Action Research for Physics

Case studies

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Contents

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Teachers' Case Studies from the Action Research for Physics Project

This case study booklet was produced as part of the evaluation of the *Action Research for Physics* (ARP) teacher professional development programme which was organised and managed by the nine Regional Science Learning Centres between September 2009 and February 2011. The research was commissioned by the National Network of Science Learning Centres and Department for Children, Schools and Families.

ARP is a model of professional development incorporating action research, with an aim to trying out new approaches to teaching physics which lead to an increase in young people's engagement with the subject, and pursuit of physics beyond GCSE level. These 18 physics teaching case studies were delivered by teachers on the ARP programme, had a high impact among their students, and were often adopted across their departments, across their schools and sometimes even in neighbouring schools. The booklet should provide a useful guide and reference point for teachers of secondary school physics.

Telephone interviews with the 18 teachers about their action research interventions were conducted between May and November 2011, for the compilation of the booklet. The case studies were written jointly by the teachers and the researchers, based on their project reports and the interviews. The final editions were approved for publication by the teachers and their schools.

Marcus Grace, Willeke Rietdijk, Caro Garrett (the evaluation research team and editors of the booklet)
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NB: Hyperlinks (highlighted in red) are inserted in the document to appendices at the end of the document but you may need to use the Ctrl button on your keyboard together with a left mouse click to use this function.

Making futures: stimulating pupils with career-based learning

Davison High School for Girls

Selborne Road, Worthing, West Sussex, BN11 2JX (**Alex Holmes**)

School context: Girls' school; 11-16 years, 1093 pupils, Specialist Technology Status. Percentage pupils from ethnic minorities and with EAL or SEN/disabilities below average.

Overview of the intervention

My intervention involved changing the focus of Key Stage 3 lessons from knowledge-based learning to a focus on careers. The class chosen was a middle ability Year 9 class, whose National Curriculum targets ranged from Level 4 to level 7. The objective was to direct girls to reconsider their perceptions of physics careers. I introduced the pupils to a range of careers, some of which they had experienced through television and other media e.g. meteorology and archaeology; and some where they had experienced the outcomes e.g. stage lighting and sound production. My hope was that this would provide a different kind of stimulation for enjoyable learning and so engage the class in a more active way.

The lessons encouraged investigation work by the pupils where they applied skills used in specific careers. After an initial questionnaire, I selected topics which related to both career and interest. Those topics which scored highly on 'some interest' and 'least interest' were chosen. This resulted in four topics: Crime scene forensics, Meteorology, Stage lighting and Oceanography. A whole lesson was devoted to each topic, with different activities.

Changes made to lessons

The lesson format remained consistent, with each hour lesson divided into the three parts: introduction including starter activity, main activity and plenary. The careers chosen were not obviously ones that pupils could identify as ones requiring a physics background, but all included some degree of physics that had been covered in Year 8 or Key Stage 2. For an overview of activities in each of the four lessons and resources used, see **[41]**. Pupils were expected to participate in team work, problem solving, measuring, building simple equipment and producing a stage show.

New resources required

The resources were mostly made with the help of science technicians. The archaeological resistivity survey apparatus was based on one produced by the Earth Science Education Unit, although Teledeltos paper proved very difficult to acquire. Other resources included the bathometry 'shoeboxes' which were constructed by the Science technicians and loosely based on the UCLA Marine Science Centre ideas. The remainder of the apparatus required were items regularly found in schools or easily acquired: the Crime Scene forensics required a polystyrene cup (of tea) as well as digital timers, thermometers and tape measure; the stage lighting required cardboard boxed and science department light equipment, as well as the pupils' own IPods. The lesson I did on weather forecasting didn't work out in terms of the students making pressure sensors. But they still learnt a lot about weather forecasting.

Timing Issues

The four lessons were inserted at appropriate times during the teaching of the KS3 curriculum. With the Year 9s under less pressure due to the absence of NCTs, I was able to find lesson time when I considered it appropriate to change the focus of learning from subject-based to career-based.

Impact on self

In writing new lessons and changing the focus of learning, it made more sense to me for some lessons to focus on careers and futures of pupils, although the Key Stage 3 curriculum has since changed to focus more on science skills and investigatory work for pupils. I found that less able pupils were more engaged when they are applied their own life experience to their learning. Stage lighting is a classic example; you don't need to be a physics graduate for it, but it is very much an application of physics. I now try to insert ideas about careers into lessons when I can. It also seems that girls enjoy doing science a lot more if they can see there is a point to the activity. For the less able, there is more participation when they understand there are people who are not science graduates who use these techniques. I now try to incorporate careers into my science teaching, not just physics, across both KS3 and KS4.

Impact on pupils
Focus group interviews indicated that the majority of pupils enjoyed the lessons, although many had not realised that they were physics lessons. The main reasons for enjoyment were "we could see the point of the experiment to answer the question"; "you could see why it was useful to work out''; "it was interesting to find out how we can see to the bottom of the sea". The main criticisms were "sometimes it was hard to understand the worksheet"; "we always had to work in a group". I also found that on some occasions, some pupils needed a lot more extra support in order to understand the investigation, especially when they had little prior knowledge about the job in question. Pupils indicated a greater awareness of careers using physics in ensuing discussions. Many were surprised at how broad the application of physics could be, and some went further in describing how many skilled professions such as builders and plumbers would also include physics ideas. I will not know the impact on their results for a long time, but the immediate response I had was these were some of the best lessons they had ever had. "If science lessons were always like this, Miss, we would love them".

The intervention I did with the Year 9s led to their physics results being higher than expected in their KS3 exams. I now teach the same girls in Year 11 and have noticed that they seem less 'afraid' of physics. It may be that my teaching methods have changed, but certainly the pupils are willing to tackle physics with more enthusiasm than in previous years. There is a degree of enjoyment and a realisation by the pupils that they have the skills required to find out the answers to science questions on their own.

Impact on colleagues
It has impacted on physics and chemistry teaching in the Department. More teachers are looking for careers related what they are teaching, and whether it is appropriate to incorporate career ideas into the theory or career based skills into investigatory lessons.

Recommendations
What worked well was the whole concept of career-driven lessons as opposed to just curriculum driven lessons, as students are quite interested in careers and sometimes quite limited in their ideas of what careers science can lead to.

Students researching and presenting physics jobs and careers; relating physics topics to careers in classes

The Billericay School

School Road, Billericay, Essex CM12 9LH (**Brynne Poole**)

School context: Large (1655 students on roll) 11-18 mixed, foundation comprehensive school with 150 staff; specialist status in Maths and Computing. The percentage of students with free school meals, with EAL, with SEN and from minority ethnic backgrounds is lower than the national figure.

Overview of the intervention
This intervention was carried out with a Year 10, set 2 class studying GCSE Core and Additional Science. We aimed to increase the number of students taking physics at A Level and to raise the profile of physics as a subject by integrating careers into the lessons.

Changes made to lessons
At the beginning of a lesson, job(s)/career(s) were highlighted that would use the physics about which they would be learning that day. The students were also set homework to research a job/career, involving physics, which they did not previously know about. This research was then shared with the rest of the class.

Initially students were given post-it notes and asked to write down a physics-related career. Students were then given homework where they had to research and write up any physics-related job or career, but not the one that they had written on the post-it note. The week after, these researched careers were reviewed in class, and students presented to each other about their findings. As part of the homework, they were also asked to find out about qualifications required for these jobs/careers (full/part physics degree, or just A levels) and about the possible earning capacity. It was an exercise to find out more about the different jobs involving physics, because student knowledge in this area was very limited.

Additionally, at the beginning of every lesson, the physics covered in that lesson was related to possible careers and jobs. The teacher is now incorporating this in all her classes, as the Head of Science has highlighted the lack of careers knowledge as an important issue that impacts on student motivation.

Timing issues
This activity can be carried out at any point in the year.

New resources required
It was helpful having a contextual textbook. It would also be useful to be signed up to a web service such as b-live.com. I also found information from the Institute of Physics careers service at www.iop.org/careers.

Impact on self
I am definitely much more aware of my practice. I am including references to jobs/careers within all my science lessons. I have learnt that physics needs to be made relevant. Talking about how the physics being learnt is applied in the outside world is important and the students are interested in knowing this.

Impact on pupils
The awareness of students seems to have increased. They are starting to realise that Science is ‘not just an isolated school subject’, but something that is relevant to their future. Students were interested in doing the research; they enjoyed the lesson where they fed back their research and what they’d found out. The career that came up the most on the post-it notes (Astronaut) was chosen by one student;

however there were some unusual jobs which were interesting and surprising for the students – Nuclear Physicist for Thermilab. Making physics more relevant gave them a better notion of the use of physics, for example talking about traffic police, using the equation to work out the speed of the cars and positioning, and then who hit who.

Impact on colleagues
The Head of Science has suggested that the teacher could carry out further Action Research around the activity that she did, as there is scope for this across Biology and Chemistry in addition to Physics. This is in the context of an in-house training session the school is doing next year and a presentation on Action Research, which the teacher is assisting with.

Recommendations
As the focus is on physics, it may be better to do the activity with a year 10 triple physics class or a top set year 9 class before they choose their options for year 10.

Which questioning techniques engage students for the longest period of time?

The Meridian School

Garden Walk, Royston, Cambridge, SG8 7JH (**Caitriona McKnight**)

School context: Mixed gender; 13-18; 544 pupils; specialist Maths & Computing; percentage of students with EAL and free school meals below national average; higher than average percentage of pupils with SEN/disabilities.

Overview of the intervention
Different questioning techniques were tried out with two Year 10 triple award (mixed ability ending towards higher ability) classes (one of mixed gender, one all-boys) to see which engaged students for the longest period of time. The hands-up approach was avoided, unless it was a completely new topic.

The questioning techniques used were: 1. Thumbs up (I understand it, could explain it to you), thumbs down (don't get it), thumbs across (I think I get it but give me time to digest it); 2. Random name generator with individual answering; 3. Thinking time given to a pair/group of students then using the Random name generator to choose an individual from the pair/group; 4. Mini-white boards; 5. Answer given, get them to come up with the question.

Different styles of questioning techniques were tried out to see to what extent they motivated or engaged students. I lined up two Year 13 students, a boy and a girl, to assist with assessing the engagement levels of the two Year 10 classes in which the different questioning techniques were tried out. These two Year 13 students were informed about the project, but the students in the two classes were not, so that they would not be influenced in their choices. The two classrooms were both able students doing triple award; one group was of mixed gender, and the other was a single-sex boys group.

The Year 13 students observed the classes to gauge which was the most motivating type of technique. A video camera was used to help me and the two research students assess the engagement levels and discuss the extent of agreement.

Changes made to lessons
I planned the use of the different questioning techniques in my lessons. The random name generator was used to choose students and make sure they were alert (especially gifted and talented students who tend to switch off because their contributions are avoided by the teacher, as "teachers often assume they know the answers"). It was not used with new topics.

Timing issues
The timing of the activities is important in terms of getting the year 13s involved; otherwise they can be carried out at any time of the year. The questioning techniques can be used in most lessons.

New resources required
Mini white boards; video cameras

Impact on self
I became more reflective about my teaching and more careful when a child says 'I don't understand something'. I now tend to ask them how they would like me to help them with their understanding. Previously I used to question the quality of my explanations, as a result of their lack of understanding, or assume that it would be dull or ineffective for students to listen to the exact same explanation more than once. However, I learned from student feedback during the project that often when students have had something explained and they don't understand it, they need to then hear the exact same

explanation again so that they can fill in the gaps of what they missed the first time it was explained to them. This was a very important discovery for me.

Another interesting thing that came up during a discussion with the sixth formers was how you decide about engagement. Having student researchers assist helped in formulating a better question about engagement, because it is not straightforward to tell this from the posture and attitude of the students. This resulted in a very interesting conversation with my A level students as to how we as an observer judge if a student is engaged (or not!).

I was already aware of the benefits of using mini whiteboards, but I became more aware of the limitations. As soon as they have the whiteboards out students are paying attention; it's very competitive, particularly with boys; they want to get the right answer. You can immediately see whether students get something or not. But the year 13s pointed that out when you then try and explain the concept, students are not interested and they switch off. The Year 13s said that using the mini-whiteboards was by far the most engaging way of questioning, but it had its limitations. I am also more cautious about overusing them.

Impact on pupils

It is very difficult to say what the impact has been on the students. It seems to have made a real difference to how comfortable students feel about asking and, more importantly, answering questions in the classroom. Students responded in a more positive way and with more intelligent answers when given time to think. This has paid off at AS where normally students seem very reluctant to come out of their comfort zone to ask or answer questions. This year they have appeared to be doing this really well on many occasions. At AS there are 23 applicants in a school of five hundred this year, which is a huge number of physics students and might be seen as (partly) due to the intervention.

Impact on colleagues

A CPD session was conducted after school; first with teachers in the Science Department, and then one with all teachers. The idea about the engagement of mini whiteboards was quite well received in the session with all teachers; it was also strongly recommended teachers used the (Year 13) students to give feedback on the engagement of the class. This is quite intrusive and one has to be quite brave to do it, because essentially it means asking students to criticise the lesson. It is hard to gauge the actual impact on the school and whether other teachers are actually implementing it. Other departments have got involved in other types of action research.

Recommendations

Using different techniques across different situations works well; there are good points and there are bad points in all of these techniques. The good point of the mini-whiteboards is that students give one word answers, so that you can immediately find out their understanding. The bad point is that it can be overused, and that kids tend to doodle which also limits the teacher to lower level questioning. The thumbs-up, thumbs-down approach is good in that one can see immediately who has and who hasn't got it, and it's not invasive. It's an on-going project, trying and incorporating these things within lessons. It depends on the group and on the situation whether something works or not.

Does working in single sex groups within a mixed class impact on the participation and engagement of students?

Bottisham Village College

Lode Road, Bottisham, Cambridgeshire, CB25 9DL (**Charlotte Daymond**)

School context: Mixed gender, 11-16, 1043 pupils, specialist Humanities; serving a relatively affluent rural area; low percentages of pupils from ethnic minority groups, with EAL or with SEN.

Overview of the intervention
With a Year 9 class 2nd set of very mixed ability and some mixed behaviour; with students quite easily distracted by each other, seating plans were changed. Students were split up and surveyed on different aspects of learning in order to obtain a view on who would work well together. Females were put on one side of the classroom and males on the other. The working groups were changed by a rota when doing practical experiments, but they would always be working with either an all-girl group or an all-boy group.

Changes made to lessons
Within the same-sex groups, students were then often mixed up so they were not always working with the same person as this tended to be unproductive. This has been implemented in other classes as well, so that students are not with the same person each time; it makes them think about it in different ways and takes them out of their comfort zone; they have to put their input in as well.

The splitting of genders and mixing of students within gender groups was done alongside working through the national curriculum; it was just implemented and added into the normal lessons. No different activities than usual were carried out.

Timing issues
Because it was started in January and students were working towards their end of year exams, this gave them and the teacher a chance to settle into a new routine.

New resources required
None in particular, the approach can be used with any topic and resource. See **[58]** for the student survey used.

Impact on self
My behaviour management has improved and I feel I have a better student-teacher relationship with the class involved. It changed my view on certain behaviour management situations in the classroom, but also on how students perceive things in the classroom. The student survey made me aware that I wasn't always fair in which students I was telling off and it increased my perception of what is actually going on in the whole classroom. This was interesting and definitely had an impact, because I then changed this in all of my lessons and students felt treated more fairly.

I felt that talking to the students and analysing their views on the questionnaire was the most valuable and rewarding part of the project. I was impressed with the maturity of some of the students and how much they were aware of the dynamics in the group.
I think I have become a lot more aware of the student needs; looking specifically at what engages students and how they interpret science and how they work well together, I've implemented and used what I've learnt in other classes. This project highlighted what students need and want from their science lessons, and how you can engage them as best as you can.

Impact on pupils
The challenge worked quite well. This particular group had to some extent become set in their ways; having mostly been in the same group, in Year 7, 8 and 9 – the fact that they realised "she means

business" was really good, and there has been a positive impact on their learning as well. They were more engaged, and hopefully they got more out of it, and they've done very well – the majority of them have gone on to do triple science this year.

My intervention has had a positive impact on the classroom and the group as a whole. The dynamics of the group changed as the project progressed. Both the boys and the girls were a lot more focussed during lessons although the boys showed less progress than the girls. The girls were the first to be aware of the changes and were much more aware of the change in their work and progress than the boys. The results of my questionnaires and my interviews showed that the students felt the opposite sex could be distracting. The quiet girls were particularly aware of this and how it could make other girls distracting because of the constant giggling and silly behaviour. One student pointed out that girls are often needed to keep the boys on track because they can get distracted by anything if they wanted to.

Students said they really enjoyed it, a lot of them who weren't really interested in doing the sciences at the beginning of the year said, we want to do it, it sounds really good fun, and we want to go on and do science in the future. Last year we had one of the largest intakes we have had for triple science – we practically had to have three triple science groups this year.

Impact on colleagues

I spoke to the Department and went through my project with the rest of the Science Faculty which they found useful and interesting. Two teachers implemented some of the questionnaires and found this beneficial in terms of what the students want and need. At a whole school staff away day I might be able to get a chance to talk to people in other Departments. I have spoken to a few people informally about what I have done.

Recommendations

I believe that for certain groups this intervention could be a great asset but in some groups could become detrimental especially to the boys, who benefit from the girls encouraging them to focus. Furthermore, I am going to continue to have a look in more detail at how certain things can change the student's engagement, especially with bottom sets in Year 7 and Year 8, who, although they're quite enthusiastic, can be quite hard to get sat down and engaged at the start of the lesson. It would be good to get student perspectives in different groups. Lastly, it was good to have the negotiated seating plan in place; it worked well to put students together according to both what I knew of them and their needs, and who they wanted to work with and sit next to, and then adapt both these factors into the plan. There were no problems with it.

Facilitating the understanding of mathematical aspects of Physics at KS4 by using an initial qualitative teaching approach

Harrogate Grammar School

Arthurs Avenue, Harrogate, North Yorkshire, HG2 0DZ (**Clare Llewellyn**)

School context: Mixed gender, 11-18, 1790 pupils, Specialist Languages and Technology. Many pupils are from advantaged homes; low levels of social disadvantage, of pupils with free school meals, with EAL, and with SEN.

Overview of the intervention

The intervention was carried out with a mixed-gender Year 11 triple science group, with a focus on using a less mathematical approach to teaching about electric circuits. Initial questionnaires given to pupils indicated that mathematics was a major barrier to understanding the topic of electricity. There was a focus on girls' learning as there was a particularly poor uptake of AS physics among girls at the school. Most of the ideas of how to make the teaching of circuits less qualitative were adapted from "Engaging with Girls; Increasing the Participation of Girls in Physics – an Action Pack for Teachers" published by the Institute of Physics.

Changes made to lessons

There was less of an early emphasis on using numbers, symbols and equations when teaching about electric circuits. The mathematical aspects were only introduced after a more qualitative approach was used to explain the relationship between voltage and current.

First of all analogies were used to explain the concepts of current and potential difference. For example, the "rope model" was used to review the concept of electric current. Potential difference was explained using analogies with gravitational potential difference. A plank of wood, lifted at one end, was used to show how potential difference affects flow of charge, which was modelled by rice placed on the plank (the higher the plank is lifted at one end, the more rice moves past a point each second).

To investigate characteristic graphs which show the relationship between current and potential difference across different components, students used circuit equipment as usual but without at first writing down any readings. The aim was to allow students to explore and come to an understanding of the relationships in a qualitative way without getting bogged down with data and graph drawing. For example, for an ohmic resistor they found the relationship was directly proportional, just by noting how the current changed in response to doubling then trebling the voltage. They then compared this to a filament lamp and were asked to think about the possible reasons for the non-proportional relationship.

Students explored changes in potential around circuits by colouring in diagrams of circuits. In this activity, each colour used represents a different electrical potential. Across a component, there will be a potential difference and so the colour will change. Students were given a worksheet with a few circuits of increasing complexity to colour. Students were also asked to think about whether or not they found this approach helpful. Most agreed that it did help them to understand the ways in which potential changes in series and parallel circuits, and a few had a real "Eureka" moment.

Only after spending a number of lessons on developing their understanding of circuits in a qualitative way did the pupils work on calculating voltage and current mathematically.

Timing issues

The approach outlined here could be carried out at any time of the academic year.

New resources made/required

No new resources were required for the intervention. See **[59]** for question sheets and teacher notes.

Impact on the teacher
As a consequence of this intervention, I have applied the initial qualitative approach to other topics, and I am now more aware of the way I teach mathematical aspects of physics (and science generally).

Impact on pupils
Feedback from pupils was excellent. The qualitative approach enabled the pupils to understand the concepts, making the subsequent mathematical aspects easier to grasp. Post-activity girls' interview responses indicated that they found the relevant mathematics less difficult, they were more confident and at ease, and had more 'ownership' of the topic. Following the activity, both boys and girls reported increased enjoyment and satisfaction in solving difficult mathematical problems, and thinking about voltage in colour was a very positive way of learning about circuits. The year following the intervention, there was an increased uptake of AS physics by students compared to the equivalent set in previous years. Clearly, this cannot necessarily be attributed to this one intervention entirely, but there is a belief that the changed approach is at least partially responsible for the increased uptake.

Impact on colleagues
At the time of writing, new Year 11 schemes of work are being written which will include this this approach to teaching electric circuits. The schemes and associated resources are used by all other colleagues teaching this topic. Some of the activities have also been adapted for use in year 12 teaching. A scheme of work, including resources, has been written which includes the rope model and voltage in colour activity.

Recommendations
Although this approach to the electricity topic may seem to take more time to teach, which is always an issue with the time constraints in Key Stage 4, I found that because students' understanding of the key concepts was so much better, their uptake when I did introduce the mathematical aspects was a lot quicker than usual. I therefore wouldn't be as concerned next time at getting through the material required by the exam board in the time available.

