and levelling in the classroom and make coherent use of the resources available. What was missing was a clearly communicable way of understanding the level descriptors. With such an understanding in place, teachers should find it easier to engage with levels and levelling in the classroom, such that measuring progression becomes an interactive relationship between teacher and pupil and not just a relentless series of unconnected topic tests. Furthermore, pupils should be able to understand how to improve the quality of their work and achievement in science.

The methodology
Working with teachers from different science departments, the Hampshire LEA science team working in partnership with Professor John Gilbert have developed a visual representation of the journey that pupils make through the National Curriculum levels as they make progression in their skills of models and modelling through Key Stage 3 ("The Levels Mountain"). This was done by studying the National Curriculum level descriptors and breaking them down into simple statements which describe the essential elements of models and modelling associated with each Level. What soon became clear was that applying a knowledge and understanding of the principles of scientific models and modelling enables the Level descriptors to be defined in terms of a clear progression of thinking and communication skills which can be taught to pupils.

![The Levels Mountain](image)

The Levels are each given simple “pupil speak” prompts for the level descriptors. This Levels Mountain is not intended as a method of labelling pupils with Levels from summative assessments (end of topic tests). It has been designed as an aid to effective teacher-pupil interaction in the classroom, giving instant feedback on verbal as well as written levels of understanding across the KS3 Science Curriculum. The best use of this tool
has been to encourage teachers and pupils to challenge their own thinking in the classroom. Pupils are enthused and motivated by the explicit use of levels and the Levels Mountain in class, they have been heard to say “That’s OK because we have got the scientific words needed for a Level 4 answer – what explaining have we got to do to get to Level 5?” (lesson observation – The Vyne Community School, Basingstoke.) or “No that can’t be level 6 because he hasn’t explained the particles in enough detail” (lesson observation – Priestlands School, Lymington.) “I know that this is something to do with energy, but can you help so I can get the level 5”. (lesson observation – Neville Lovett Community School, Fareham.)

If the journey is imagined to be like climbing a staircase, you will notice that not all the steps are of equal height or depth. Level 5 is a key area since significant numbers of pupils fail to progress from level 4 at KS2 to level 5 at KS3. Level 5 has very complicated level descriptors in the National Curriculum. However it was distilled down into two parts. The first part of achieving level 5 requires pupils to be able to apply scientific ideas and explanations in unfamiliar situations whilst the second requires them to begin to engage with models of abstract concepts to explain phenomena.

To assist teachers in visualizing level 5 for pupils it is best described as “a big step and a long journey” because of the cognitive demands, as well as the breadth, of the materials covered by this level. This visualisation becomes very useful to explain to pupils (and their parents) why they may have been working at level 5 for some time. In some schools they have adapted the ‘long journey’ of level 5 to be visualised as a slight incline. In the light of experience, and the result of many of our classroom based action research projects, it became apparent that some of the abstract models contained within the curriculum are easier than others for pupils (and teachers) to access and apply. For example, the particle/kinetic theory models seem to be easier abstract ideas for pupils to engage with and apply than the energy transfer model.

The snakes and ladders in the diagram are used to visualize the reliance that science has upon literacy and numeracy skills. When pupils have satisfactory or good literacy and numeracy skills, these have the potential to act as a “ladder”. They enable pupils to progress to the next level, providing that there is an appropriate degree of challenge given within their science teaching... If they have weaknesses in either of these skills then this has the
potential to act as a “snake”, making progression to the next level a more demanding process for both the pupils and the science teacher.

Levels 5, 6 and 7 (and in the higher version level 8) are all described in terms of the pupils’ understanding and application of abstract models (energy, forces, particles and cells). Many Hampshire schools have reported that they find models and modelling to be an excellent way of enabling pupils to make tangible progress through the curriculum levels. Models and modelling also therefore becomes a highly effective way of measuring and monitoring pupil progress through the curriculum Levels.

As a result of our programme of action research projects in the classroom, we have come to differ in our interpretation of the fifth key idea (Interdependence) as described in the Framework of the National Strategy. In the Framework, Interdependence is described in terms of environmental biology; the ‘interdependence and energy’ section then links energy flow along food chains etc. Neither our project, nor its predecessor initially identified interdependence as a key idea (or curriculum-structuring concept) at Key Stage 3. However, as some of the schools involved the project became more adept at integrating models and modelling into their curriculum and more enlightened as to the interpretation and application of National curriculum levelling, it emerged that interdependence is the key to progression to Level 7. The interpretation of “interdependence” in the light of the findings of our experience can be described as, ‘The inter-reaction between two or more of the 4 key models (energy, forces, particles or cells) to explain more complex phenomena’. For example, when teaching balanced forces, pupils sitting on their chairs can often be used as an example within the classroom. The answer to the question “Why does a chair push up with an equal and opposite force?” requires the application of the model of balanced forces (level 5 or 6, depending upon the quality of explanation). However the question “How is the chair able to push back with an equal and opposite force when different people of different weights sit on it?” requires an answer that links the interdependence between the models of particles and forces to explain why the chair’s reaction is different (this linking of models is level 7).