Improving the quantitative nature of practical work through new equipment

Mill Hill School

Peasehill, Ripley, Derbyshire, DE5 3JQ (**Daniel Powell**, now moved to Colonel Frank Seeley School, Calverton, Nottingham, email: daniel.powell@cfs.notts.sch.uk)

School context: Mixed gender, 11-18 school, 1135 pupils; specialist Arts status. The main difficulties are social, emotional and behavioural or moderate learning difficulties.

Overview of the intervention
The intervention was started with a Year 11 group additional science group and then moved down to BTEC Science in year 10 and 11, and to year 7, 8 and 9 for some of the easier things. We needed to improve our physics classes to boost enjoyment, results and retention at A-Level. Also there was a lack of quantitative experiments being completed and students were bored by a lack of practical science as it was usually done by teacher demos or on old equipment which gave unreliable results. Energy meters and associated input and output devices (transducers) which enabled readings for power, current, voltage and time to be taken quickly and easily were bought using the impact award and a subsequent Rolls Royce award. This enabled pupils even of a low ability to set up the experiments themselves and get reliable concrete data to create tables and draw graphs. Then they could spend more time conducting analyses and making concrete conclusions about energy flow.

Changes made to lessons
We conducted simple electricity experiments using new equipment mainly from SEP (Science Enhancement Programme, bought from Middlesex University Teaching Resources, now 'Mindsets') with a variety of groups including ISA experiments for GSCE coursework. Each individual group of two or three could now use a proper energy meter and see digits and numbers, and put the numbers into formulae or graphs or tables and do a much higher level of work, and very hands-on. We started with Key Stage 4 and then rolled it out further to Key Stage 3; we also bought large size windmills where you could change the blades.

Timing issues
None, apart from having the equipment delivered. It also takes time to work out all the different experiments one can do with the equipment. SEP Associates, who produced the whole set of resources, provided downloadable PDFs with the equipment, which helped the timescale (now available at http://www.nationalstemcentre.org.uk/sep).

New resources required
The equipment mentioned; see **[63]** for the resource pack and teacher questionnaire.

Impact on self
It has been a revelation for me that the £1000 we got initially and spent on equipment was enough to make a difference, and then that success bred the success with the Rolls Royce award. My teaching before this was mainly theoretical. With Physics, girls and boys alike have to be able to see things in front of them with the numbers or they don't believe it, and this equipment allowed for that.

The new practicals have also gone into our electronic schemes of work. Since the schemes of work are changing, staff will have to use the new equipment as the BTEC scheme has to be followed, unlike the old schemes where you can pick and choose. This project raised the profile of Science with the governing body of the school and HT; as they saw the success of the project they invested another £1500 of money into buying a whole set of radioactive sources, a protactinium generator, and a spark counter. The success is breeding more success. The Governing body realise that as a teacher it is possible to work in this way if released from school, so I will promote this in other areas as well through my STEM involvement.

Impact on pupils

Pupils have stated how much they enjoy using the new equipment. Pupils have done more experiments so they feel better about every aspect of the subject. Pupil enjoyment and engagement in turn impacted positively on behaviour. But most importantly, pupils were learning and accessing stuff at a higher level, through the equipment. Because of the equipment, the profile of science has also been greatly raised. The results are definitely going up; we also expect students to pick more Science at A-Level which will bring further investment into the department. Girls' uptake of the subject has also increased, so they are definitely happier. We are looking at doubling in AS numbers for the past 3 years.

We have been able to do different ISA exams for KS4 which is really good as the test was better for our students to take. In KS3 pupils have used the new class sets at a lower level than KS4 but at a higher level than previous years which is obviously very good progression.

Because the energy meters are so easy to wire up and so reliable, this ensured an easy entry point for year 7 pupils, and also enhanced the level of their work and conclusions greatly. The fact that they are now doing experiments that they'd have never been able to do, will only increase their use and understanding in the future. This kind of equipment works especially well for pupils who need to see things and need hands-on work; lower-set students all used the equipment, they all plotted a graph, they all got results, whereas normally they wouldn't have got it all. This is very simple and very powerful.

Impact on colleagues

Because I was the only Physics teacher, I've shown the other teachers how to use the equipment in their classes. All of the twelve teachers in the department now use the kit in their Physics teaching. Teachers are happier and more confident teaching those subjects. I made a booklet about the project that I shared with everyone, with lots of examples and what the project was about, and I put a little picture on a sheet that showed each piece of new equipment and a brief description, which will help the understanding of how to use the kit as there are many different parts. The sheets I used mainly came from SEP which can be edited.

Having bought the equipment, and made the resources and hand-outs, they are there forever, and will be used over and over. Long-term I believe teachers will see that they can do Physics and when they come to purchase new equipment, they will realise that it is more important to put the money into doing a whole class practical than buying things for a demo, even if it is a small practical with a cheap bit of equipment.

Recommendations

Staff needed more training than they actually got; they don't always know themselves how to use equipment.

Using career-based starters to contextualise the topic of the lesson

International School and Community College

East Birmingham, B33 9UF (**Gemma Donald**, now working at Highfields Sciences Specialist School, Boundary Way, Penn, Wolverhampton, WV4 4NT)

School context: Mixed comprehensive, 675 pupils on roll, urban, SEN proportion in the 80th percentile nationally. Overall attendance improving.

Overview of the intervention
We implemented careers based starters into a Year 9 group's SATS based lessons, relating the current physics topic to a career progression route. It was a small scale project with different classes, comparing high and low ability levels. The SATS lessons were delivered over about three weeks and we tried to link the careers based starters into most of those lessons. Following this intervention, seeing some students engaging in specific areas of science, I looked at how using questioning activities could be used to enhance students understanding. This broadened the scope further to more general science and career understanding.

As a result of an initial questionnaire, it was discovered that few students seemed to understand the distinction between physics, chemistry and biology. Therefore there appeared to be little understanding of how physics could be utilised within a career. Within a teaching role, there appeared to be few students sharing their development of aspirations with their teachers; 88.3% of students stated that they had some sort of aspirations for their futures, whilst staff felt that this attitude from students was not always apparent.
Whilst teachers could be a valuable resource to aid students in understanding their future choices, there seemed to be few opportunities to have such conversations, especially within a subject teacher to student context. The aim was to assess students' interest in physics and the physics based careers.

Changes made to lessons
We would start with, for example, a profile of someone working in a University Astronomy Department and talked about how it linked to the topic to try and contextualise it. We also tried to link in some informal question sessions to get the students talking about physics as part of the career based starters. The aim was to contextualise physics topics and link the topic to a career based application. Additionally I introduced informal "question sessions" where students had the opportunity to ask questions relating to jobs in physics. This was developed into a "question box", where students could place more broad science based questions, so that they could be answered later in the lesson/week. Students get some time between activities, or at the end of a lesson, where some questions are pulled out and discussed.

New resources required
Adaptation of PowerPoint; physics careers posters were also used to inform and inspire pupils.

Timing issues
With more time, I would have liked to have involved physics professionals more heavily. For example, holding a Q and A session or hosting guest speakers, to see what effect this may have on student's physics understanding and/or aspirations.

Impact on self
My teaching practice has become more flexible and much more open to the needs of the students. My future teaching will certainly include further linkages to careers, both in a formal and informal manner. It made me a lot more aware of linking to context, even if it's not a topic where students could go straight into a related career, and also made me think about what skills they could get from learning about that topic that they could use in a career. It made me much more aware of how I delivered my

lessons and of providing opportunities for questioning. I'm more aware now of introducing careers into my teaching.

Impact on pupils

Following the implementation of career linked physics starters, a greater proportion of students expressed an increase in interest in physics (10%). When further questioned, many students expressed the view that they had not previously completely understood what physics involved. It seemed to begin to change some of the students' attitudes and engagement within a low ability year 9 group. Some students were coming up at the end of the lesson and asking more about it or were interested in what other careers they could do, so it led into further questions; it was quite useful in getting students thinking.

Measuring the impact was tricky and I can't be certain that there was an effect. A lot of it was informal and building student's interest, so it is very difficult to measure whether it had any influence on scientific ability. In terms of motivation however, I think it helped students to start to consider where they might go in terms of jobs or learning. We don't offer A level physics so it is not possible to measure the impact on post-16 uptake.

Impact on colleagues

Thus far I have shared results informally with faculty staff and students who expressed an interest in the research. Potentially the research could be shared across a wider area, although research would need to be carried out on a larger scale to see whether there is a significant effect on student aspirations/scientific ability. Department staff were very supportive, and it is hoped that career linked contextualising will continue through shared practice.

Recommendations

The informal aspects of the research appear to be sustainable but require a sustained change with consistent contextualisation and informal questioning prevalent in most lessons. This may be difficult to achieve where there is a huge requirement for content at ks4. However, these strategies may be more easily implementable within ks3, and may aid in the development of students' growing understanding of science. There is a potential to investigate and compare different year groups and gender groupings. Students appeared to be uncertain about the *paths* into physics careers so this is also an area to be addressed.

Linked starters appeared to help to set the wider context for the lesson. We also developed a question box for a couple of lessons which is something I'd like to do more of. This allowed students autonomy to engage with science personally, without any of the surrounding peer pressure. This also helped to fuel student's curiosity about science as a whole, and start to understand that we don't always "have all of the answers".

Lessons, Case Studies and Posters in Physics Careers

Cove School

St John's Road, Farnborough, Hampshire, GU14 9RN (**Hywel Jones**)

School context: Mixed gender, 11-16, 1002 pupils, Specialist Technology status.

Overview of the intervention
Years 9, 10 and 11 students (three classes in each year) were first surveyed about their knowledge of physics-related careers and how they would research information on careers. The science teachers were also surveyed on the extent to which they included careers information within their science lessons. The responses from this survey were used to tailor the provision of careers information within lessons to Year 9 classes of medium to high ability.

Many students requested leaflets, brochures, posters; resources with more information on specific careers; salary indications and career progression etc. Career posters were prepared for display inside and outside classrooms, which included physics-related case studies. These materials were specifically geared towards girls in order to balance the gender emphasis often associated with males in physics careers.

Changes made to lessons
Initially a single lesson was used in a Year 9 class dedicated to science/physics careers, which included group discussion on the role of women in Physics/Science and the opportunities open to them.

In subsequent lessons a variety of case studies were used focussing on women in physics careers. The websites used for this were primarily the Institute of Physics, Future Morph, Physics.org, and a Geology website. A range of professions were included, for example Food Technology, Clinical Science, Weather Forecasting, Structural Engineering, Chemical Engineering, Climate Science, and also Law and Finance roles. Careers where it was not immediately obvious that physics would be beneficial and often seen as male dominated were chosen, but shown with female examples.

Furthermore, case studies of careers, in the form of PowerPoint slides, were introduced within specific topics. For example, when teaching the use of infra-red wavelengths, a weather forecasting career was included that emphasised the physics qualifications of a female forecaster and how this qualification was used.

Timing issues
Ideally the entire round of actions should be initiated early in the academic year with Year 9, in order to give them more careers information on physics prior to them deciding on their subject options for GSCE exams in Years 10 and 11.

New resources made

- Posters from the Institute of Physics showing the use of physics in different areas, “Physics creates…”, “Physics serves…”;
- PowerPoint slides with case examples of careers in physics, showcasing females for use within individual lessons;
- A dedicated A2 sized poster on careers in physics: “physics is not just a boys’ game”, and women in physics. The poster cited websites, gave indications of careers in areas such as light and sound etc., including photographs of case studies and career options.. The key point for use of these resources was to ensure a high visibility to all students within the science department.

Impact on self
As a non-physics specialist, this project has given me the opportunity to expand my knowledge of careers within physics, which was previously very low. I now have a much better idea of what

prospects there are for students, and can give them a better indication of what careers options there are. It has probably made my teaching a lot more relevant, giving examples of where physics is applied.

Impact on pupils

As this intervention has yet to be completed and needs to continue for a longer period for a fuller effect, the final impact has not yet been assessed. Within the target group there has been an observed interest in a minority of students with some of the careers highlighted. However, the actual amount of time dedicated to the target group has been limited by the curriculum timetable and needs additional time with that group for further action.

The resources prepared for this project are intended to enable the intervention to be continued over a longer period and across a range of Year groups. The target group for the project will continue to be provided with careers information within lessons, and the work will be extended to other classes and Year groups.

Impact on colleagues

Whilst there is a strong emphasis on teaching physics within the department, this project has provided a whole-department benefit. The number of resources available to students on careers in physics has now significantly improved and can be incorporated into future lessons. There is a greater awareness of careers in physics across the whole science teaching department.

The results from initial project surveys have already been shared with other science teachers to make them aware of its findings. The use of physics careers posters has been spread throughout the department to address a wider audience of students. Additionally, at least one other teacher has ***incorporated more*** physics careers information into lessons. A future aim is to more formally embed careers information into our Schemes of Work. Disseminating further information will again be an ongoing project based on the success of individual actions for intervention.

Recommendations

This type of intervention needs to be aimed at several groups during the year in order to provide continuity of information to students. Especially when, as with us, students are often taught by many different science teachers across the timespan of just a few years. There were issues of sharing/ensuring continuity with the other science teachers (especially with those with less physics experience). However, with the syllabus changing, there will be fewer class rotations, giving longer periods with one class, which should help.

The careers case studies need to be linked in with the teaching and need to be relevant to the specific topic that is being taught. Embedding them within Schemes of Work is part of this process. Providing a dedicated careers provision lesson is not recommended as students quickly lose interest.

Encouraging students to distinguish between physics and other sciences; improving knowledge of physics-related careers

Bradfield School

Kirk Edge Road, Worrall, Sheffield, S35 0AE (**Jeannette Allen & Jennifer Callaghan**)

School context: Mixed gender comprehensive, 11-16, 910 pupils, specialist STEM school; serving a rural area. Students are from an above average socio-economic area; there is an average percentage of students with SEN.

Overview of the intervention

Two Year 10 groups (a top set and a third set) were given separate printed descriptions of science topics and asked to categorize them as physics, chemistry or biology. The students had difficulty achieving this task (for example they struggled to classify topics such as rocks, energy and digestion). Initially the researchers sought ways of improving students' understanding, including specifying the discipline at the beginning of a topic. The method to improve knowledge of physics-related careers involved having a class discussion on factors important in deciding career choices, completing a quiz on significant physics developments using the Institute of Physics leaflet *Expand: physics at A level - the logical choice*, then the students spent two lessons carrying out research on physics-related careers. Over two further lessons, the students prepared and gave presentations on the range of careers they had explored, including aspects such as starting salaries and required qualifications, and this was supported by a display of their findings outside each classroom.

Changes made to lessons

Two lessons for students to carry out research on physics-related careers; two further lessons for them to give presentations on the range of careers they had explored.

Timing issues

The only time available for this work was at the end of the academic year, but this approach could be used at any time of the year and would be applicable for the end of topics.

New resources used or recommended

Institute of Physics leaflet *Expand: physics at A level - the logical choice* (www.iop.org). A range of short videos from *Future Morph* are useful to help raise physics careers issues. The display boards outside the classrooms now highlight careers in physics and these are regularly updated.

Impact on self

We now have a better appreciation of how and why to integrate careers education into physics lessons. Also, the findings from this action research have prompted us to change our approach to teaching physics. We are careful to point out to students which parts of the science curriculum are physics, and try to introduce and discuss physics-related careers as we go along. Closer attention is also paid to avoiding gender-oriented language and stereotyping by relating certain careers to men or women. We are planning to highlight the difference between the sciences at appropriate stages at Key Stages 3 and 4 (e.g. at the start of the new academic year or start or end of a topic).

Impact on pupils

There was excellent feedback from students; they particularly appreciated the class discussions and brainstorming about career opportunities. It is still early days but students appeared to show more interest in physics and in studying physics at A level or degree level.

Impact on colleagues

Other colleagues are now using careers-related resources such as *Future Morph* videos.

Recommendations

It would be beneficial for groups that are taught science as science rather than the individual disciplines to carry out a topic sort to help them to know the difference. It would be an idea to extend the research to include careers in biology and chemistry.

Improving a lack of confidence in the maths aspects of physics

Uplands Community College

Lower High Street, Wadhurst, East Sussex, TN5 6AZ (**Mary Bellhouse**)

School context: Mixed gender, 11-18, 1044 pupils, Science specialist; rural comprehensive, few students from minority ethnic backgrounds or with EAL; percentage of students with free school meals and with SEN below average.

Overview of the intervention
This project took place with a Year 8 (mixed, relatively high ability) class. We were looking at how students perform in maths in science and how this is linked to a mismatch between their perception of their abilities and their actual abilities. To investigate this I gave them a questionnaire asking them about their views on their abilities and confidence in maths and science, and then a short SATS test with maths and science questions. I liaised with the maths department on how to deliver the algebra and graphs topics I picked out (key topics for that age and ones they tend to struggle with), and then did a couple of lessons after which the students did a similar short test and the questionnaire again to see if there was any change. It was small-scale and short time-scale.

Changes to lessons
I liaised with the maths department on which topics are taught and when and analysed the science curriculum to find the most common maths topics utilised in science. I used the maths department expertise to help in the planning and delivery of lessons on these topics within science lessons and I looked at their resources. Students were given positive feedback on their performance in these topics. The lessons were pure maths lessons within the science context, whereas normally in science we do the science and put the maths in. I did a whole lesson on graphs, and a whole lesson on algebra, within science lessons. I tried to teach them different ways of re-arranging equations, by doing group work. We also did a case study and presented graphs on that - the independent learner project we have already where they plot graphs of different data on the solar system.

New resources required
Nothing in particular - I was looking at how things were taught and introduced in maths. See **[69]** for worksheets, questionnaires and PowerPoints used.

Timing Issues
Probably at the very latest in January time to see it through.

Impact on self
I have learned that students do not know their targets (even when told them the previous lesson!) nor do they have an accurate idea of their current performance. They need constant reminders of both their targets and current performance so that they can use that information to guide their learning. Another important change for me is that I don't assume that students have done anything in maths. I always start from the beginning and I try and teach them the maths before rather than assume that they've done graphs or algebra. In an ideal world you'd dovetail the two but I don't think that is ever going to be possible. I'm now also more aware that their confidence in maths is quite low and it was quite a discovery that didn't match at all with their abilities. Some would be quite confident but when you looked at their data they weren't that brilliant at it; and some would be really under-confident, but they were fantastic mathematicians. I therefore changed to aim to build the confidence whatever it is. It changed my awareness generally about what they were capable of doing, and how they lacked confidence.

Impact on pupils
The main thing for me was that pupils seemed to understand their own abilities more at the end of the project. That was quite a major thing and quite important. In the test their abilities did not change massively, but it also depends on the questions and that is something that I hope to work on more in the future.

I found very little difference in the results of the mini-tests. Overall there was a tiny increase in results; strangely the change in results for the maths questions in the test was negative, whereas the change in the results for the science questions was positive. On average, there was a small positive change in attitude and confidence in physics and chemistry compared to a larger negative change in attitude and confidence in maths and biology. The time period was mid-May to mid-July which may explain why there was a negative shift at all towards maths and biology. There seemed to be a noticeable increase in correlation between perceived ability and actual ability in both maths and science. With such a small group, however, correlations are not secure. Boys tended to be somewhat more confident in their abilities, on the whole, but that confidence didn't always match their natural abilities.

Impact on colleagues
I have had a verbal feedback session with my head of department. By extending the project I have shared the project with other teachers in my department but they've not experienced it first-hand. Several teachers were interested in it, and in getting more support with their maths, especially some non-physics specialists. A project like this will help them become more confident, but they felt they needed the support first. This is something for the future, and it was interesting. They were expressing their under-confidence in some parts of maths which hadn't occurred to me as a confident mathematician.

Recommendations
I am hoping to extend the project by introducing maths-for-science lessons to other classes and other teachers. Non-physics specialists have supported this idea. If this comes about, then I believe there will be a long-term effect in increasing students' confidence in the maths in science and so increasing the likelihood that they feel that they have the ability to take science at a higher level. Having a bit more time to liaise with the maths department would also be good. It was quite tricky to find time to discuss things with them which is why I feel it would be a good idea to develop that in science, do a maths lesson rather than rely on maths to support us; we need to teach our own way of doing things and the way it's applied to science.

I had some fantastic discussions with the students and I think it made a difference discussing where they thought they were and what they could do to improve their maths; I think that did make a difference. Providing the opportunities to develop their skills also worked well; it was great to have whole lessons to work on graphs for example and discuss it.

No hands up questioning policy combined with new physics language approaches

Edmonton County School

Great Cambridge Road, Enfield, Middlesex, EN1 1HQ (**Maxwell Mbofana and Eldred Apanya**)

School context: Mixed gender, 11-18, 1608 pupils, specialist Technology, diverse range of socio-economic and ethnic communities (Turkish, Greek, Black Caribbean and Black African); percentage of pupils with free school meals well above and pupils with SEN above the national average.

Overview of the intervention
We explored the effectiveness of our use of language, questions and answers in helping pupils learn and understand physics in our lessons and how this impacted on our teaching and learning environment. We did this with a Year 9 (mixed ability top set) and a Year 10 group (triple science) initially but it quickly spread out to other teachers through our feedback in department meetings.

Changes made to lessons
At the start of that academic year, our school had just adopted a 'no hands' policy across the whole school. I was interested in it because I found from reading that it engages students because you include everyone and pupils don't have the opportunity to switch off as they have when using hands up. We used lolly sticks or random name generators to make sure the distribution of the questions was wide and everybody was aware they could be picked. The lolly sticks had names of everyone in the class; every class had a set. Questions were directed to the class orally and in writing on power point; 20 seconds thinking time were allowed and students were picked randomly (we kept a no hands up - except to ask a question - policy). The electronic random selectors would be linked up with our teaching PowerPoint.

Familiar vocabulary was used before scientific terms were defined and or used. We also incorporated some aspects of the language good practice that the Girls into Physics put into place. In our questioning, we thought carefully about the technical or non-technical language that we used in asking the question; we felt that in physics particularly, when introducing definitions or formulae, some teachers stick to using symbols, which complicates things. We thought it would be easier to develop the understanding using ordinary language; after they've understood the concepts in terms of words, you can then include the technical notations like formulae and symbols with the formulae. When we started, we discussed this at department meetings so that other teachers were trying to do the same, which meant we would get feedback about the impact of the approach.

Through learning logs we designed, we also assessed pupils' attitudes towards physics at the start and during all lessons we did. At the end of the lesson, they would get a triangle divided in four sections and we would ask them to write down one question that was challenging through the lesson, two things that they enjoyed most and two things that they didn't like, and then write what they thought should happen in the next lesson! This became part of our teaching; it wasn't a lot of work because they were small A5 size pieces of paper or card, and we would for example give it to them in the first and last lesson of the week and then compare all the data, analyse it over the weekend in preparation for the next week.

Timing issues
Timing was dictated by the whole school no hands-up policy which started at the beginning of the school year.

Resources used
Lolly sticks; random name selectors; 'no hands' (like 'no smoking') posters were also used

Impact on self
The intervention we put in place really opened our eyes; it changed our lessons completely. The pupils were more engaged, enthusiasm was improved; even the behaviour issues were eliminated because everybody was engaged and I think our lessons became a little bit more interesting than they were before. We learned that using strategies which do not expose pupils' failure to comprehend some concepts leads pupils to enjoy physics more, and find it more interesting and valuable. The 'no hands up' practices give pupils the privacy and confidence to take risks when answering questions and therefore also shift pupils' perceptions positively. The appropriate use of language/ technical terms we found helped pupils to engage and think through the concepts being developed.

Impact on pupils
The 'no hands up' policy has improved pupils attention; more thinking time has improved the pupils' phrasing of their answers and on the whole pupils have become more confident to answer questions and less afraid of getting answers wrong. The use of non-technical terms in early stages has made pupils more comfortable with the technical and short hand forms when introduced. Pupils feel confident using symbols in formula triangles as a strategy for rearranging formulae as opposed to learning them. Pupils were interested in the random name generators; they were keen about the technology and they really enjoyed it.

Generally assessments results in our classes and the department are up. In addition pupils' perception of physics and other sciences is becoming more positive. Pupils have consistently written positive comments in the learning logs about the interventions put in place and there is notable enthusiasm and motivation in science lessons in light of the whole department adopting the interventions. We have some students progressing onto A level physics. There are more students pursuing A level physics now compared to the period prior to the intervention. From the least of the improved ones in our present year eleven, we actually had three girls that made tremendous progress. Two are definitely going on to take physics and one has put it as reserve.

Impact on colleagues
All of us in the department are trying to improve our questioning techniques and our use of language and feel that we have benefitted from being involved in the programme. We consistently fed back to our department and people were trying different ideas that we used. It is now filtering through to all other faculties because our former head of department has been promoted to deputy head and he is using the ideas on a wider school-level.

Recommendations
Next time we would need to develop techniques to ask questions of varied levels. I recorded and analysed a few lessons and found that we did not cover the whole broad spectrum of Bloom's taxonomy. My colleague is extending the language aspect.

Delivering an INSET session on energy transfers and energy transformations to teachers in the science department

Crown Hills Community College

Gwendolen Road, Leicester, East Midlands, LE5 5FT (**Meena Bates**)

School context: Mixed gender, 11-16, 1203 pupils, specialist Sports; 2/3 pupils from Indian backgrounds. 50% of students with EAL; above average percentages of students eligible for free school meals and with SEN/disabilities.

Overview of the intervention

When writing the scheme of work for the topic on energy in KS3 for the National Curriculum 2008 the non-specialist Head of Science suggested that all teachers would benefit from having the opportunity to understand the difference between energy transfers and energy transformations. Thereupon I delivered an INSET session on energy transfers and energy transformations to teachers in the science department in my school. To prepare for the INSET I consulted physics textbooks to research how clearly authors distinguished between transfers and transformations. The INSET involved a practical activity and series of worksheets from basic to complex problems associated with energy transfers. I wanted to find out how non-specialist physics teachers can be supported when teaching the principles of energy transfers; what knowledge and understanding is needed to teach the difference between energy transfers and energy transformations.

The activities during the INSET were very specific: energy transformations and energy transfers, energy converters and energy transfer devices. The teachers indicated they wanted clarification on these topics. I prepared the experiments and worksheets for the CPD. We looked at examples; the teachers worked in groups and they did some experiments, which they followed through, then filled in the worksheet, to see where transformations and transfers were, and why we should call them energy convertors. I produced a booklet which is available at [81]. The second time was much more informal; the teachers wanted a different topic experiment to do and requested coaching in a different topic.

Changes made to lessons

As this was an INSET for teachers, no direct changes to lessons were made, but teachers were more aware of students' lack of understanding of the topic and teachers incorporated new experiments in their lessons which had been covered in the INSET.

New resources required

Depending on the topic of the INSET and experiments used; materials for new experiments; e.g. for the paper kettle experiment to boil water in.

Timing issues

The timing is significant in terms of when the teaching of the topic is scheduled; this creates a momentum, a sense of urgency in the department which is useful for an INSET and the teaching of the topic.

Impact on self

It gave me an idea about how other teachers feel about the teaching of this topic. I'm aware how some people who haven't been taught the topic themselves could find this topic difficult to deliver as teachers, so I'm even more aware how difficult it is for the students to understand it. I am taking a bit more time over the topic in lessons, giving the pupils time to assimilate the topic a lot more than before. I also have a much greater awareness of students' lack of knowledge (and the questioning/curiosity they show) with regard to this topic; and more awareness of how interested students become in learning about everyday devices and how these work. It has increased confidence in my ability to deliver the CPD and given me a sense of satisfaction. The impact on my teaching to the students would be that it increased my confidence in how to teach this subject.

Impact on pupils
The work done during the INSET will benefit the students through greater understanding of the topic by staff. Generally I feel they are much better at science than they used to be. It is one of the topics that they had to learn for the exams, but don't want to claim to have made a massive impact as I have no way of judging this.

Impact on colleagues
All the participants gave the highest feedback rating for how informative the INSET was and for how much they enjoyed it. There was a clear improvement in the understanding of energy transfers and energy transformations following the INSET intervention, and every teacher participating increased his/her knowledge of the topic. Teachers also expressed a willingness to share ideas and resources to improve teaching and learning in the classroom. Overall I was pleasantly surprised at the enthusiasm and the thoughtful input by the team.

The understanding acquired through the INSET will stay with the teachers throughout their career, particularly if they are actively teaching the topic. The retained knowledge in energy transfers and transformations will result in better teaching and learning in the classroom.

The worksheets and the practical activity were shared with the science faculty team. Instructions for making a paper saucepan for heating water generated a great deal of interest. The INSET made teachers realise they can have more of a learning environment; because it was done in school rather than asking somebody from outside to deliver the CPD it created a greater awareness of the resources people can use in terms of asking each other: "Can you show me?", or "How is this done?". I think teachers would say they have learned enough to be able to teach more confidently, and then they took the same approach for other topics. All this is only based on teacher feedback; no lesson observations took place. One or two of the experiments introduced in the INSET are in the scheme of work now.

Recommendations
I would like the science department to have a teaching and learning slot during meetings so the focus is not wholly on administrative matters. Teachers should be given the opportunity to tell the team how they would teach a named topic. This would reinvigorate staff meetings to centre around teaching and learning. If I did a CPD course for colleagues in the future I would certainly like to test their knowledge about a topic before and after the CPD; find out where they are beforehand and what they have learned from the CPD; and see how they changed their teaching because of it.

Student-led questions and answers with teacher questioning techniques using Bloom's taxonomy

Batley Business & Enterprise College

Batley Field Hill, Batley WF17 0BJ (**Mohammed Hanif Abid**)

School context: Gender: Boys; 11-16; 556 pupils; Business and Enterprise specialist status. Most pupils are from areas with high levels of social and economic disadvantage; high numbers are eligible for free school meals. A higher than average proportion of students with learning difficulties and/or disabilities; 80% are from minority ethnic backgrounds; 75% of students with EAL.

Overview of the intervention
With a high ability triple science Year 10 group, the focus was on how effective questioning techniques help make physics easy, relevant and more understandable.

Changes made to lessons
I changed teaching & learning to focus more on different level questioning techniques which took place with the P1B Radiation and Universe module. I asked one group of pupils to come up with different levels of questions from the text that I was going to teach, and then I asked the other group to find the answers. The questioning was related to Bloom's Taxonomy: student comprehension, application and different levels of recalls. Before every class I photocopied the text I wanted to teach them; for example the electromagnetic spectrum; nuclear radiation; or digital and analogue signals; and then I asked them to work in a group and make or prepare at least 10 to 15 questions from this information. In the second lesson the other group prepared the answers, and they would discuss question and answer. Then the groups reversed roles. All the while I was circulating the groups and they could discuss things with me. Later on, when I used the why-questions for some of the open questions, this was about same text. When we had all the answers we discussed them. All in all it would take about 45 minutes. Students enjoyed this activity.

I first did this every two lessons in a week; in the second round of my intervention, to prevent me giving too much input, I asked more 'why?' questions, and the pupils explored the answers using text books. I did this for two lessons a week until I had taught the whole topic. Because I'm a chemist I teach them chemistry as well, so I changed my teaching style similarly in their chemistry classes because of this project, in terms of questioning techniques. I told them about Bloom's taxonomy. For this activity, most of the time students are in charge of the learning, and so it was very much a pupil-based approach. They looked up further information from the internet and they were asked to make Powerpoints from the information they found, in their own words, and they discussed this in their group.

New resources required
Information from the internet, cuttings, textbooks, exam papers; texts from various sources. Powerpoint for students to access and work on and make a Powerpoint in their own words.

Timing issues
This approach can be adopted for any topic at any time of the year.

Impact on self
My teaching has completely changed because of this project: before this research it was much more teacher-led; I tended to talk a lot more. Because it was such a successful project in terms of results and post-16 take-up of physics, it was really satisfying and personally I learned a great deal; it really made me think about changing my approach to teaching.

Impact on pupils
The response I got from the pupils after every lesson was very good. Before the intervention they found physics boring and difficult – a dry subject. All across the abilities, they found it very interesting. Because I gave them the chance to explore by themselves, using different sources, ICT and internet etc., they didn't find it boring, they enjoyed themselves; and they learned a lot each lesson. It works across all the physics concepts, whether difficult or easy; for example forces, radiation or energy; they understand it better and enjoy it more, because you break things down into smaller steps, and anybody can do physics in this way.

The GCSE grades for this module, after this project, were fantastic - the highest of all groups. Nine out of 16 pupils got As and A*s and the rest got Bs, and a couple of Cs. This is much better than the chemistry modules I taught before. Six pupils decided to carry on physics at advanced level and they got a place in one of the Sixth Form Colleges/Grammars. When I started this project and undertook the intervention, I asked how many wanted to carry on physics, and nobody put their hand up. They said, "It's difficult Sir, is very difficult. I like chemistry, biology, but not physics". But when they finished this and the results came they were enthusiastic, and when I asked them again to put their hand up if you want to carry on physics at advanced level, I think it was 8-10 hands up, and 6 definitely got a place. The results were better than my chemistry classes, and I am a chemist!

Generally student attitudes changed, pupils became more positive about Physics, and there was a more positive environment in class. I have been doing this with other groups as well, Year 11, and in my chemistry classes, so there will be an effect across the board.

Impact on colleagues
The whole Science Department were informed before this project, and after this project they compared GCSE and NVQ results with us, and were shocked; they realised that this is very good practice. They found it very interesting and have also tried the approach with their groups and changed their practice. They will be trying it further, although they are more interested in the type of questioning I used. It is also worth considering across other subjects. When Ofsted came this year, they were looking for questioning, mostly open why-questions, thinking time, and more time to respond. So the staff and the school are all aware that this is good practice, and they will use Bloom's taxonomy more.

Recommendations
Next time I would use higher level (in terms of Bloom's taxonomy) and more research based questions, with students looking up research using the internet and other resources. It depends on the ability of the group as well - though this will be appropriate for lower ability children as it will make things easier to understand. It's a matter of finding different texts, different resources, and taking small steps with questions and answers.

Looking at questioning; pupils designing lessons; physics mural

The Sweyne Park School

Sir Walter Raleigh Drive, Rayleigh, Essex, SS6 9BZ (**Nerys Aylen**)

School context: Mixed gender, 11-16, 1273 pupils, specialist Science; few from minority ethnic backgrounds; average percentages of pupils with SEN/disabilities

Overview of the intervention
Different ways to get pupils involved in answering and asking questions were tried with a high ability Year 8 group. Mini white boards were used in a number of lessons where all pupils had to try and answer open and closed questions; the only writing that took place was on the white boards. With other lessons a stimulus was provided and all pupils had to think of a question that they then asked the class and then the class tried to answer. Furthermore, I planned lessons according to what the students wanted across a whole physics topic. Alongside, they worked with an artist in residence on a physics mural about the relevance of physics in their lives. I also went on a trip to CERN and involved them in the activity before and after the visit.

Changes made to lessons
Lessons were delivered in the same way but by using the mini whiteboards, students were expected to respond in a different way. I made the conscious effort of not asking for hands up, but for them all to write a response on the whiteboard, sometimes throughout the whole lesson.

I also had pupils designing the lessons, based on a questionnaire which I used as a plenary. It was hard work because it involved incorporating what the pupils wanted in the following lesson based on what they suggested, but it did give me feedback about what they thought was going on and I could assess their understanding and identify misconceptions. I was trying to give them ownership of the subject, trying to get them engaged with the subject and listening to what they wanted to be doing in the next lesson.

Another activity was providing a video stimulus (a YouTube video) to the class. They all had to come up with a question about the video and try and answer each other's questions. I believe the pupils enjoyed it because they were more involved with it. In effect it was learning directed by them; I found out what they understood, what they were thinking about and which way to direct them, and also it helped identify misconceptions. It involved the more quiet pupils that would normally not involve themselves as much in the lesson.

Students made a physics mural with the schools artist in residence. In preparation for the mural, I talked with the artist and pupils about identifying key areas of physics and how it had impacted their lives, and they then had to find or draw their own images and with help of the internet focused on where physics is in their lives. The artist then helped draw things out on a stair case in the school, which is seen by all pupils and staff on a daily basis.

I was also lucky to be involved in a trip with the Science Learning Centre to CERN. Instead of seeing it as a trip just for myself I involved the pupils with the planning and preparation. I got them to research what was happening at CERN. They all had to write questions for me to ask the scientists whilst I was there. When I returned I gave a lesson where I discussed the trip, gave answers to their questions and just excited them with the world of science. On a personal point of view it also helped me with my engagement of physics.

New resources required
Mini whiteboards; YouTube videos; art materials. See **[86]** for related questionnaires, posters, and documents.

Timing
All these activities took place in a period of a term and a half.

Impact on self
I felt that the white boards have had a positive impact in the lessons. I had engagement from more pupils in the class; I was able to identify misconceptions, involve more pupils in the lesson and turn the classroom into an environment in which all are active members. I learned that I should "go with your instinct" - I was able to respond to the needs of the pupils and change the direction of my lesson with regards to all getting the chance to ask and then answer questions. It was very powerful to let (almost insist) that all pupils ask questions. It has also helped my behaviour management because some of the pupils who had been switching off before suddenly had to listen to involve themselves.

My teaching has changed in the sense that I'm less scared to try things out, which then obviously benefits the pupils and meets their needs! It's also made me think about resources I've been using. I am not a physics specialist; however these activities have led to a major growth in my confidence, understanding, enjoyment and my use of resources in the specialism which I think must also have a direct impact on my pupils.

Impact on pupils
The key findings for me were that there were pupils who felt too shy to ask and answer questions in my classroom; and the effect on pupils' engagement when using the mini white boards – 93% of the class said they enjoyed the use of mini whiteboards in the lesson. However I have not managed to measure the impact on their learning as I have yet to carry out an end of unit test where the white boards were a major factor in the module's lessons. The activity of providing the stimulus which the pupils then had to question was also very much enjoyed. Quite a few pupils were 'chomping at the bit' to do the physics mural and that got them thinking; they were involving themselves a lot more. They were happy to be in my lessons and happy to involve themselves.

The top set for triple science in year 10 is made up of pupils who were in similar ability year 9 top sets. Normally one third of the year 10 top set would come from each year 9 group however 14 of the 21 pupils came from my year 9 group – twice as many as might be expected. This is an indication that the pupils liked the intervention as they wanted to study science further.

Impact on colleagues
I think that as a result of my involvement, teachers who want to do something about their subject weaknesses have seen me going on courses to improve my subject knowledge, which people within the department now realise they can do as well and they seem a lot more open to it. I'm not aware of other colleagues trying the questioning techniques but there is going to be a whole school push on questioning so maybe there will be an opportunity for us to do some CPD to then make it their practice.

Recommendations
I wouldn't use the white boards every lesson; I don't think it would have such an impact if it was used all the time. When pupils are designing the lesson it was hard work however there were rewards in terms that I could assess their understanding. I would try and get them to design aspects of the lesson at the start of teaching a module giving me more time to integrate their ideas into my plans. Providing a stimulus where pupils need to ask and answer questions was a nice activity and is a good tool for engaging pupils; however it would not be suitable in every lesson, but could be scaled down with perhaps a leading question to get them thinking.

Cross-curricular lessons to re-engage demotivated students in Physics and to get them to consider their place in the universe

South Dartmoor Community College

Ashburton, Devon TQ13 7EW (**Phil Atherton**, now working at The International School @ ParkCity in Kuala Lumpur, helping to set up the new school)

School context: Mixed gender, 11-18, 1658 pupils, Sports specialist, rural comprehensive; percentage of pupils eligible for free school meals below, and percentage of pupils with SEN above national average.

Overview of the intervention

The P7 Observing the Universe topic of the GCSE Physics syllabus was delivered to a Year 10 (fairly able but demotivated about physics) triple science group using creative, cross- curricular teaching and learning techniques which led to benefits in motivation, interest and attainment for this group. We chose to work with and created a series of lessons linking the subjects of Physics, English, Art, Photography, ICT and Drama. I also wanted to investigate the 'wow' side of physics and the social and emotional aspects of physics, while giving students the opportunity to have fun studying physics.

From my previous research, space science and the universe appeared a good way of capturing the interest of girls. I collapsed the normal science timetable for the second half of the summer term, and we gained time from other year groups that had left on study leave etc. so that's how I was able to engage other teachers in the project. The Head of Department was very forward thinking and allowed me to do this. We all worked together to get this 'wow' element into physics and get students to develop their emotional and intellectual curiosity about science and the universe, with an overriding question: what is their sense of place within the universe? The final outcome of the project was an integrated piece of artwork which used science, photography and creative writing and brought it all together.

Changes made to lessons

Students were working in a very independent and creative way. Lessons were delivered by multiple teachers with a common goal. Students were introduced to a fieldwork/observation task for which we used the Norman Lockyer Observatory in Sidmouth. We wanted students to get a real 'wow', and hands-on use of professional telescopes observing the night sky. They were looking at different photographic techniques and art techniques and then going to the observatory and being taught by the astronomers and getting to use all of the professional telescopes at the Observatory. We also studied photography techniques, where they learned macro-photography and micro-photography, and made light pictures with torches – this was all building towards their final piece of artwork. At the same time we were introducing various different artists as well, such as Kurt Jackson and Andreas Gursky, who had already looked at the issues of putting small objects in big backgrounds to create this idea of a sense of insignificance, as it were, within a background.

New resources required

The resources used in this project are all electronically available, see **[102]**. They include a selection of fantastic images from the Hubble Telescope, practical physics activities including making telescopes and a whole selection of videos and images for stimulus.

Timing issues

Because of the cross-curricular nature and the need to involve other teachers, the second half of the summer term was really the only point in the year where this could be done without it incurring quite a lot of expense in buying in extra expertise.

Impact on self

I have learned about the power of Action Research as a teaching and learning tool and from attempting to deliver more of the physics curriculum in creative and cross-curricular ways. Also I learned to consider the physical environment when planning teaching and learning strategies.

Impact on pupils

From student interviews, journal entries and staff interviews it was obvious that the majority of the class enjoyed the “new” way of teaching and learning. The class as a whole were more engaged with and focussed on the work. There has been a longer term positive change in attitude toward physics generally and a number of normally disruptive students really came into their own and worked in a very different way to their “normal” lessons. However some of these have returned to their previous modes of work and behaviour.

All students produced a final piece of work to be proud of. From the student questionnaires it turned out that students found physics slightly harder, but more interesting, and they were more likely to choose it post-16 than before the project; the latter was also confirmed in confidential interviews. Some students in the class indicated that they found it “hard to get their head round” the fact that they were using teaching and learning techniques from other subject areas within science. This was backed up by teacher interviews, where non science staff felt that students found it more difficult to access the skills in the science classroom that they had developed in other subject areas.

Impact on colleagues

In terms of changes to lessons this was a complete change for me and my colleagues; a total change in planning, because we all sat down together and actually organically grew the project from start to finish , which is quite rare in teaching, to be able to do that across disciplines. There was a school-wide, or inter-departmental cultural shift going on, which is something that the school as a whole is working towards. I have also disseminated quite a lot of this through various courses that have been run, for teachers here and across the South West, because I work as a freelance consultant for the Triple Science Programme and the Science Learning Centre. We have what we call “Deep Learning Days” at this school where we collapse the curriculum for a day; the success of this project got the college thinking about adopting the collaborative learning approach more widely during these.