Research in several Hampshire schools has shown that the explicit teaching of models and modelling enables pupils to recognise and understand what levels 5 and 6 are about. Level 7 can be thought of as the application and explanation of the links (interdependence) between
two or more of the four key curricular models. It has been shown that it is easier for pupils to engage with and comprehend more complex areas of the curriculum, such as respiration, if they can be presented as being a process that involves a relationship between cells, energy and particles. When teachers use the simple models and modelling associated with particles, cells and energy to introduce and then explain aerobic respiration, then pupils can assimilate these models into their own explanations of the more complex phenomenon. This focus of developing understanding through the application and refinement of models and modelling promotes pupil understanding by allowing them to see that they can use their existing knowledge and understanding to seek more complex explanations. In a similar way chemical reactions occur as a result of the interdependence of particles and energy; electromagnetism is a result of the interdependence of particles, energy and forces; human reproduction - cells, energy and particles, etc. Getting the progression and sequencing of the 4 key models (energy, forces, particles and cells) correct and giving them the emphasis that they deserve is the bedrock to the success of the whole KS3 curriculum.

The value of the Levels Mountain approach to using levels explicitly within class:

“It helps me to explain to the pupils much more easily, and in doing so, helps me to gain a clearer picture of where they are in their own understanding so that I can inform them of how to progress…..” G. Jackson (Second in Science), Warblington School, Havant.

“The levels Mountain has helped me to put into perspective the different demands made of pupils at each level, and the time needed within our schemes of work to consolidate the associated ideas. It has helped me to illustrate this to both pupils and teachers alike. I have also found it a most useful tool for focussing booster work to target specific pupils to achieve their different targeted levels.” A. Grevatt (AST), Uckfield Community Technology College, East Sussex.

“The introduction of the Levels Mountain changed not only the teachers understanding of levels, but it has had a revolutionary affect upon the pupils understanding about what they need to do to progress onto the next level. It has given the teachers and pupils a common language. Whilst the Science Strategy has had a very positive impact upon the teaching and learning in science, the use of the Levels Mountain has enabled both teachers and pupils to
‘see’ where they are at present and where they are going.” D.Seib (Head of Science) Fort Hill School, Basingstoke.

Application of the Levels Mountain in different schools

As with all initiatives, this visualization of the National Curriculum levels and progression was found to be far more effective when schools are encouraged to customise it to their own needs. A number of alternative approaches have evolved:

1 – “Pupil Speak” level descriptors

It is good practice to share the level descriptors with pupils so that they can have an active and meaningful involvement in monitoring and tracking their own progress and self assessment. These have appeared as posters in science teaching rooms and as information in pupils’ exercise books. Non teaching assistants and special needs staff have also found these to be a valuable resource for understanding and applying levels to everyday classwork in science lessons and formulating questions.

2 – Using the levels mountain explicitly within lessons

Teachers and Consultants working in the County have found that using the Levels Mountain explicitly within lessons can not only engage and motivate pupils; it also assists teachers with planning effective and levelled learning objectives and learning outcomes. When teachers have planned starter activities, they have found it to be a highly useful tool with which to identify expected learning objectives and outcomes and so aid more focussed and challenging differentiation.

Many different science departments have developed their own approach to this use the Levels Mountain. Figures 2a and 2b show wall displays in Staunton Park and Warblington Schools in Havant.

Fig 2a        Fig 2b
Teachers have found that the levels mountain has been a very useful tool for engaging Year 9 (14 year old) pupils in revision for their forthcoming SATS exams. In this way it has served to support and coordinate the Science Strategy’s Booster materials.

Lesson observations conducted by HIAS and Prof Gilbert have identified that the use of the Levels Mountain has been shown to be a very useful method of raising the standard of pupils’ verbal contributions in classroom discussions and debates. When the teachers use the Levels Mountain both to make evident and to value pupil’s verbal levels, it has been shown that this can be an effective tool for raising standards of engagement with literacy issues within science. If pupils can appreciate that verbally they can achieve a higher level of understanding and explanation than they can achieve in written tests, this promotes an internal ‘frustration’ within the pupil’s mind so that they want to engage in improving their literacy. “If they believe that they are clever enough to do something then they want to try!” (teacher quote – Cove School, Farnborough.)

Currently our work in the Cams Hill Science Consortium is focussing upon the development and trials of a resource to challenge pupils thinking skills and support raising standards of their verbal and written explanations within lessons. Further details of this work can be found on our website www.thinkingframe.com

Teachers have also found it very useful to have two copies of the Levels Mountain on display in the classroom, one for view by the pupils and another upon the back wall for the teacher to use as a tool for levelling pupils’ responses during question and answer sessions. Where teachers use the Levels Mountain as a resource, pupils have become very motivated to use it themselves. Through our work supporting schools we (MN, DH and the rest of the HIAS science team) have both delivered and observed lessons where pupils are being encouraged to level their own discussions and work. What is very noticeable is that pupils
become surprisingly adept at understanding and implementing the levelling criteria and motivated to achieve the best level answer that they can. The Levels Mountain has become a very useful tool for focussing pupil’s discussions and debates to assist progression whilst also becoming a focus for teachers own professional debate and development.
References


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