I think that the school will be carrying on using this cross-curricular working. All staff involved in the project felt it was an incredibly powerful way of working and from a professional point of view really enjoyed being able to work with colleagues in this creative, cross-curricular way. The work has already been disseminated within the department and other teachers have taken on board the ideas and developed “spin off” pieces of work. There is a will from teaching staff to continue with the work. I also disseminated the project to the senior management through discussion and meeting with leadership team. Some of the images from this project are going on display at an art exhibition in the South Bank.

Recommendations

We should be doing this more often, as some students fell back into their ‘old behaviour’. The more open ended, free working, creative environment which sometimes science (slogging through a GCSE curriculum) doesn’t lend itself to, worked really well. There was more time for the students to reflect. Because of the difficulty students experienced transferring skills from one subject to another, the next time we would consider non-subject specific geographical areas to do it in.

Experimenting with mini-whiteboards

Phoenix High School London

The Curve, Shepherds Bush, London W12 ORQ (**Ruth Armitage**)

School context: Inner city comprehensive, West London; 850 students (year 7–11); 80 in new 6th Form; diverse intake; large proportion of students with EAL/SEN

Overview of the intervention
The use of mini whiteboards was explored in a Year 9 top set Science group, who started GCSE the previous year – a big group of boisterous pupils, with a wide range of current levels and targets. I was therefore experiencing issues supporting the learning of all pupils. I wanted to ensure all pupils are focussed on learning all the time and that I could check this; i.e. support any lower ability students whilst pushing the higher ability ones.

Changes made to lessons
Mini White Boards were used in a variety of ways: short answers to questions and mathematics problems; working out complex systems, with the teacher correcting parts and pupils then copying this into books; long answer questions (students are amazingly comfortable writing these on mini white boards when they feel there is too much writing in lessons!). It has evolved a lot from when I were actually starting to use it; from very basic, to now using it in group work, with the scribes writing the notes onto mini-whiteboards; or if they are peer marking they can go round each other's posters and write notes on a mini-whiteboard instead of a permanent red ink on somebody's work. Part of the success of it is that it's not set in stone what they write and that's why pupils like it.

Creative use of the whiteboards made my lessons more interactive and has had a positive impact on the learning. It very quickly made me aware of who was 'getting' things and who wasn't. It does require a certain level of discipline. If a class hasn't used whiteboards much before you have to remember to go back to basics with discipline, such as when they use them and when they put them aside and focus. Using the whiteboards allows you to instantly correct and improve; it's a nice way to do diagrams: pupils can represent things in different ways and show you, and then translate it across to their book. By experimenting you learn lots of ways of using the mini whiteboards.

Timing issues
These methods can be used during any time of the academic year; recently I have found them very useful in revision activities.

New resources required
Mini whiteboards for all pupils; enough working whiteboard pens and sponge rubbers – or tissues. I evaluated the possibility of storage – having each one in a plastic bag with rubber and pen, but have settled on having them all together in a box, and handing them out – usually pen last.

Impact on self
It has made me much more aware of what students are doing in the classroom. I don't use the whiteboards in every lesson, but wish I could. It is just so good to be able to see that (or whether) everyone is being productive all the time. By using mini whiteboards you can see how much effort they are putting into their answers all the time. Students need to be tuned in all the time and it is quite obvious if they are not. Before I started this in my second year of teaching I hadn't a clue where most of the kids were because I didn't have time to get round everyone; using mini whiteboards was a big eye opener for me in realising that you can't teach pupils and help them progress if you don't know where they are!

Impact on pupils
Students are verbally more confident – they understand more now; enjoy the lessons; are less scared of exams. Students are less able to coast below the radar in lessons if they are expected to show answers to questions all the time. Each student has a higher number of interactions with teachers when using mini whiteboards than without. Using whiteboards enables students to know straight away whether they've got it right or wrong and they like that.

I have noticed particularly that the lower ability classes really value the use of whiteboards. This morning I asked students to write a long answer to a question and three separate students asked if they could draft it on the mini whiteboards first, then copy into their books. Others saw this and copied. It was very impressive.

Impact on colleagues
I pushed for all teachers to get a set of whiteboards in their classroom. Each teacher now has got a full set which means they're there all the time waiting to be used, which helps. At a science faculty meeting I did some basic initial training – shared ideas. All this has made a big impact on the department. I am organising an update for our department, discussing what worked well, and whether there are any new ideas. I also did a training session for an INSET last Christmas and I spoke about mini-whiteboards to the whole staff.

In my position of Coach of Teaching & Learning I'm working with individuals across the school that have been isolated by the Headmaster and who would potentially benefit from one-on-one coaching and I have spoken to the Headmaster and the Deputy Head involved about the benefits of using the whiteboards, which they are now sourcing for more teachers.

Recommendations
One of the key things is introducing the whiteboards to the class and being very strict with rules about how to use them. You have to be resilient with the use of them, if pupils mess about students lose the privilege of using them.

I find that with different classes, different things work. With the low ability classes, real special needs groups, they can write out full answers and you can come round and correct – you can write a sentence and you can rub out a word and ask them to think of a better word for it. I introduced LSAs to it by working in small groups and using it as a mini teacher's board, so they can write out sentences for the kids, and then do brainstorms as starters on the mini-whiteboard, as well as correct spellings.

It's also brilliant for learning how to draw graphs because you can just say "sketch" for example speed-time, or distance-time graphs; they can just split their board into four and draw a graph in each quarter. This saves time without reducing any educational benefit of the exercise. It also allows me to see straight away who is right or wrong.

Student careers presentations about physics during one lesson a week

Levenshulme High School

Crossley Road, Levenshulme, Manchester M19 1FS (**Sophie Brickland**)

School Context: Girls' school; 11-16, 953 pupils; specialist Language; pupils from a wide range of ethnic backgrounds; high percentage of students eligible for free school meals and with EAL.

Overview of the intervention
With a top set Year 8 class, I first spent about twenty minutes talking about what physics is and what it involves and from then on, two pupils a week did a presentation on their own about physics. They had to produce a presentation about anything they chose as long as it was related to physics; for example, it could be a famous physicist, an invention, or some physics that had been in the news. Often the presentation would then lead to a conversation about what we had learnt from it.

Changes made to lessons
Once rolling, it was easy to maintain; it just meant making sure that there was somebody on the presentation rota for each week. However the length of the presentations tended to vary and therefore I needed quite a lot of back-up work from the scheme of work. But it was really the students doing all the work and me just facilitating it! Occasionally students had to be put back on the right path: students who weren't very interested in physics sometimes went off topic, so I would find out from them in advance what they were thinking about doing their presentation on, and we would look into "where's the physics in that?". One girl did her presentation about tornados and we had a discussion about the physics in extreme weather and thunderstorms.

Timing issues
Because they were top set, I was able to get through the scheme of work in other lessons. This took up one period out of the four a week we have, so it was really only feasible because they were a group who would get through the scheme of work quite quickly. But it worked out quite well because we had one lesson a week that was difficult to fill because we were not in a lab.

Resources needed
Ideally, interactive whiteboards for students to do the presentations on; audio and video devices for sound and video material in the presentations.

Impact on self
I've used some of their presentations in other lessons because they are so good; some of them included some really good videos. Because we talked about space a lot, when it came to teaching space with Years 9 or 10, an unexpected outcome was that it gave me more confidence to hand over the lesson to the pupils, to have more open lessons with a bit of a debate; pupils all putting their hands up rather than me teaching. Sometimes the presentation finished and about fifteen hands would go up with questions and I would spend ages answering all the questions! It made me realise you can do a lesson like this as well.

A survey I gave them before and after the project about "what do you think physics is?" showed they didn't know very much at the beginning whereas afterwards they could all list about fifteen things! They all said that they were more interested in physics and they ask a lot more questions. I think they are more confident when they hear the word 'physics'; they now see physics as a much more positive thing and enjoy it more because they have had a lot of fun in lessons learning about many interesting aspects of physics (I had a parents evening recently and one of the Year 8 girls said she wants to be an astrophysicist!). I think they have gained presentation skills and personal skills in terms of confidence. I am not aware of it having impacted outside the classroom –but they have been talking about it with other pupils.

Because of the ARP project I was encouraged to do this; I don't think I would have come up with the idea myself. In the day-to-day school environment, you are not very often forced to come up with a completely original idea that you then commit to do. When I started it this time last year I was an NQT and I don't think I would have had the confidence to do it unless inspired to by the IOP.

Impact on students

The project inspired a lot of conversations with some very bright Year 8 girls about physics topics that are not in the National Curriculum for Year 8! Topics like aliens and black holes students just find mind-boggling and it has inspired quite a lot of questions and discussion. They wouldn't otherwise have had any of these conversations and now we have a group of girls who are interested in physics. As it is driven by them; and they have chosen topics they find interesting, there is a good chance that it interests other girls in the group too. At the end the students were still coming up with ideas for presentations and asked if they could do more!

It did not impact on grades at the time but I think it eventually will, because when they get to GCSE they will have a better understanding of some topics. It is possible that the time lost in lessons may have resulted in them making slightly less progress overall in science during the 12 months, however I thing that the fact that they have a much better understanding of science in general and they're much more enthused about it, more than compensates. As there is a move to focusing on "How Science Works" within the SOW, this project supports this as many presentations were about by looking at the work of scientists, how they gather evidence and how they collaborate together on projects.

Impact on colleagues

All colleagues were aware of my project and one tried it; however, because it does not directly relate to the scheme of work, and we get assessed on student progress every six weeks, some teachers didn't want to take on that responsibility or risk giving up this much time in class.

Recommendations

Not all of the presentations were brilliant; about half of them have been good enough to generate a real debate and interesting conversation in class. Occasionally we needed a reminder about what physics is. Also, I would have liked them to find out a bit more about famous scientists and what inspired them. We are a very multicultural school, so it would be nice to have presentations about what physics came from their part of the world or to look at science in different parts of the world. I also had to be careful that it didn't affect their grades because then I would be questioned on giving up an hour week. I would like next year's Year 7 and 8 teacher to do it, but I fully appreciate that some teachers may not be confident enough with the topics or to allow pupils to spend this much time on it. It would be difficult to do this project with a KS4 class, as it is difficult to fit in the amount of content at GCSE. Lastly, because it does not directly relate to the SOW, it has to be a carefully chosen class and carefully chosen year.

Improving course organisation; integrating more practical work into the schemes of work at AS-A2 level

Groby Community College

Ratby Road, Leicester, LE6 0GE (**Sue Woolhouse**)

School context: Mixed gender, 14-19, 918 pupils, specialist Language; Indian pupils largest subgroup; small minority of students with EAL; percentage of pupils with free school meals and SEN/disabilities well below average; Key Stage 4 provision made in partnership with local FE college.

Overview of the intervention

I wanted to look at improving student engagement in the AS course with a view to improving both the attainment at AS and the percentage of students progressing to A2. I therefore improved the course organisation (including use of topic summary sheets and past paper booklets), and engagement with outside agencies (trips to the Space Centre for the Careers Fest and for Master Classes). I also made sure there was more practical work, integrating the practical skills component of the course into the scheme of work. As we got more knowledgeable about the way the practical was assessed, we were able to integrate it more in our day-to-day teaching. I think that's upped our practical marks. I also tried different teaching and learning strategies to promote engagement. For example I allow the students to do much more group work or pair work where they were encouraged much more to discuss ideas and work through problems together.

I carried out the project as subject leader for Physics (the Physics department consists of me and a member of the SLT). I am now doing similar things on an annual basis; it's embedded in what we do, and I am trying to keep on improving what I do, so the next thing would be to try and get things more formally embedded in the scheme of work.

New resources required

Topic Summary Sheets
Past Paper Booklets

Timing Issues

This approach can be used at any time; for us this particular time was important because we had poor results and the numbers carrying on to A2 were dropping off, so something needed to be done.

Impact on self

The opportunity to share ideas and meet together with other teachers increased variety and led to a better range of teaching and learning strategies. The Action Research Programme has kick-started a reflective cycle of continuous research, intervention and evaluation that will help me to keep improving our A level Physics provision. I will continue to look at our data and listen to the student voice (via questionnaires and discussions), respond with appropriate interventions and evaluate their impact. The project was a great opportunity to reflect on my own practice.

I have learnt how powerful the student voice can be. The questionnaires provided a lot of positive and encouraging feedback on our course and some good ideas on how to improve. As a result I have employed a wider range of strategies in my classroom. I will continue to listen to students and respond to their ideas. I have been impressed with the students' positive reaction to the Careers Fest at the Space Centre. It was great to see so much enthusiasm about Physics! I will keep using outside agencies to enhance our provision.

I am looking ahead to the way in which I might teach Key Stage 4 Physics, because the changes I implemented in AS already made me start doing things differently at Key Stage 4 level. For example, we started to adopt a certain language around practical skills, and students are assessed according to how they evaluate practicals; we incorporated a little chant: limitation, improvement; limitation, improvement; to get them to look at what the limitations are and how they could improve every time they do a practical. Knowing that we do this at A Level, you naturally start doing it at GCSE, encouraging them to look at things in that way.

Impact on pupils
The summer 2010 AS results were much improved (from only 6% achieving their target or above in 2009 to 50% in 2010, and 80% this year) and the stay on rate increased (from 25% in 2009 to 74% in 2010 and 90% this year!). We now have healthy numbers in both AS (20) and A2 (23). We now have students coming through who have done separate sciences so that will probably raise the profile of the subject as well. In 2009 we didn't have any girls; 2010 we had a quarter girls and it is the same this year as well. Looking at the figures I feel that what we've done is significant in Physics; we've impacted hugely, in pushing this number of students through a challenging A Level.

There is a more positive feel in physics. For example, the students in Year 12 were definitely enthused by their trip to the Space Centre which opened their eyes to the exciting careers opportunities in Physics. In the classroom, there is a greater range of teaching and learning strategies employed to encourage more active and reflective learning. When students were asked to rate the course on average the students scored it 8.2/10, a shift upwards from the 7.5/10 rating from last year's Year 12! There is a definite buzz about the subject now; students are really switched on and enthused by it and come to me with ideas and challenging questions.

The trip to the Space Centre enhanced the work in school, for example the master class around modelling the Universe enhanced this particular module at school; and the students were taught less of it in school because they were going to explore so many of the key concepts at the Space Centre.

Impact on colleagues
The action research is sustainable and will have a long term impact as it has started a reflective process that will enable me to continually look at ways of improving our provision. Some of the changes are embedded in our practice; others will need to be written into our schemes of work. I will share the learning with the other Science Subject Leaders and have shared my experiences with the Action Research Forum in the East Midlands Region.

Recommendations
I feel that the improved course organisation has hit the spot for students in terms of helping them through the course. The next thing to develop is formalising and improving the schemes of work so that the changes are more embedded into what we are doing, and are easier to disseminate when we get a new member of staff. With the Space Centre trips, we could look into doing more of a build-up and follow-up; at the moment it is more a self-contained day.

Crime scene forensics

The first lesson set the scene with a cup of tea on the front bench. Pupils were divided into groups of four and introduced to the scenario. (see Appendix 6 'Crime fighting and forensics). After an initial class discussion of probable actions to follow (e.g. reconstruct the crime scene, measure time taken for boiling water to cool, work out how fast someone walks), each group was left to solve the problem. In the first instance, some pupils were doubtful that the techniques could be considered viable to solving 'the crime', although all groups completed all the tasks. The results for each group were considered during the plenary and students were impressed by how close individual group results were to each other. The worksheets included questions both about their work and a self-evaluation part, where pupils could reflect on what and how they had learned during the lesson. 52% of pupils highlighted working as a team as a measure of their successful investigation, and 64% included factors such as improving measurement precision and repeating experiments to better their investigation. Quantitatively, 44% of pupils rated the lesson as very enjoyable, 40% as enjoyable and only one pupil (4%) stated they had not enjoyed it at all. When asked about how much they had learned about physics and forensics, 20% stated they had learned lots, and 68% stated they had learned some, with again only one pupil stating they had learned nothing. 64% of the pupils had had no idea that forensics involved the use of such methods to investigate crimes, and of those 36% who had some knowledge, they cited the television as the main source of that information.

Meteorology

The second lesson focused on weather forecasting and began with a broadcast of a weather forecast from the BBC. Pupils were asked what they knew about how air pressure influences the weather and what a barometer shows. Pupils were shown a barometer scale asked how the pressure seemed to correlate with the weather. Most identified that falling pressures seemed to mean poorer (i.e. windy or wet) weather. Each group then proceeded to make a very basic aneroid barometer and set up a scale for future reading. The groups were then given a weather map from different locations in the UK and asked to produce a weather forecast presentation. Many groups decided to use television weather forecasts as the basis for their presentation and produced posters to use as their 'blue screens'. Each group then presented the forecast of their area and the class decided where their area on a UK map, using the pressure isobars. The pupils had previously done lessons on pressure looking at scuba diving; however none of them had previously linked air pressure and weather forecasting to previous lessons on pressure.

Stage lighting

The third lesson in the sequence was in response to the number of pupils who had highlighted their desire to have careers in the arts or on the stage. Various laser and light shows were shown as a starter (including a light show by Polish students - http://www.youtube.com/watch?v=Uv8M2qLEMuE). Pupils were then given a cardboard box, ray box, lenses and mirrors and an assignment brief to create their own stage show, with permission to use their IPods to provide the music. After 40 minutes, each group visited the other 'arenas' and provided feedback to the groups about the quality of their shows. All the groups enjoyed this lesson with one pupil feeding back to me as the lesson having been "the best Science lesson ever, Miss." (see Appendix 7 for photos of the finished arenas).

Oceanography

The fourth lesson took sound and sonar as the topic to be covered. The class were shown a sequence from 'Finding Nemo' where the fish and sharks swim through a minefield. The ensuing discussion focused on how we could find out about minefields underwater, and similarly mountain ranges and abysses. The idea of sonar and bouncing sound waves was introduced (and compared to ultrasound for prenatal testing). Each group was given a sealed box as their 'underwater landscape' and skewers to model the sounding sticks. Grids were given out and the class set about recording their landscapes on the grids. Once these were completed, the contours were cut out and stuck down so that a 3-D landscape ws illustrated. Then box lids were opened and compared to their model. Pupils were astounded that their models were so close to the reality. We examined the submarine contours in Google Earth and established that contours were very wide where there was little data.

Archaeology

The final lesson in the series was an adaptation from one produced by the Earth Science Education Unit at Keele University. This lesson allowed those who had some knowledge of archaeological practices to model how geophysicists locate subterranean structures using electricity. Electricity was identified as one of the subjects that pupils identified with least and so I felt it was important to include a more applied approach to using electricity rather than the usual bulbs and circuit methods. Pupils were given a preset up board with a series of gridded slots. Into these, they had to insert electrodes and measure resistance, recording the resistance onto a grid. When the whole board had been completed, areas of no resistance were identified as metal structures, and those of large resistance identified as wooden structures. All the mid-range quantities were identified as soil (which preliminary experiments had determined had varying resistance according to salinity and saturation). Due to time constraints during the summer term, not all pupils completed this lesson: those that did found these concepts the hardest to understand; however they were secure in what the results described and could relate it to the geophysical structures shown on 'Time Team'.

Physics Careers

A range of lessons that allow pupils to consider how Physics is used in different careers.

Contents

Careers

- Forensics Scenes of Crime officer
- Meteorologist
- Stage lighting engineer
- Oceanographer
- Archaeological Geophysics Surveyor

Physics Career 1

Crime Scenes & Forensics

Crime fighting and Forensics

- You are a group of forensics experts at the scene of a robbery.
- You have evidence to work with, but a limited amount of time.
- A criminal is escaping and you need to help the armed response unit search in the right location.

Crime Scene

- There has been a robbery.
- An elderly person has been left unconscious.
- Some items are missing.

- The robber was so calm and collected after their crime that they helped themselves to a cup of tea.
- The police sirens have scared them away. All that remains is half a cup of lukewarm tea.
- Your job is to work out how far the robber has got away from the scene of the crime.

What to do?

- Work out the temperature of the tea now.
- Work out what the initial temperature of the tea would have been.
- Investigate how long it would have taken to cool down.
- Decide how far the robber would have gone in this time if they had walked away from the scene.
- Physics careers worksheets - forensics.docx

Equipment list (for technicians)

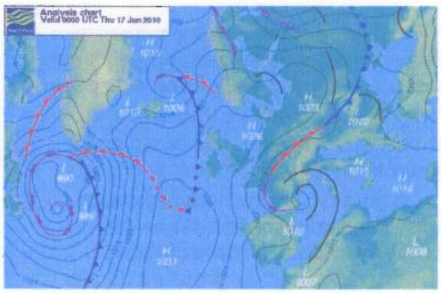
- Kettle
- Thermometers
- Beakers
- Timers
- Measuring cylinders
- Trundle wheel

Physics Career 2
Meteorology
(or weather forecasting)

Met Office

Weather forecasting

- You work for the Met Office as weather forecasters.
- Most changes in the weather is caused by changes in atmospheric pressure.
- You are going to build a simple aneroid barometer to watch for changes in the weather.



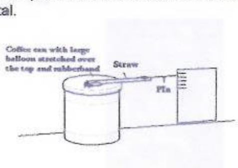
Learning objectives

- Understand and explain how a barometer works.
- Build a model aneroid barometer.
- Use a model barometer to indicate when atmospheric pressure is rising or falling.
- Use barometric information to make weather predictions.
- http://sprott.physics.wisc.edu/wop.htm

- Weather forecasters make predictions using wind speed, pressure, humidity and temperature.
- The most valuable information in making predictions is **atmospheric (barometric) pressure**.
- A weather forecast based only on pressure trends is about 70-75% accurate.
- The maps have isobars (lines)of air pressure.
- You will be building an **aneroid barometer**. Although it is not as accurate as a water barometer, it is easier to make and use.

Making a barometer

- Work in groups of 4.
- Stretch the balloon over the jar until it forms a tight drum over the top.
- Use a rubber band to hold it in place.
- Glue a toothpick in the centre of the rubber so that it is horizontal.



- Place the barometer near a wall and attach the cardboard to the wall behind it.
- To calibrate the barometer, write initial barometric pressure reading on the piece of cardboard at the spot where the needle is pointing.
- Record the actual weather conditions.
- Observe barometer for 1 week, recording the direction the needle is pointing on their barometer and the actual barometric pressure for that day.

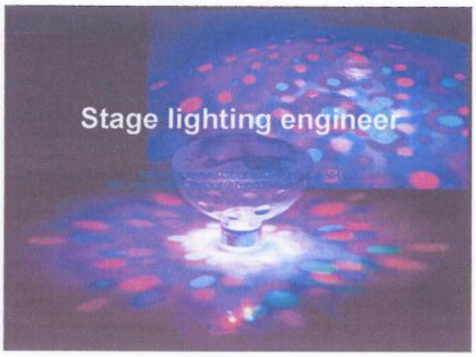
- Your forecast is valid for 12-24 hours into the future so predictions can be made for the next day.
- Can you predict the weather?

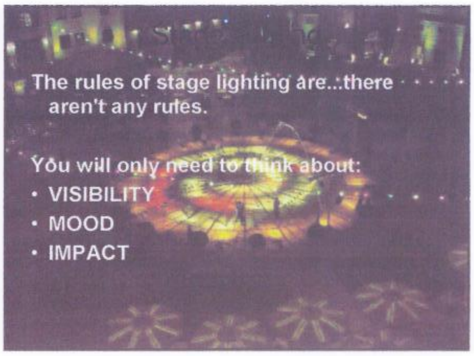
- When air pressure increases, it exerts more pressure on the balloon, pushing it down and the pin upwards on the scale.
- When the air pressure decreases, the pressure lessens on the balloon and a lower reading is recorded.
- In general, low air pressure means rainy or cloudy weather. When the barometer drops, a storm may be approaching. High air pressure usually indicates clear weather.

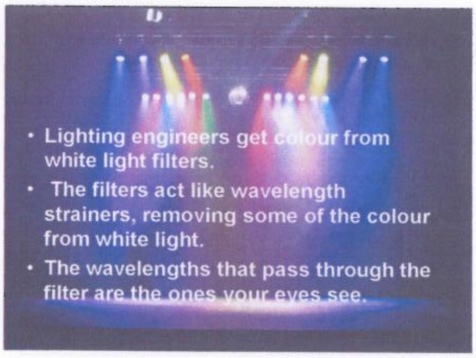
Resource (for technicians)

Each group needs:

- 1 wide-mouth jar
- 1 large gas impermeable balloon
- 1 heavy, thick rubber band
- 1 small ball of bluetack
- 1 toothpick
- 1 piece of cardboard approx 8 x 10 inches
- 1 each Barometric pressure log
- Graph paper







You are going to light your very own stage – concert, circus or theatre

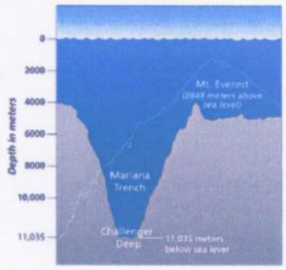
- You can use your own music on your phone
- cardboard for the arena and stage
- Cut-out models to stand on your stage.
- Powerpacks and ray boxes for light.
- Colour filters to produce colours).
- Cut out different shapes to make shapes appear on your stage.

Remember to think about mood, impact and visibility.

Oceanography

Bathymetric Surveying

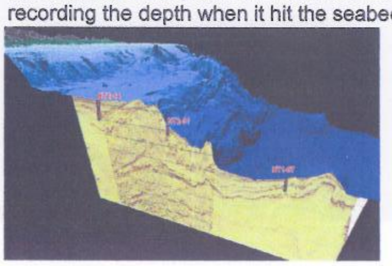
- The Marianas Trench is the deepest place on Earth, deeper than Everest is high.



Oceanography and seabed mapping

- But how do we know this?
- Today you will take measurements that show how we map the sea floor.

- How was seafloor mapped in past?
- By dropping a weight off the boat and then recording the depth when it hit the seabed.

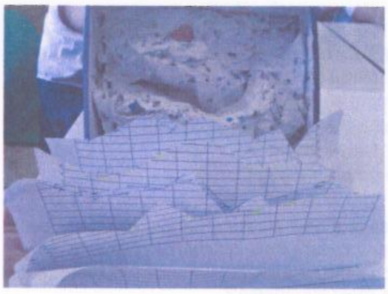


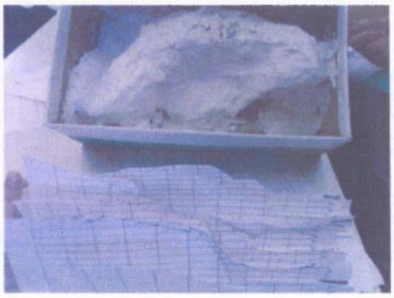
Mapping the sea floor

- Each row of dots on the box needs a profile sheet.
- Place the stick into the first hole (row 1 column 1) on box lid.
- Note how far the stick entered into box, remove stick and measure distance to the bottom.
- Plot distance on row 1 profile sheet with an X. Continue across the row.
- Connect the measurements with a line
- Cut off the top of the page along the profile line.

- Repeat for all rows (new sheet each time).
- Each profile (or row) corresponds with a line on the bathymetry sheet.
- The cut out profiles should be glued onto the bathymetry sheet on the right profile line.

- Then have a look inside the box and compare it to your bathymetric sheet.





Discuss

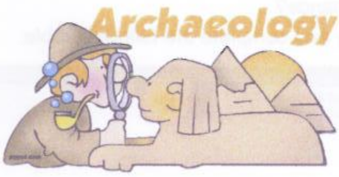
- What type of data we want from oceans? depth, sediments, animals, salinity, temperature, O_2, currents, nutrients, etc
- Why is it important to know what the sea floor looks like? habitat, animals, commercial uses, extracting resources, navigation safety.
- What kinds of ways can we map the sea floor ? sonar, soundings, remote sensing.
- What types of sea floor features are there? volcano, seamount, trench, ridge, abyssal plains

Resources (for technicians)

- Shoebox with lids, with grid of small holes (10 x 10)
- Lids to be sealed.
- "Seafloor" fixed onto box bottom (different bathymetry profiles made from plastic, hardened clay, rocks, etc) Should include seamounts, trenches, ridges, volcanoes.
- Sounding stick: thin rod, longer than depth of box.
- Data collection sheets to create profile (1 sheet per row on lid).
- scissors
- rulers
- glue

Physics Career 5

Archaeology and geophysics

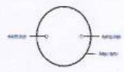


Geophysics and archaeological resistance surveying

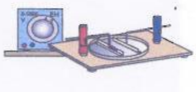
- Archaeologists use geophysicists to help them find where to dig.
- Geophysicists use the difference in electrical resistance to find buried structures.

Electric field lines demo

What is an electrical field?
This demo shows how electricity flows
around electrodes to form field lines.



- Fill the petri dish with castor oil to a depth of about 0.5cm.
- Sprinkle a thin layer of semolina over the surface (too little better than too much).
- Put the two electrodes in the castor oil in the positions shown.
- Connect the two electrodes to the leads and the leads to the EHT supply.
- Adjust the supply to give 3000 to 4000 volts and turn on.
- http://www.youtube.com/watch?v=bG9XSY8i_q8



Activity one

Do different soils conduct different amounts of electricity?

Learning objectives:

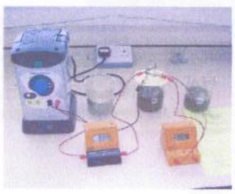
- Using the electrical resistance of soil to look for buried artefacts.
- To practice using Ohms' Law (V=IR).

Investigate how different sands (dry, salty, wet) and compare their conductive properties.

Which sand has the lowest resistance (conducts the most electricity)?

Resource list: (for teachers)

- 3 sand samples (400 cm^3 dry) in three 500 ml beakers
- 150ml distilled water
- 150ml saturated salt water
- power pack
- ammeter
- voltmeter
- 5 connecting leads and crocodile clips
- 2 steel electrodes (mounted 3cm apart)
- iron bar to fit horizontally inside a beaker



Figures obtained during a pilot run

Sample	Voltage (V)	Current (I)	Resistance (R)
Dry sand	4.76	0	Infinity
Sand soaked in deionised water	3.16	0.01	316
Sand soaked in salt water	2.86	0.45	6.3

- Dry sand has infinite resistance. It cannot conduct electricity because there are no free electrons or ions to carry the current.
- The lowest resistance is found in the salty sand where the ion-rich water is able to conduct electricity well.
- The resistance of soil decreases after rain. Sand contains more water than clay, and so it will have lower resistance.
- Archaeologists can use this information to find buried ditches, since the fill is likely to be more porous than the surrounding area.
- Buried conducting materials, such as the iron bar, greatly reduce resistance (because it conducts electricity).
- We can use this information to look for metal deposits such as copper, iron and zinc ores. (but not

Follow-up:

- Investigate the salt water sample again, but bury a steel bar low down in the beaker. What effect does it have on the resistance?
- Copy and complete the following table:

Sample	P.D. (V)	Current	Resistance
Sand soaked in salt water			

Activity 2 - Resistance survey

Learning objectives

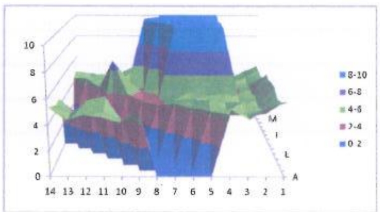
- describe how archaeologists use the electrical properties of the ground to search for evidence.
- Explain how resistance measurements can help to find hidden structures

Geophysics survey

- Use a multimeter to record resistance.
- Insert the probes and measure the resistance across each pair of holes.
- Use Excel to plot the data and produce a 3D graph.
- What can you see?

Resource list (for technicians)

- multimeter
- 2 x 4mm leads with clean ends (to clean, sand with emery paper)
- hardboard sheet, about 30cm square, with a grid of ready-drilled holes (if the hardboard does not have holes, make them about 2cm apart and just big enough to take the ends of the leads)
- Teledeltos™ paper, the same size as the hardboard sheet (Teledeltos™ paper is electrically conductive, but still fairly resistive paper)
- paper glue
- cooking foil
- cork tile, same size as the hardboard sheet or slightly larger
- strips of wood to make the frame (alternatively use elastic bands or clips to secure everything together)
- Pen
- access to a computer running a spreadsheet and graphing package



References

- http://www.earthscienceeducation.com/
- http://www.teachengineering.org/browse_activities.php

Crime fighting and Forensics

There has been a robbery. An elderly person has been left unconscious. Some items are missing. The robber was so calm and collected after their crime that they helped themselves to a cup of tea. The police sirens scared them away. No one was seen running from the scene of the crime, but the police passed a few people walking away as they arrived.

The only evidence you have to work on is half a cup of lukewarm tea.

Your job is to work out how far the robber has got away from the scene of the crime. You must work as a team as the longer you take to measure and analyse the data, the further the robber will get away from the crime scene.

What will you do? You will need to find out a few things first.

How hot is a freshly made cup of tea?
How long does it take to get to the same temperature as the cup of tea left at the scene of the crime?
How fast would the robber have travelled if they had walked away casually?
How far would they travel in the time it took for the tea to cool down?

Describe what actions you each need to take (your method for collecting data)

Put your results in a table

Write up the analysis of your data, directing the armed response police unit to where they need to go to find the robber. You can also include any concerns you migt have about the reliability of your data.

Questions

Can you give one reasons why you think your investigation was successful?

....

....

Can you give one ways in which your investigation could have been better?

....

....

What science subject do you think you mainly used to solve the crime? Please tick one.

Biology		Chemistry		Physics	

Give details of any lessons you remember where you measured temperature or time?

....

....

Could you summarise in one sentence what you learned this lesson?

....

....

Can you rate how much you enjoyed this lesson? (1 very enjoyable - 4 not at all)

1		2		3		4	

Can you rate how much you learned about forensics careers this lesson? (1 lots - 4 nothing)

1		2		3		4	

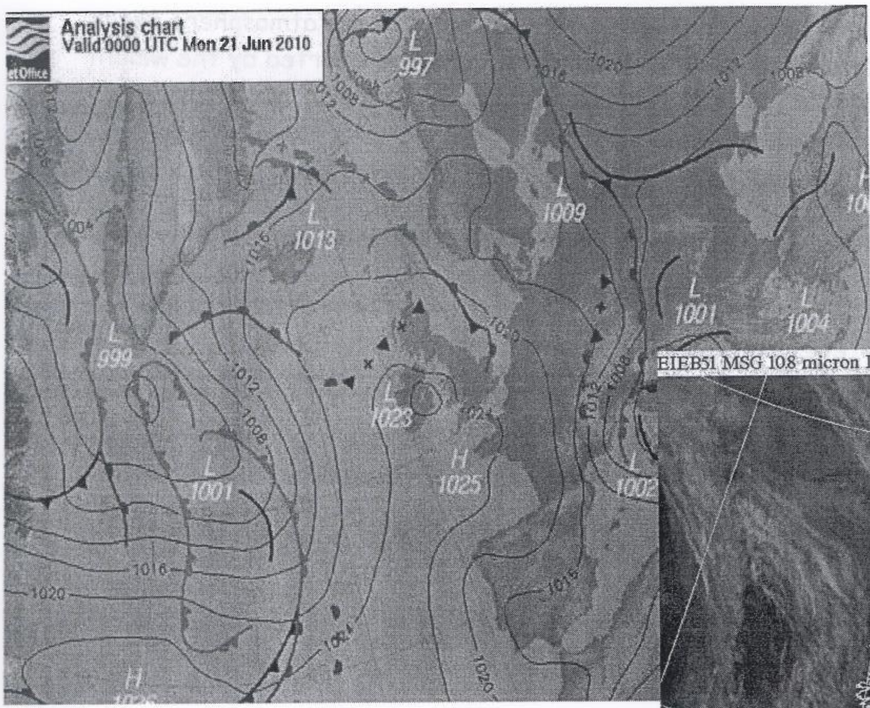
Did you already know that forensic detectives use these methods to help solve crimes?

Yes		No	

If yes, where did you find this out?

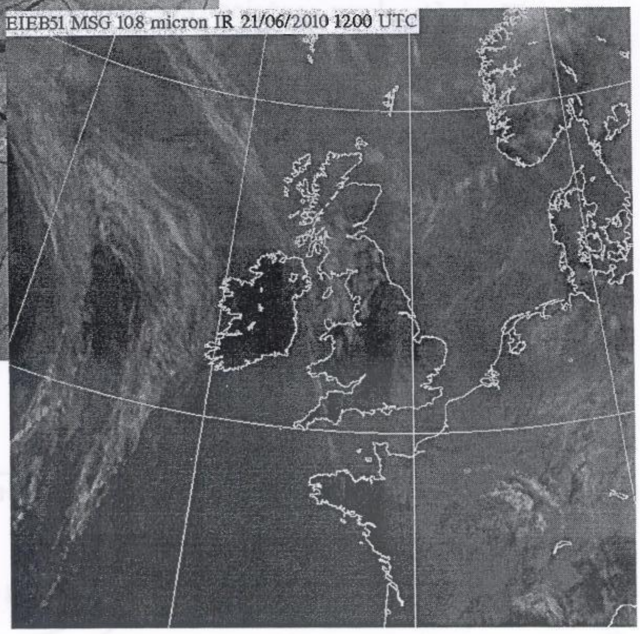
....

Weather forecasting



You have been invited to give a brief weather forecast on the weather of the UK.

This will involve talking about what the weather is currently like and what could happen to it.



You will need to

- Talk about what the weather is currently like and what will happen to it in the next few days
- Include terms such as low/high pressure, wind, temperature, rain, sunshine, etc
- Try to describe and explain by showing the audience a map with symbols
- Use actual place names to describe the different weather conditions; e.g. Bristol, London, Edinburgh, Cardiff, Belfast

Some ideas to help you

An area of Low pressure – strong winds
Warm front/ Cold front/Bands of cloud and rain
Cooler temperatures or temperatures dropping
Moving eastwards - most Depressions do this over the UK
An area of High pressure- gentle winds
Stationary - most anticyclones do this for several days
Clear skies and a danger of low night temperatures/frost
Clear skies and sunny hot days-possibility of drought
Gentle winds
Onshore breezes - cooling

Regions

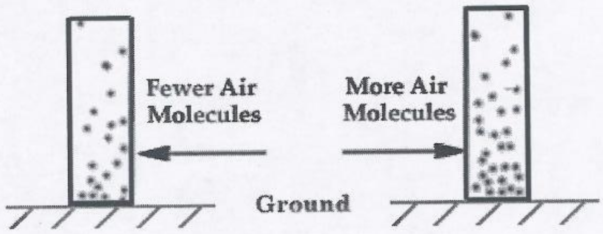
South West
South East
Midlands
The North
Northern Ireland
Scotland
Wales

Feel the Pressure

Although you may not realize it, air has weight. All the air molecules in the atmosphere exert a force, or pressure, on our bodies. Atmospheric pressure is the force exerted by the weight of the air above an object or surface. Variations in pressure generate winds, which play a significant role in day to day weather conditions.

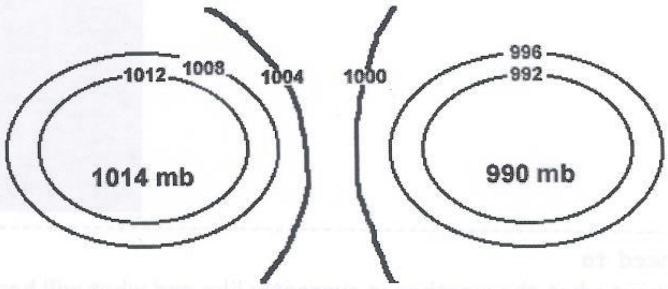
Characteristics of Pressure:
Underline the correct answer: Pressure increases / decreases with height.

Pictured below are two columns of air molecules exerting pressure on the surfaces below them. The left column contains fewer air molecules than the right column. Label the appropriate columns: high pressure & low pressure.

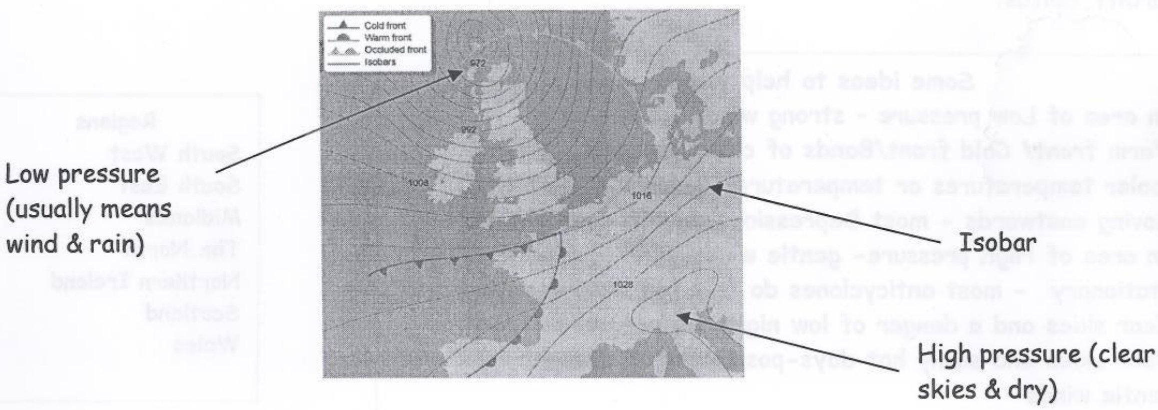


Analysis of a Pressure Field

This diagram is an idealized pressure field resembling those commonly found on surface weather maps. Can you label the low and high pressures?



The numbers along each contour show the pressure value (in millibars) for the particular contour.



Profile row: ________

6.6”										
6.2”										
5.8”										
5.4”										
5.0”										
4.6”										
4.2”										
3.8”										
3.4”										
3.0”										
2.6”										
2.2”										
1.8”										
1.2”										
0.8”										
0.4”										

Box#: ________ Sea Floor Feature? ______________________

Student name: ______________

Profile 1	
Profile 2	
Profile 3	
Profile 4	
Profile 5	
Profile 6	
Profile 7	
Profile 8	
Profile 9	
Profile 10	

Resistance survey data sheet

Fill in the readings from the multimeter for each gap on the board.

Gaps	A	B	C	D	E	F	G	H	I	J	K	M	N	O	P
1	1	1	1	1	1	1	1								
2	1	1	1	1	1	1	1								
3	1	1	1	1	1	1	1								
4	1	1	7	3	2	2	1								
5	1	1	2	3	3	1	1								
6	1	1	8	2	2	1	1								
7	1	1	1	1	1	1	1								
8															
9															
10															
11															
12															
13															
14															
15															

multimeter set to 2m Ω

Appendix 2: 9Y2 Questionnaire – Bottisham Village College

Physics in Action Research – Student Questionnaire

Do you enjoy your science lessons?

What part of science do you enjoy the most?

……………………………………………………………………….

The science I learn relates to my personal goals

Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

I would like to do better than other students

Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

Earning a good science grade is important to me

Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

I think about how learning science can help my career

Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

I find learning science interesting

Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

Understanding science in lessons gives me a sense of accomplishment

Never ☐ Rarely ☐ Sometimes ☐ Usually ☐ Always ☐

Do you get on well with other member of your class?

Name 2 members of the same gender who you work well with?

Do you get annoyed or frustrated with other pupils in the class?

Does disruptive behaviour in the class cause problems with your learning?

What do you think the teacher could do to improve your lessons?

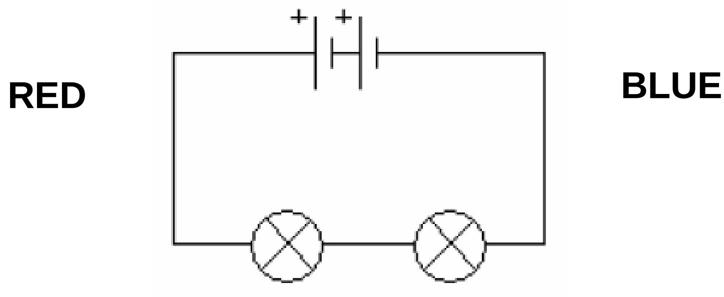
……………………………………………………………………………………………

……………………………………………………………………………………………

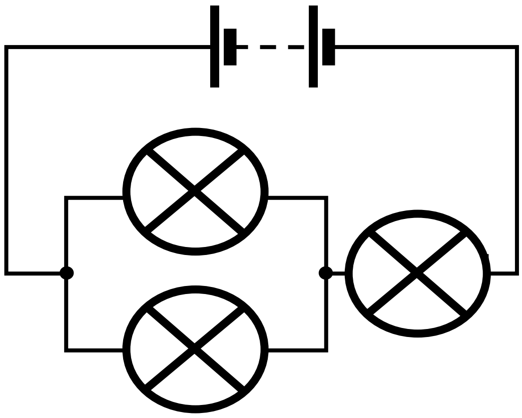
Voltage in Colour

In these circuits, each colour will represent a different potential. Across a component, there will be a potential difference and so the colour will change.
From the highest potential to the lowest the colours should go in the following order, from red (highest potential) to blue (zero potential):
RED, ORANGE, YELLOW, GREEN, BLUE

Example:



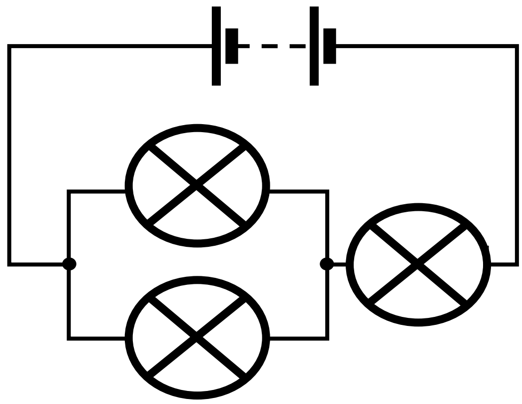
1) Copy and colour in the following circuit:



2) Create three of your own circuits and add the potentials in colour.
3) Are there any circuits for which this idea doesn't work well? Draw them and explain why.
4) How and why does colouring potentials help some students to understand potential difference in circuits?

Appendix 3b: Colour Model Teacher Notes Y12 – Harrogate Grammar School

Voltage in Colour Teacher Notes



Going clockwise, draw in one colour from the battery to the first bulb, where the pd is zero. Where there is a change in potential, e.g. across a bulb, change colour and draw on the other side in a new colour. Continue back to the battery.

This model may help students to work out when there is a potential difference and the size of potential differences.

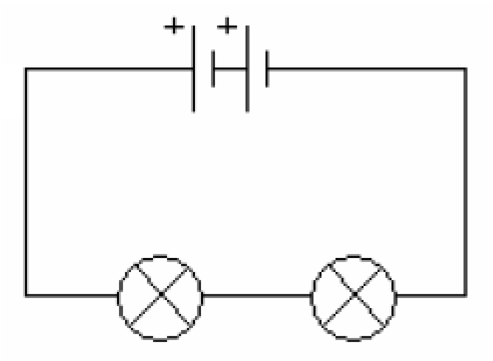
Live wire is software that colours voltages automatically for various circuits. Free download from: www.new-wave-concepts.com/

Appendix 3c: Colour Model Question Sheet for Y11 intervention group – Harrogate Grammar School

Voltage in Colour

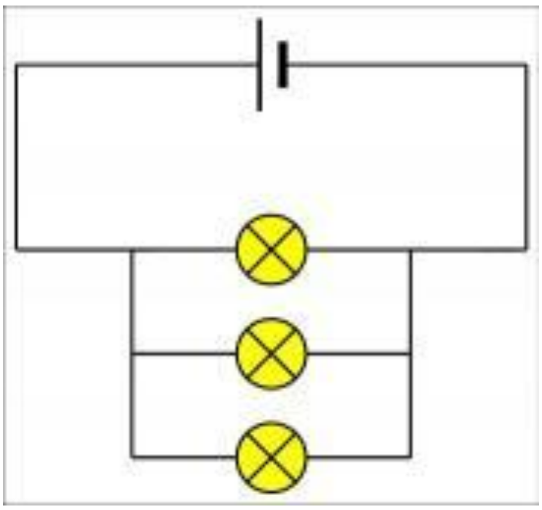
In these circuits, each colour will represent a <u>different</u> electrical potential. Across a component, there will be a potential <u>difference</u> and so the colour will change.

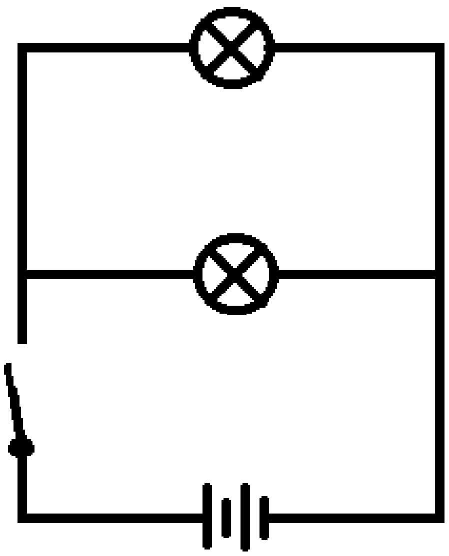
Example:

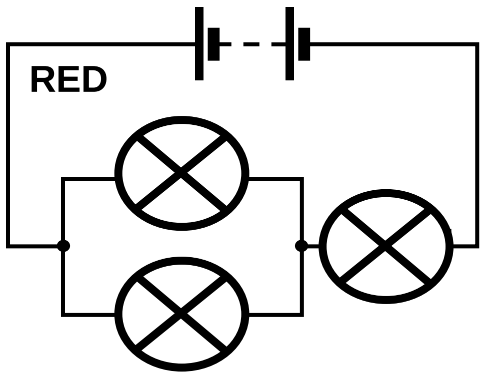


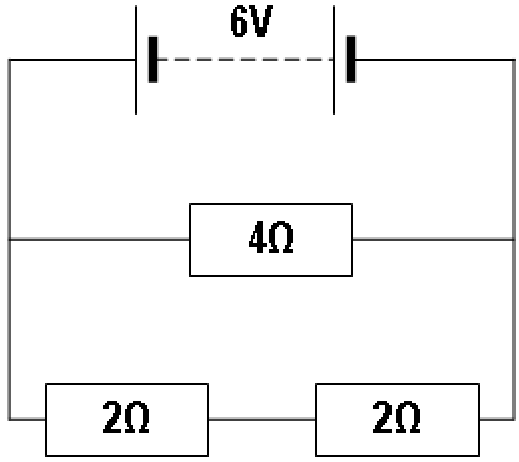
BLUE

1) Colour in the following circuits:









Does this exercise help you to understand potential difference in circuits?
Explain your answer in full.

Appendix 4a: Final Surveys – Mill Hill School

Action Physics Project Review

As part of Action Physics review if you have used any of the new equipment bought as part of this initiative please can you report back here by 3rd December?

Teacher:

Specialism:

1. **Equipment Used**

2. **Class details (i.e. number/ sex/ ability/age)**

3. **Practical(s) Completed.....**

4. **Pupils enjoyment/ Satisfaction**

5. **How equipment has enabled better learning.....**

6. **Your learning as a teacher...**

Action Physics Project

Mr Powell

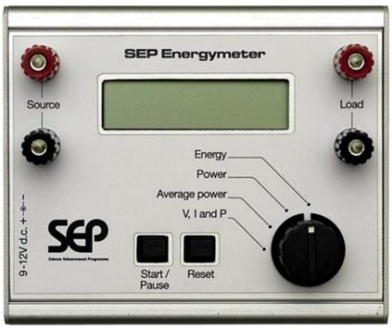
Mill Hill School

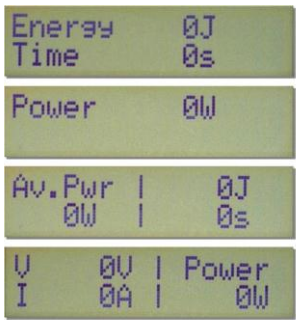
2009-2011

Teacher Resources Pack

Practical "Energy" Physics

Mill Hill School has been selected to take part in an experiment looking at how we study science in secondary schools. The focus of the project is to look at the place that practical physics which leads to calculations has in helping you achieve highly in exams and also improve your enjoyment of lessons.
The process is simple and all pupils taking part in the study will complete a questionnaire. Then you will take part in some practical lessons using some new equipment like that shown below. Then you have the chance to change your responses. We will then collate the results school wide. Here are some pictures of the new equipment you will be using. The set below **costs £70** so we have to be very careful when using it and listen to instructions carefully.

		
Special meter which can record, time, Power, Energy Transferred, Average Power, Voltage, Current. It is a like a mini-data logger. **Not to be used with High Currents from Power Packs**	Motor or Generator. You can attach a cord and pull up a weight or let it fall. You can also hand crank the device and see an output straight away.	Simple motor which turns a fan to show output.



So the main idea of the experiments will be to look at Physics and Energy transfers using numbers and formula but with the backup of real life practical to make the maths come alive.
Thanks for helping out with your time, I hope you enjoy the practical experiments and also in shaping how Science is delivered in other schools across the country. Our research will be shared with other schools and if we can show that using type of equipment in our lessons was useful to you there will be more schools able to use the same kit. Also we might get some more practical equipment as well.

Thanks

Mr Powell (Ks5 Science, Physics & eLearning Coordinator)

Name:
Class:
Teacher:

Student Questionnaire

On the scale pick which option suits best, do not pick two options. **Answer all questions honestly** how you feel not a partner or how you think your teacher wants you to respond. The crucial thing is to be clear about your first choice, then when you complete the form later on to indicate the change if any so I can record them for every student in the study. When thinking about Physics and particularly energy, energy transfers, energy types, flow of electrical energy how would you answer the following;

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Example before and after...		✓			✓
I feel that I can explain simple energy transfers					
I can wire up simple electrical circuits in experiments and obtain readings from meters without help.					
I feel confident about using units such as the Watt or Joule					
I understand units such as the mW or mA as smaller units of a Joule or Amp.					
I can express my ideas about energy using formulas					
I enjoy using formulae in Energy calculations					
I use formula triangles to help me understand the relationship between variables i.e. d/t = speed					
I like to reason out a formula without using a triangle from the units involved i.e. m/s as meters per second.					
I can explain the concept of efficiency in terms of electrical devices and back this up with calculations!					
I am going to pick the Higher Tier exam option for Physics					

Name:

Staff Questionnaire

Please try and make a full comment (hand written or electronic)

1. How many times have you used the Energy Meters?

2. What type of experiments did you try?

3. Did the pupils find then easy to set up and get results?

4. Did you find it easy to set up and get results?

5. Did the pupils learn more by using this piece of equipment than if they had to use a voltmeter and ammeter and complex wiring?

6. Has your or your pupils confidence in doing work involving Physics equations and numbers improved?

7. What is the next step for you?

List of All Equipment Purchased

Item	Description	Unit Cost - EX VAT
IT5 025	Electronic Callipers (KS5)	£ 14.94
IT9 001A	Thermocolour Sheet (Ks4) 150mm x 160mm	£ 22.39
SEP 091	SEP Mini Hotplate 5x5cm	£ 25.20
SEP 092	Double Glazing Kit	£ 9.12
EL1 006	New Solar Module (Ks4/5) (discount for 10)	£ 2.73
QTC 012	QTC Sheet Holders	£ 3.37
QTC 001	QTC Pills (Ks3/4/5)	£ 0.13
QTC 011	QTC Testing Kit	£ 24.45
QTC 002	WTC Sheet 305mm x 50mm	£ 1.67
SHO 319	Newtons Cradle (momentum) Ks4/5	£ 4.25
314-220	Galileo's Little Telescope (one use kit 6x mag)	£ 5.04
SEP 043	SEP Energy meter	£ 38.00
SEP 054	SEP Small motor Unit	£ 5.13
SEP 074	Motor/Generator Unit	£ 21.64
314-212	Solar Airship	£ 8.69
211-015	Fog / Mist Making Machine	£ 19.99
IT9 001A	Thermocolour Sheet (Ks4) 150mm x 160mm	£ 22.39
SEP 015	SEP Charge Indicator	£ 14.99

Appendix 5a: Drawing Graphs – Uplands Community College

Drawing Graphs

Task 1: (5/10 mins) a) Draw a table with **three** columns.
b) Sort and copy the following into the correct columns:

The thing you are measuring	The thing you change
The thing you think may affect something else	Goes on the x-axis usually
Goes on the y-axis usually	Does not get plotted on the graph
Things you must try to keep the same	Reasons why your investigation may not be accurate
The thing you are investigating	Should have no effect on the results

c) Write in what you think the column headings should be.

Task 2: (5/10 mins) Draw the axes of a graph.
Add to it all the things you thing a perfect graph should have (e.g. Title)
Add tips for a new year 8 on how to draw a good graph (e.g. How to do a line of best fit)

Task 3: (25/30 mins) Do the levelled task.
You have a choice of data to investigate by drawing an appropriate graph.
Use the level ladder on the back of the task.

Task 4: (5mins) Assess some-one else's work.
Give them:

a) A draft level
b) A reason why you think they have reached that level
c) An idea of how they could add to their work to try to reach the next level.

Homework: Improve your levelled task.

Rearranging Equations

1. <u>How do you rearrange equations?</u>

$$a = b + c$$

a) Make up your own numbers for a, b and c which will work in this equation.

b) Note them down.

c) Rearrange the formula to make b the subject. ie you need an equation which has b = on one side.

d) Check you've got it right by putting in your numbers again.

e) Rearrange the formula to make c the subject.

f) Check you've got it right by putting in your numbers again.

Repeat 1 – 6 for the following equations:

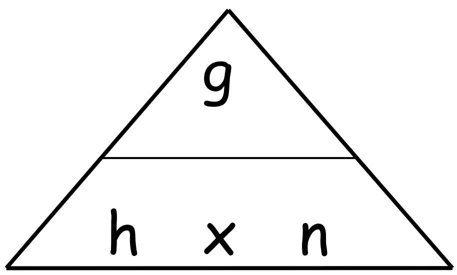
$d = e - f$	$g = h \times n$	$j = k \div m$

<u>What are the rules for rearranging equations?</u>

Discuss and note your ideas down

<u>Cheat's way of rearranging $g = h \times n$ equations</u>

Use a triangle:



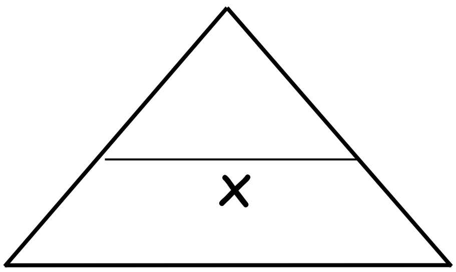
Cover up the one you want to find. The answer is what's left. If there is a line, it means divided by.

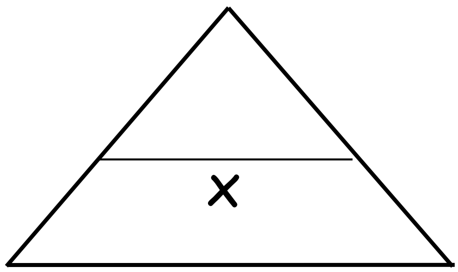
So: $g = h \times n$ $\quad h = g \div n$ $\quad n = g \div h$

2. Use the triangle to fill out the table:

g	h	n
	2	5
20	10	
50		2
	6	3
150	5	
30		2

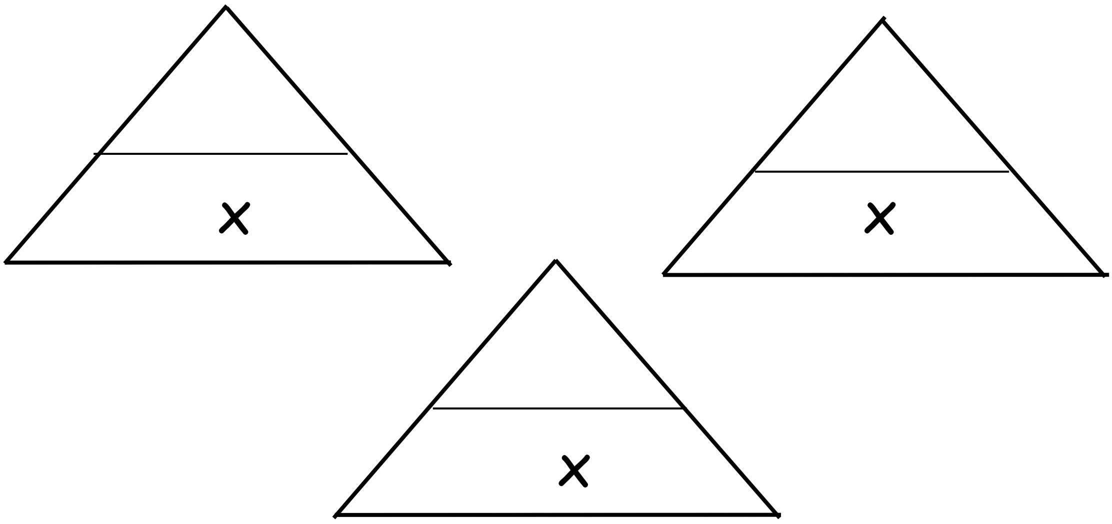
3. Draw an equation triangle for these science equations;
   a) Weight = mass x gravity (W = m x g)
   b) Energy = power x time (E = P x t)





4. Use these to work out the following problems:
   a) Sophie has a mass of 60kg. What is her weight on Earth if Earth's gravity is 10N/kg?
   b) What is the value of gravity on the moon if her weight there is 100N (mass stays the same at 60kg)?
   c) Her friend Katie is also on the moon…..She finds her weight there is 85N. What is her mass?
   d) How much does Katie weigh on Earth? (Her mass stays the same).
   e) How much energy does a light bulb of 60W power use in an hour (use 3600 seconds)?
   f) What is the power rating of a computer if it uses 120,000J of energy every minute (use 60 seconds)?

5. Draw an equation triangle for these science equations;
   a) Cost of energy = energy units x cost for each unit (C = e x u)
   b) Speed = distance ÷ time (s = d ÷ t)
   c) Pressure = force ÷ area (p = f ÷ a)



6. Use these to work out the following problems:

a) How much does it cost to run a playstation all day if it uses 25 units of energy and they cost 12p each?
b) What is the cost per unit in Italy if it costs 300 eurocents for 20 units?
c) What speed is an athlete going if he runs the 100m in 10s?
d) How far have I run if I keep up a speed of 30m/s for 30s?
e) How long does it take Mrs. Edmonds to walk to the bottom field if it is 200m away and she is walking at 0.5m/s?
f) Mr. Smith decides to run there. If he is travelling at 2m/s, how long does he take to get there?
g) What is the pressure on the floor of a stiletto heel if the woman/man wearing it weighs 800N (= her/his force on the ground) and the area of the heel is $0.01m^2$?
h) What is the pressure if the woman/man then put on trainers and the heel is $0.25m^2$?

Well Done!

Appendix 5c: Initial Questionnaire – Uplands Community College

Name:

What is your target in Science? at the end of year 9?

Do you think you will achieve this?

Physics is the study of Forces, Energy and Matter.

How interested are you in Physics? (Please circle)

Very Not at all

1 2 3 4 5

How good are you at Physics?

Very good Not good at all

1 2 3 4 5

What sort of things do you find difficult in Physics?

Biology is the study of living things.

How interested are you in Biology?

Very Not at all

1 2 3 4 5

How good are you at Biology?

Very good Not good at all

1 2 3 4 5

What sort of things do you find difficult in Biology?

Chemistry is the study of chemicals and their reactions.

How interested are you in Chemistry? (Please circle)

Very Not at all

1 2 3 4 5

How good are you at Chemistry?

Very good Not good at all

1 2 3 4 5

What sort of things do you find difficult in Chemistry?

Maths is the study of numbers, shapes and their manipulation.

What is your target in Maths? at the end of year 9?

Do you think you will achieve this?

How interested are you in Maths?

Very Not at all

1 2 3 4 5

How good are you at Maths?

Very good Not good at all

1 2 3 4 5

What sort of things do you find difficult in Maths?

Plotting Graphs

A student measured the time it took for salt to dissolve at different temperatures. Their results are shown below:

Temperature (°C)	Time to dissolve (s): Try 1	Try 2	Try 3	Average
20	55.2	55.5	55.8	
22	48.3	47.8	48.0	
24	41.3	41.8	41.5	
26	35.6	35.1	34.8	
28	27.6	27.7	27.3	
30	19.8	20.2	20.5	
32	12.3	11.9	12.4	

Work out the average time to dissolve.
Plot a graph (**don't** start the temperature scale at zero).
Draw a line of best fit.
Write a brief conclusion for them.

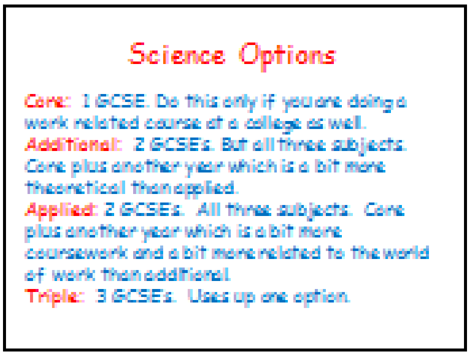
Plotting Graphs

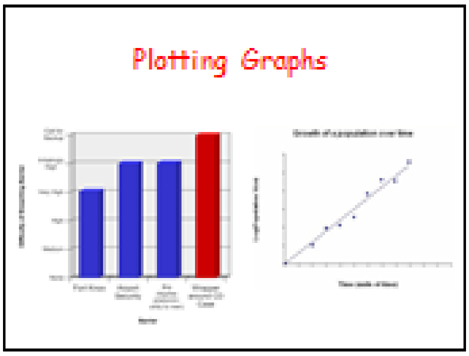
A student measured the time it took for salt to dissolve at different temperatures. Their results are shown below:

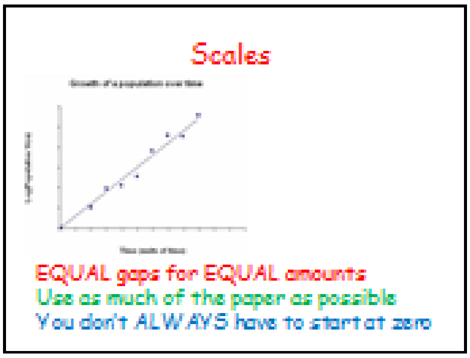
Temperature (°C)	Time to dissolve (s): Try 1	Try 2	Try 3	Average
20	55.2	55.5	55.8	
22	48.3	47.8	48.0	
24	41.3	41.8	41.5	
26	35.6	35.1	34.8	
28	27.6	27.7	27.3	
30	19.8	20.2	20.5	
32	12.3	11.9	12.4	

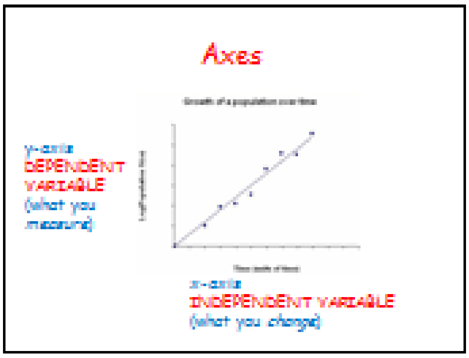
Work out the average time to dissolve.
Plot a graph (**don't** start the temperature scale at zero).
Draw a line of best fit.
Write a brief conclusion for them.

Appendix 5e: Plotting Graphs Powerpoint – Uplands Community College



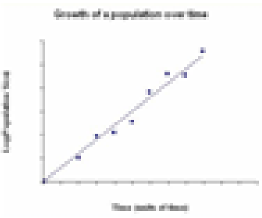






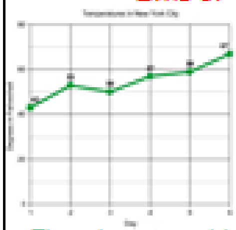
Labelling

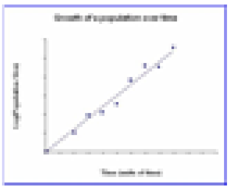
Title: Explains what it is



Axes:
•Variable
•Units

Line of best fit





Through as many points as possible.
Then as many above the line as below it.

Working out averages

What is the average of these numbers?

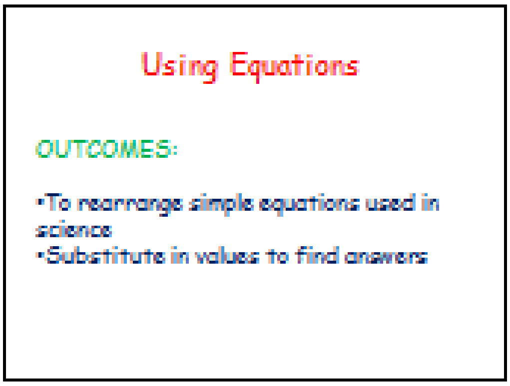
1, 2, 3, 4, 5, 6, 7, 8, 9?

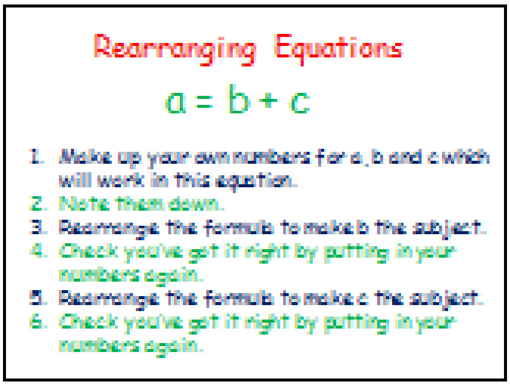
How did you work it out?

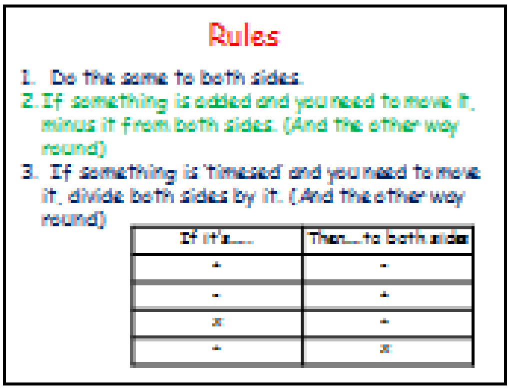
Rule: Add all the numbers up and divide by how many there are.

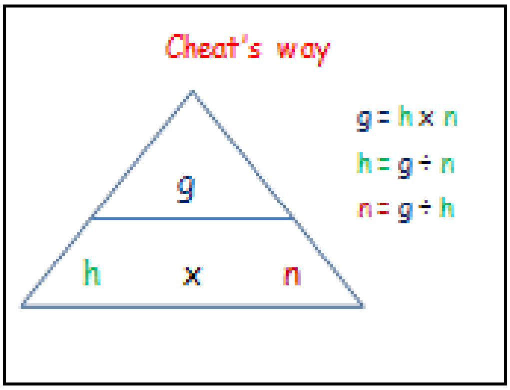
Average = (1+2+3+4+5+6+7+8+9) ÷ 9 = 5

Appendix 5f: Rearranging Equations Powerpoint – Uplands Community College









Answers

Question 4

a) 600N
b) 1.7N/kg
c) 50kg
d) 500N
e) 216,000J
f) 2000W

Question 6

a) £3 (300p)
b) 15 eurocents
c) 10m/s
d) 900m
e) 400s (6.7 mins)
f) 100s (1.7 mins)
g) 80,000 N/m^2
h) 3,200 N/m2

Appendix 5g: Year 8 Discussion Questions – Uplands Community College

Year 8 discussion questions: (There are no 'right' or 'wrong' answers!)
What do you see as the main differences between the sciences (chemistry, biology, physics)?

What appeals/doesn't appeal about each of the sciences?
Physics:

Chemistry:

Biology:

What do you think about Maths?

Do you think the maths you have to do in science puts you off at all?

Does the maths put you off some science subjects more than others?

What are the benefits of studying science to a high level?

Thank you for your ideas!!!!!

Appendix 6: Booklet – Crown Hills Community College

National Curriculum Topic

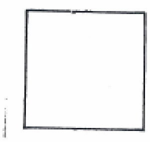
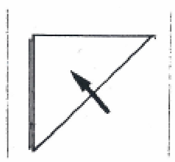
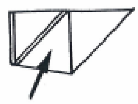
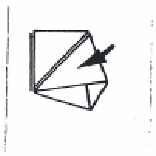
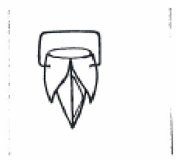
4.1 Energy transfer and electricity

For Science INSET

Using a model to describe and explain energy transformations and transfers in everyday devices.

M.K.Bates

Making a Paper Saucepan

1. Smooth paper 20 cm square 	**2. Fold to make a triangle** 	**3. Fold as shown** 
4. Fold again as shown 	**5. Pull down the top flaps** 	**6. Fit a wire handle** 

Apparatus—Bunsen, heat mat, thermometer, 10c.c. measuring cylinder, tongs, wire 20 sq cm paper and matches.

1

Use the KEY WORDS to explain how water can be heated up (or boiled) using a paper saucepan

Chemical heat energy transfer transform

NOTES	DIAGRAMS

Circle the key words. Underline 2 more KEY WORDS in your notes

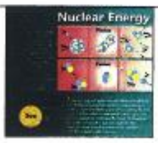
<u>Section 4 of the National Curriculum under Yearly Teaching Objectives and Amplification for "Energy, electricity and forces" reference is made to energy transfers by</u>

1. heating
2. sound
3. light
4. electric current
5. and in biosystems

In the amplification documents there is no mention of the following;
forms of energy
transform devices
or energy transformations

It is implicit from the numbered list 1 to 5 above that we have to teach students what the different forms of energy are.
However how clear are we about what energy transforms and energy transfers are and what appliances do?

Let us make a start to answer the above question. (1)List and illustrate 9 forms of energy

<u>When teaching about energy transfers it is important to be conceptually clear where energy is transformed and how it is transferred in appliances.</u>

The following are extracts from 2 physics books. (Note the lack of clarity in the way transform and transfer are put across. Also see who the publishers are!)

4

Extract 1-Physics; Bryan Milner; CUP; 2nd edition 2001

"Why is electricity so useful?
We use electricity a lot because it is a very useful sort of energy. Electricity can be easily transferred as other kinds of energy. For example a torch transfers electrical energy as light.

Here is a way of showing this energy transfer"

			
Input Energy / Energy Changer / Energy Output	Input Energy / Energy Changer / Energy Output	Input Energy / Energy Changer / Energy Output	Input Energy / Energy Changer / Energy Output

(2) Are these devices transforming energy or transferring energy? Discuss and state

5

Extract 2-Science to GCSE; Stephen Pople, Michael Williams, OUP; 2002

Energy

Energy can take different forms. Here are some names to describe them…………………………….

Energy Chains

Just like money energy does not vanish when you spend it, it just goes somewhere else. In every energy chain the total amount of energy stays the same. This is called the Law of conservation of energy.

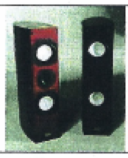
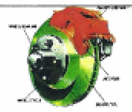
"Energy can change into different forms, but it cannot be made or destroyed."

In any chain some energy is always wasted as heat. However the total amount of energy stays the same."

Here the concept of Sankey Diagram is being hinted upon. (3) What does the Sankey Diagram show?

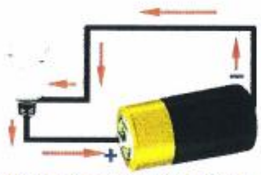
Answer ____

Complete

			
Input Energy / Energy Changer / Energy Output	Input Energy / Energy Changer / Energy Output	Input Energy / Energy Changer / Energy Output	Input Energy / Energy Changer / Energy Output

(5) Draw a model of the path of electrons in the heating element of the kettle and explain how electrical energy is changed to heat energy.

6



Simple circuit with light

(6) Complete (Higher level thinking skills-synthesis)

Energy in the cell is stored as _______________ _________________.

It is transferred/transformed to the bulb as _e_____________ _e_____________ by the connecting copper wires.

In the filament of the bulb it is transferred/transformed into _____________ and ________________.

Bulbs are filled with an enert gas. The energy from the filament to the glass is transformed/transferred as e_____________ m__________________ waves.

Light and heat energy is transformed/transferred through glass to air and into our eyes.

In the retina of the eye energy transfer/transformation takes place into electrical inpulses.

7

In conclusion

The element of a kettle and the filament of a bulb are energy transformation devices. In addition within the kettle and the bulb energy transfers also take place.

Movement of energy from one place to another is called energy transfer.
Change; from one form to another is called energy transformation

Do you think the authors of the two physics books I have used quotes from are both right?
(7)Comment and give a reason

____

____

Is the paper kettle a transformer or a transfer device?

P.S. In the original version of the story by Brothers Grimm the frog transforms into prince charming when the princess throws the frog across the room onto a wall.

8

Feedback

Did you find the INSET	Fully	Mostly	Only slightly	Not at all
Informative?				
Enjoyable?				

What aspect of the INSET will you use in your classroom teaching at

1. KS3____

____

2. KS4____

____

Thank you to all.

10

Appendix 7a: Analysis of Southampton questionnaires - The Sweyne Park School

Part 1

Male

How difficult do you find physics	Very difficult	Quite difficult	Quite easy	Very easy
		2	10	1

Female

How difficult do you find physics	Very difficult	Quite difficult	Quite easy	Very easy
	1	5	10	

Male

How interested in physics are you?	Very interested	Quite interested	Not very interested	Not at all interested
	2	10	1	

Female

How interested in physics are you?	Very interested	Quite interested	Not very interested	Not at all interested
		10	6	

Male

How likely are you to study physics after your GCSE's?	Definitely	Very likely	Maybe	Not likely	Definitely not
		2	9	2	

Female

How likely are you to study physics after your GCSE's?	Definitely	Very likely	Maybe	Not likely	Definitely not
			5	11	

Part 2

Male

How difficult do you find physics	Very difficult	Quite difficult	Quite easy	Very easy
		4	10	

Female

How difficult do you find physics	Very difficult	Quite difficult	Quite easy	Very easy
		6	10	

Male

Do you find physics more, the same or less difficult than before	More difficult	The same	Less difficult
	1	4	9

Female

Do you find physics more, the same or less difficult than before	More difficult	The same	Less difficult
	1	8	7

Male

How interested in physics are you?	Very interested	Quite interested	Not very interested	Not at all interested
	3	9	1	1

Female

How interested in physics are you?	Very interested	Quite interested	Not very interested	Not at all interested
	1	8	5	2

Male

Do you find physics more, the same or less interesting than before	More interesting	The same	Less interesting
	5	9	

Female

Do you find physics more, the same or less interesting than before	More interesting	The same	Less interesting
	8	5	3

Male

How likely are you to study physics after your GCSE's?	Definitely	Very likely	Maybe	Not likely	Definitely not
		2	11	1	

Female

How likely are you to study physics after your GCSE's?	Definitely	Very likely	Maybe	Not likely	Definitely not
			9	6	1

Part 3

Male

How difficult do you find physics	Very difficult	Quite difficult	Quite easy	Very easy
		5	8	1

Female

How difficult do you find physics	Very difficult	Quite difficult	Quite easy	Very easy
	1	5	7	1

Male

Do you find physics more, the same or less difficult than before	More difficult	The same	Less difficult
		8	6

Female

Do you find physics more, the same or less difficult than before	More difficult	The same	Less difficult
	1	5	8

Male

How interested in physics are you?	Very interested	Quite interested	Not very interested	Not at all interested
	2	11	1	

Female

How interested in physics are you?	Very interested	Quite interested	Not very interested	Not at all interested
	4	5	3	2

Male

Do you find physics more, the same or less interesting than before	More interesting	The same	Less interesting
	7	7	

Female

Do you find physics more, the same or less interesting than before	More interesting	The same	Less interesting
	9	4	1

Male

How likely are you to study physics after your GCSE's?	Definitely	Very likely	Maybe	Not likely	Definitely not
	2	4	5	3	

Female

How likely are you to study physics after your GCSE's?	Definitely	Very likely	Maybe	Not likely	Definitely not
		1	8	2	3

Appendix 7b: CERN Questionnaire - The Sweyne Park School

CERN Questionnaire

Question	Female		Male		All	
	Yes	No	Yes	No	Yes	No
1) Had you heard of CERN before Mrs Aylen talked about it?	7	6	8	7	15	13
2) Did you know what CERN was about before Mrs Aylen talked about it?	5	8	5	10	10	18
3) Had you heard for the Large Hadron Collider before Mrs Aylen talked about it?	11	2	7	3	18	5
4) Did you know what the Large Hadron Collider was doing before Mrs Aylen talked about it?	7	6	9	6	16	12
5) What did you know or had you heard about related to the Large Hadron Collider before Mrs Aylen talked about it?	7	6	6	9	13	15
6) Did you like the fact that Mrs Aylen involved you on her journey to CERN and the Large Hadron Collider?	12	1	14	1	26	2
7) Did you like the fact that some of the questions that you asked were answered by scientists?	13	0	15	0	28	0
8) Would you like the opportunity to speak to scientists who work at CERN?	11	2	13	1	24	3
9) Would you like to visit CERN and find out for yourself what goes on there?	13	0	13	1	26	1
10)Has Mrs Aylens visit inspired you further with science?	8	5	13	2	21	7
11)Has Mrs Aylens visit inspired you further with physics?	8	5	14	1	22	6
12)Did you like the lesson that Mrs Aylen gave about her findings and what she got up to at CERN?	13	0	14	1	27	1
13) What could Mrs Aylen do differently to show what she found out about CERN and the Large Hadron Collider?	Written response given					
14)Are you more interested in science as a result of Mrs Aylens visit to CERN?	7	6	14	1	21	7
15)Are you more interested in physics as a result of Mrs Aylens visit to CERN?	9	4	14	1	23	5
16) What do you remember about Mrs Aylens visit and feedback to you about CERN and the Large Hadron Collider?	Written response given					
17)Has your involvement with Mrs Aylens trip to CERN highlighted more areas of science than you were aware of?	9	2	12	2	21	4

18) It there anything that you would like to add to this questionnaire about CERN and the Large Hadron Collider? When can we go

Pupil feedback

5) What did you know or had you heard about related to the Large Hadron Collider before Mrs Aylen talked about it?
Big bang
That we were all going to die
Speeding up particles
10) Has Mrs Aylens visit inspired you further with science?
Yes - Because I now know what goes on and want to know more
Yes - Because I would like to see the science that goes on
Yes – Because it is exciting
Yes – Because it has made me realise how fun it is
Yes – It is interesting to see how it works
Yes – It was better than a normal lesson
Yes – It shows how fun it can be
Yes – I think it's more interesting now
Yes – Because it's interesting
Yes – Because it makes me interested in all the big science projects in the world
Yes – Because you get to see how you exist
Yes – Because she is a good teacher
No – I would not like to do about it / I don't find it that interesting / Because I don't really like science
No – Interested in different subjects
12) Did you like the lesson that Mrs Aylen gave about her findings and what she got up to at CERN?
Because I wanted to know what it was like there
Because it was involving us and was interesting
It was interesting / I found it interesting / Because it was interesting
Because I would like to go there
It was different and interesting
Because it was something different
We got to know a lot of what happens there
It was fun / It was more fun
Amazing to see what went on
It was nice to listen to what happened rather than work
Because we got to find out about what she did
Because it was interesting to hear how things are done by scientists
Because were were explained what happened there
13) What could Mrs Aylen do differently to show what she found out about CERN and the Large Hadron Collider?
Had a video / take videos
Make it more fun and get involved more
Take us there maybe
Make it fun
Introduce it differently
16) What do you remember about Mrs Aylens visit and feedback to you about CERN and the Large Hadron Collider?
That there is more to than atoms and how it functions
That she was one of the last people to go down before it was turned on
There are different particles that go at different speeds in the different areas
About what the LHC is doing
About dark mater and the speeches
She talked about what she did and answered our questions
That it takes two years to get the atoms at the right speed
About the protons and the big bang and what the LHC really does
The particles
Explaining about what it did and everything else too
The chambers (ALICE / ATLAS / CMS)
How it worked
Speeding up particles
What they do at CERN
To do with Physics
That they were making atoms go round the Hadron Collider making them bump into each other
Atoms collide and Higgs Boson as well. Other colliders are involved as well
That she had loads of lectures
17) Has your involvement with Mrs Aylens trip to CERN highlighted more areas of science than you were aware of?
She has showed us a lot more
I know more about what different areas relate to each other
The way the world began
I didn't realise how every piece of science was connected to CERN
I didn't realise CERN was involved in physics
It went into detail about what there is
I didn't know it existed
It was interesting
Because it made sense of what I was confused on
That it was big

Appendix 7c: Evaluation of Light Module Questionnaire - The Sweyne Park School

Evaluation of Light module
Date:
Sex: M / F

Please give a rating out of 10 with 1 being poor and 10 being brilliant when questions require a rating. Please expand each question if you can to give as much feedback as possible.

1) Did you enjoy the light module that you recently studied? (1-10)
2) Did you enjoy the fact that you could decide how the following light lesson was going to be taught? (1-10)
3) What aspects of the lessons did you enjoy?
4) What could have been improved about the lessons?
5) Did you like the fact that your ideas were taken on board with regards to designing the next lesson? (1=10)
6) What would you like to see done differently when studying science?
7) What would you like to see done different when studying physics?
8) What would you like to see done the same when studying science?
9) What would you like to see done the same when studying physics?
10) Do you feel that you learnt more or less than other science subject you have studied this time by being involved in the lesson design process? If so please explain why. If not please explain why.
11) What sort of activities do you like doing in science?
12) What sort of activities do you like doing in other subjects?
13) What sort of activities do you not like doing in science?
14) What sort of activities do you not like doing in other subjects?
15) Do you feel that you have a better understanding of light following the teaching of the module?
16) Do you feel that you have made progress in this unit? If so why, if not why?
17) Do you enjoy science?
18) Do you enjoy physics?
19) Did learning in this way improve your enjoyment of physics? If so why
20) Have you considered studying physics once you leave SPS?
21) Did the light unit you have just studied increase your interest in physics?
22) What would make you think about studying physics once you leave SPS?

Appendix 7d: Lesson grading sheet - The Sweyne Park School

Lesson grading sheet
Sex: M/F
Date of lesson:

3 things that you found out from the lesson:
1)
2)
3)

What you enjoyed about the lesson:

What you would like to have seen done differently:

What could be improved on:

What you would like to do next lesson:

How could you have been pushed further in the lesson:

Grade out of 10 with 10 being excellent and 1 being terrible for the lesson:

Lesson grading sheet
Sex: M/F
Date of lesson:

3 things that you found out from the lesson:
1)
2)
3)

What you enjoyed about the lesson:

What you would like to have seen done differently:

What could be improved on:

What you would like to do next lesson:

How could you have been pushed further in the lesson:

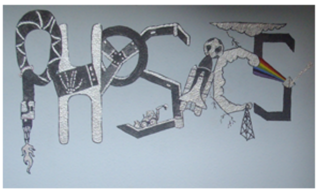
Grade out of 10 with 10 being excellent and 1 being terrible for the lesson:

Appendix 7e: Physics Mural Data Analysis - The Sweyne Park School

Female															
2) Have you enjoyed getting involved in the project so far?	1	0	1	1	1	0	1	1	1	1	1	1	1	0.5	0.82
6) Has the project increased your understanding of what physics is?	1	1	1	1	1	1	1	1	1	1	1	1	0.5	1	0.96
7) Has the project increased your awareness of how physics impacts your life?	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0.93
8) Has the project made you more interested in physics?	1	0	1	1	0	1	1	1	1	0	1	1	0	1	0.71
13) Do you feel that you could study science after you have done your GCSE's?	1	1	0	1	0	1	1	0	1	0	1	1	1	1	0.71
14) Do you feel that you could study physics after you have done your GCSE's?	1	0.5	0.5	1	0	0.5	1	0	0.5	0	0	1	0	0	0.43
15) Do you wish to study science of physics after your GCSE's?	0.5	1	0	1	0	1	1	0	1	0	1	0	0	1	0.54
Male															
2) Have you enjoyed getting involved in the project so far?	1	1	1	1	1	1	1	1	1	1	0.5	1	0.96		
6) Has the project increased your understanding of what physics is?	1	1	1	1	1	1	1	1	1	1	0	1	0.92		
7) Has the project increased your awareness of how physics impacts your life?	1	1	1	1	1	1	1	1	1	1	0	1	0.92		
8) Has the project made you more interested in physics?	1	1	1	1	1	1	1	0.5	1	1	1	0	0.88		
13) Do you feel that you could study science after you have done your GCSE's?	0.5	1	0	0	0.5	1	0	0	1	1	1	1	0.58		
14) Do you feel that you could study physics after you have done your GCSE's?	0.5	1	0	0	0.5	1	0	0	1	1	1	1	0.58		
15) Do you wish to study science of physics after your GCSE's?	1	1	0	0	0.5	1	0	0	1	1	1	1	0.63		
Both															
2) Have you enjoyed getting involved in the project so far?	0.89														
6) Has the project increased your understanding of what physics is?	0.95														
7) Has the project increased your awareness of how physics impacts your life?	0.93														
8) Has the project made you more interested in physics?	0.78														
13) Do you feel that you could study science after you have done your GCSE's?	0.65														
14) Do you feel that you could study physics after you have done your GCSE's?	0.51														
15) Do you wish to study science of physics after your GCSE's?	0.58														

Appendix 7f: Poster CERN powerpoint- The Sweyne Park School

Appendix 7g: Poster Physics Mural powerpoint- The Sweyne Park School



Physics in our Universe Mural

Activity

Pupils were introduced to the idea of the physics mural looking at where physics impacted their lives.
Ideas were developed and pupils worked with our Artist in Residence to bring ideas together.
Ideas linked together to produce a mural concept map of the pupils ideas.
Images are to be painted on the walls with our Artist and the pupils.

Purpose of activity

To raise awareness to the target group and the whole school about how physics impacts their life.
To raise the profile of physics in the school.
To enthuse target group and whole school about physics.

Feelings about the project

- I'm really excited about it – taking over a large areas of the school
- Some pupils have been asking when we are going to do the next stage
- Though pupils have fed back it is still in its early stages and pupils interest in it might change when complete
- Would be interesting to see what others in the school feel about the Mural and physics when complete.

Physics in our Universe Mural Evaluation

Had the pupils enjoyed getting involved in the project so far?
Female – 82%, Male – 96%, Class – 89%

Has the project increased the pupils understanding of what physics is?
Female – 96%, Male – 92%, Class – 94%

Has the project increased the pupils awareness of how physics impacts their life?
Female – 93%. Male – 92%. Class – 92%

Has the project made pupils more interested in physics?
Female – 71%, Male – 88%, Class – 79%

Do the pupils feel that they could study science after their GCSE's?
Female – 71%, Male – 58%, Class – 65%

Do the pupils feel that they could study physics after their GCSE's?
Female – 43%, Male – 58%, Class – 51%

Do the pupils wish to study science or physics after their GCSE's?
Female – 54%, Male – 63%, Class – 58%

Feelings about pupils responses

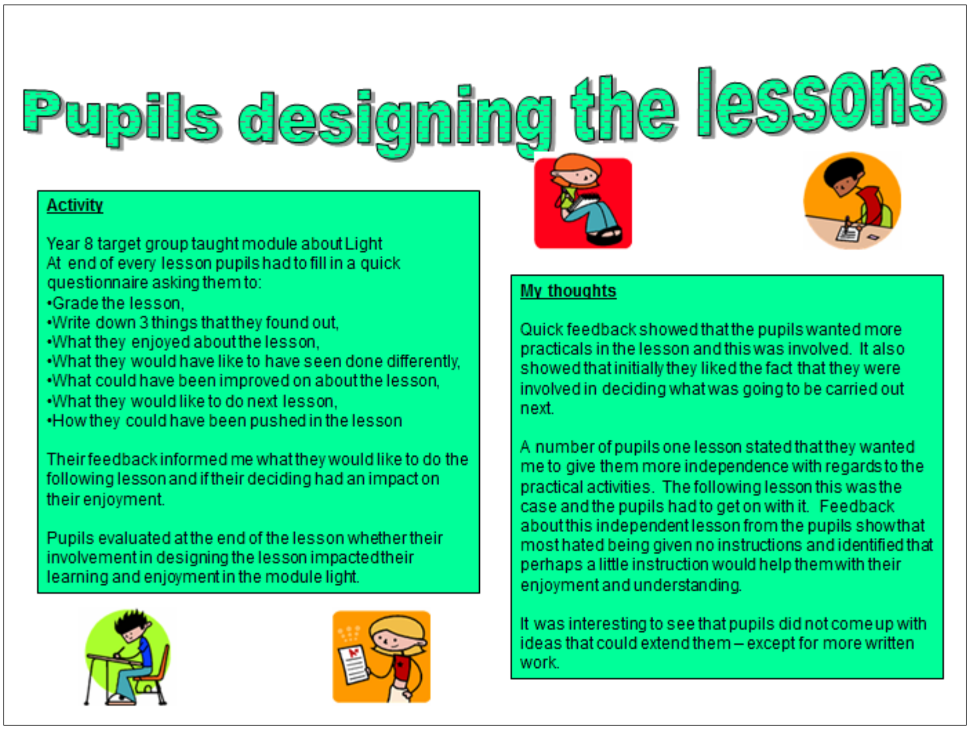
It appears that pupils are not saying whether they feel they can study science / physics after their GCSE's but giving the opinion that they do not want to study science / physics as it is not the direction they want to go.

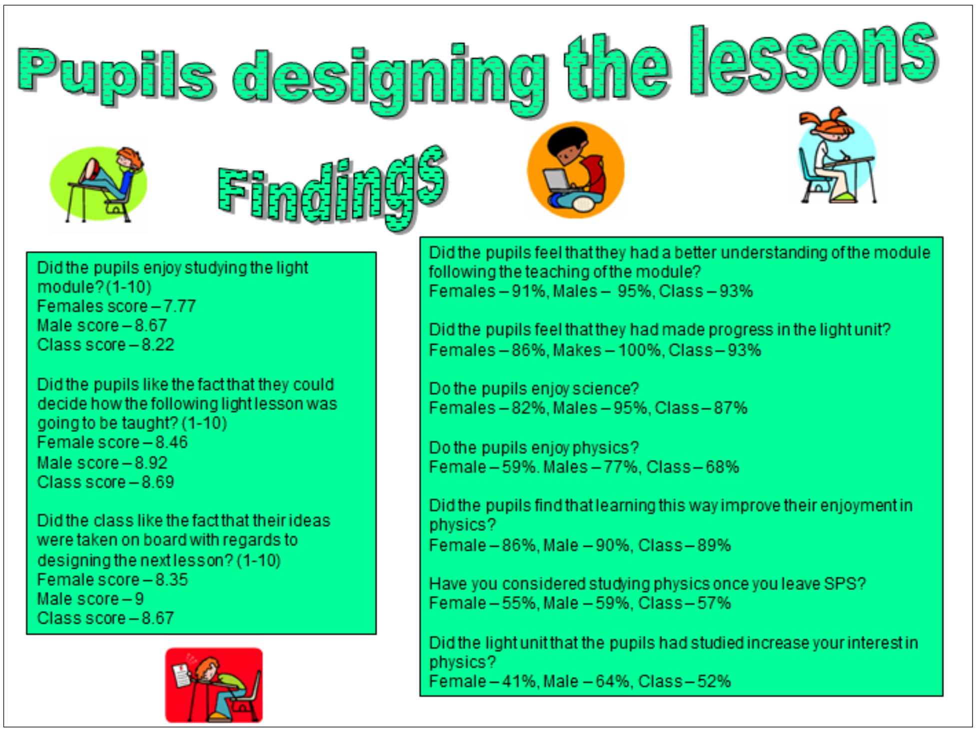
There are a couple of pupils that have said they find science boring???

Physics in our Universe

- A year 8 class are working with Science and Art to create a mural within this space looking at where physics has an impact on their life. It is also looking at where physics can take them through a greater understanding of the universe and the development of technology
- Research and drawings are in progress to produce a huge 'mind map' linking key concepts of physics that impact our lives. At the centre will be the Large Hadron Collider one of the biggest science experiments ever investigating the beginnings of the universe.
- Special interference paints that change colour in different light aspects will be used, this paint itself is a good example of how physics can be used in world around us.
- The aim of this project is to encourage pupils to look at physics as something that is relevant to their everyday life and to intrigue them about the world of physics.

Appendix 7h: Poster Pupils designing the lessons powerpoint- The Sweyne Park School





Appendix 7i: Pupils designing the lessons data analysis- The Sweyne Park School

Female														
1)Did you enjoy the light module that you recently studied? (1-10)	9	6	8	8	6	8	8	8	8	7	8	8	9	7.77
2)Did you enjoy the fact that you could decide how the following light lesson was going to be taught? (1-10)	10	3	8	9	10	9.5	10	9	8	7	8	9.5	9	8.46
5)Did you like the fact that your ideas were taken on board with regards to designing the next lesson? (1-10)	8	7	8	8	9	9	8	9	8	8	7	9.5	10	8.35
Male														
1)Did you enjoy the light module that you recently studied? (1-10)	8	7	8	10	10	10	8	9	9	9	8	8	8.67	
2)Did you enjoy the fact that you could decide how the following light lesson was going to be taught? (1-10)	8	6	9	10	10	10	10	8	8	10	9	9	8.92	
5)Did you like the fact that your ideas were taken on board with regards to designing the next lesson? (1-10)	8	6	8	10	10	10	10	9	9	10	9	9	9.00	
Both														
1)Did you enjoy the light module that you recently studied? (1-10)	8.22													
2)Did you enjoy the fact that you could decide how the following light lesson was going to be taught? (1-10)	8.69													
5)Did you like the fact that your ideas were taken on board with regards to designing the next lesson? (1-10)	8.67													
Female														
15) Do you feel that you have a better understanding of light following the teaching of the module?	1	1	1	1	1	1	1	1	1	0	1	0.91		
16)Do you feel that you have made progress in this unit? If so why, if not why?	1	1	1	1	1	1	1	0	1	0.5	1	0.86		
17) Do you enjoy science?	1	0.5	0.5	1	1	1	1	1	0.5	0.5	1	0.82		
18) Do you enjoy physics?	1	0	0	1	1	0.5	1	1	0	0	1	0.59		
19) Did learning in this way improve your enjoyment of physics? If so why	1	0	1	1	1	1	1	1	1	0.5	1	0.86		
20)Have you considered studying physics once you leave SPS?	1	0.5	0	1	1	0	0.5	1	0	0	1	0.55		
21)Did the light unit you have just studied increase your interest in physics?	1	0	0	1	0	0.5	1	0	0	0	1	0.41		
Male														
15) Do you feel that you have a better understanding of light following the teaching of the module?	0.5	1	1	1	1	1	1	1	1	1	1	0.95		
16)Do you feel that you have made progress in this unit? If so why, if not why?	1	1	1	1	1	1	1	1	1	1	1	1		
17) Do you enjoy science?	1	0.5	1	1	1	1	1	1	1	1	1	0.95		
18) Do you enjoy physics?	1	0.5	1	0	0.5	0.5	1	1	1	1	1	0.77		
19) Did learning in this way improve your enjoyment of physics? If so why	1	0.5	1	0.5	1	1	1	1	1	1	1	0.91		
20)Have you considered studying physics once you leave SPS?	1	0	0.5	0	0	1	1	1	1	0	1	0.59		
21)Did the light unit you have just studied increase your interest in physics?	1	0	1	0	0.5	0.5	0	1	1	1	1	0.64		

Both														
15) Do you feel that you have a better understanding of light following the teaching of the module?	0.93													
16)Do you feel that you have made progress in this unit? If so why, if not why?	0.93													
17) Do you enjoy science?	0.89													
18) Do you enjoy physics?	0.68													
19) Did learning in this way improve your enjoyment of physics? If so why	0.89													
20)Have you considered studying physics once you leave SPS?	0.57													
21)Did the light unit you have just studied increase your interest in physics?	0.52													

Appendix 7j: Responses about questioning - The Sweyne Park School

	Male		Female		Total		Total (%)	
	Yes	No	Yes	No	Yes	No	Yes	No
Do you feel questioning is important in science?	14	1	14	0	28	1	97	3
Do you feel that you can ask questions in science?	15	0	14	0	29	0	100	0
Do you like to ask questions in science?	9	6	10	4	19	10	66	34
Do your questions get answered in science?	15	0	13	1	28	1	97	3
Do you think the environment is crucial to you feeling secure in asking questions in class?	12	3	12	2	24	5	83	27
Do you take an active role in asking questions in science?	12	3	10	4	22	7	76	24
Do you enjoy using the white boards in answering questions in lessons?	15	0	12	2	27	2	93	7
Did you enjoy the activity where you watched a video (stimulus) and then had to prepare a question to ask?	15	0	14	0	29	0	100	0
Do you feel that questioning helps your understanding in science?	14	1	14	0	28	1	97	3

Appendix 7k: Results from CERN questionnaire - The Sweyne Park School

	FEMALE		MALE	
	YES	NO	YES	NO
1) Had you heard of CERN before Mrs Aylen talked about it?				
2) Did you know what CERN was about before Mrs Aylen talked about it?				
3) Had you heard for the Large Hadron Collider before Mrs Aylen talked about it?				
4) Did you know what the Large Hadron Collider was doing before Mrs Aylen talked about it?				
5) What did you know or had you heard about related to the Large Hadron Collider before Mrs Aylen talked about it?				
6) Did you like the fact that Mrs Aylen involved you on her journey to CERN and the Large Hadron Collider?				
7) Did you like the fact that some of the questions that you asked were answered by scientists?				
8) Would you like the opportunity to speak to scientists who work at CERN?				
9) Would you like to visit CERN and find out for yourself what goes on there?				
10) Has Mrs Aylens visit inspired you further with science?				
11) Has Mrs Aylens visit inspired you further with physics?				
12) Did you like the lesson that Mrs Aylen gave about her findings and what she got up to at CERN?				
13) What could Mrs Aylen do differently to show what she found out about CERN and the Large Hardron Collider?				
14) Are you more interested in science as a result of Mrs Aylens visit to CERN?				
15) Are you more interested in physics as a result of Mrs Aylens visit to CERN?				
16) What do you remember about Mrs Aylens visit and feedback to you about CERN and the Large Hadron Collider?				
17) Has your involvement with Mrs Aylens trip to CERN highlighted more areas of science than you were aware of?				
18) Is there anything that you would like to add to this questionnaire about CERN and the Large Hadron Collider?				

Appendix 8a: Images - South Dartmoor School

For Hubble telescope images, see:

https://www.google.co.uk/search?q=kurt%20jackson&oe=utf-8&aq=t&rls=org.mozilla:en-GB:official&client=firefox-a&um=1&ie=UTF-8&hl=en&tbm=isch&source=og&sa=N&tab=wi&ei=imRPULrzLejZ0QXUiYDIAQ&biw=1525&bih=654&sei=jGRPUJL5PMfW0QXT_IGYDg#um=1&hl=en&client=firefox-a&rls=org.mozilla:en-GB%3Aofficial&tbm=isch&sa=1&q=hubble+telescope+pictures&oq=hubble&gs_l=img.1.4.0l10.87957.89159.0.91349.8.6.1.1.1.0.330.1056.0j4j1j1.6.0...0.0...1c.1.OPX8N9HZxak&pbx=1&bav=on.2,or.r_gc.r_pw.r_qf.&fp=7167c5af6238161&biw=1525&bih=654

Appendix 8b: Kurt Jackson Images - South Dartmoor School

For images, see:

http://www.kurtjackson.co.uk/kurt-jackson-this-place-st-just-in-penwith-thumbs.html

http://www.kurtjackson.co.uk/kurt-jackson-this-place-st-just-in-penwith-publication.html

https://www.google.co.uk/search?q=kurt%20jackson&oe=utf-8&aq=t&rls=org.mozilla:en-GB:official&client=firefox-a&um=1&ie=UTF-8&hl=en&tbm=isch&source=og&sa=N&tab=wi&ei=imRPULrzLejZ0QXUiYDIAQ&biw=1525&bih=654&sei=jGRPUJL5PMfW0QXT_IGYDg

Appendix 8c: Videos available - South Dartmoor School

Journey to the Stars

The Simpsons

The Known Universe

Appendix 8d: Materials available for schools from the 21st Century Science (University of York/The Nuffield foundation)

Focal length and power
Pinhole cameras
Telescopes

Making telescopes

One of the first telescopes was used by Galileo Galilei in 1632 to observe the moons of Jupiter. His discovery that they went round Jupiter and not the Earth got him in a lot of trouble with the Catholic Church in Rome and they only forgave him and let his soul into Heaven in 1981!
Your task is a lot easier than looking at the moons of Jupiter and less risky! You can make a telescope very easily using two lenses of different sizes and a tube of card.

1. Find out what the "focal lengths" of the lenses are. You can tell this by the coloured stripes on the edges of the lenses:
   - White 5cm
   - Red 15cm
   - Yellow 25cm
   - Green 50cm
2. The whole telescope needs to be as long as these two numbers added together. So a White lens (5cm) and a Yellow lens (25) would be 30cm over all.
3. Roll the coloured card around the cardboard tube and stick the card together so that it can slide up and down the tube. This is how you will focus the telescope on near and far objects.
4. Stick the lenses to each end with Sellotape, being careful not to get Sellotape over the lenses too much or you won't be able to see anything!
5. Slide the telescope until the two lenses are the right distance apart that you worked out in part 2. That's it!
6. Hold the "thicker lens" (the one with the smallest focal length) near to you eye and look out of the window. You might need to focus it a little bit.
7. What do you notice about the image you see?
8. Can you focus it to look at closer things?
9. Try with different lenses and see what difference that makes to the telescope.

Focal length of lenses:

- White 5cm
- Red 15cm
- Yellow 25cm
- Green 50cm

Length of Telescope = Add together the two focal lengths

Magnification of Telescope = divide the two focal lengths

e.g. 5cm lens and 50cm lens: $\frac{50cm}{5cm} = 10 \times magnification$

Appendix 8f: Sense of Place trip letter - South Dartmoor School

Sense of Place: Microcosms and Macrocosms Project

Dear Parent/Guardian

I would like to take this opportunity of inviting your son/daughter to take part in this interesting and exciting cross curricular project and to inform you of a field trip we are planning as a launch to it.
The project will take place in triple science physics lessons after half term and will be an innovative and creative way of looking at the science contained within the student's P7 Observing the Universe module.
We will be combining a number of different teaching and learning styles and it will be a collaboration between the Science, Photography, Art, English and Drama departments.
The whole premise of the project is to consider our place within the vast expanse of the universe and to investigate how the tiny can be both insignificant but also highly significant.

Callington Space Centre Field Trip – Mon 7th June 3.35pm – 11.30pm

I have organised for the group to visit the world renowned Callington Space Centre in Cornwall for an observation evening using their professional telescopes. The idea will be to look at near space objects like the moon and the planets but also to look into the deep recesses of space to find distant galaxies and super novae.
On the evening we will also be teaching the group a diverse range of photographic techniques so that they can gather their own images for the rest of the project.
Students will **NOT need to wear college uniform** on the day of the trip but must **wear warm suitable clothing to be outside until late at night**. We aim to leave for Callington at the end of the college day and will not return until about **11.30pm Obviously parents will need to collect their son/daughter from college at this time.**

Students may wish to bring a packed evening meal to school that day but we will be stopping somewhere where food can be purchased.
There will be NO COST to students for the visit or transport as the project is being funded through our Creative Schools Award. It would be good if students could bring their own **Digital Cameras and Torches** (but if they haven't got their own we will have a number that can be loaned out).

Could you please complete and return the attached consent (as soon as possible) saying that you are happy for your son/daughter to take part in the project and to attend the field trip on Monday 7th June at Callington Space Centre.
I look forward to working with your son/daughter on this very exciting opportunity.

Yours sincerely

Phil Atherton
Teacher of Physics

Appendix 8g: Sense of Insignificance Final Writing

Sense of Insignificance - Writing

1) Your Experiences

What are your experiences of the project as a whole.
What did you like/dislike, how did you find working in this cross curricular way?
What will be your memories of the project?
What is your understanding of what the project was about?

2) Final Art work

How did you come to produce the image that you did?
What were you thinking?
What does it show?
What are/were your feelings?