IOP Institute of Physics
Education *Supporting Teachers*

Classroomphysics

The newsletter for affiliated schools

June 2013 Issue 25

Policy

Schools lack provision for practical science

IOP

Taking part in practical work is an integral and essential part of learning in the sciences.

New evidence shows that a worrying number of students are not experiencing a complete and authentic education in the sciences, due to a lack of resources for practical work.

Research commissioned by the Science Community Representing Education (SCORE), a collaboration of leading science organisations, including the Institute of Physics, shows that, on average, state-funded secondary schools and sixth-form colleges have just 70 per cent of the equipment and consumables they need to teach science subjects.

The research is published in two new SCORE reports on resourcing practical science that were launched on 2 May. The data come from a survey of teachers at primary and secondary schools and sixth-form colleges across the English regions.

Secondary schools report not having enough of some of the most commonly used basic equipment for teaching practical biology, chemistry and physics, such as microscopes, eye protection and connecting leads for circuits. Nearly half of secondary school teachers felt they did not have enough funding for practical science, although, not surprisingly, levels of satisfaction rose with the amount spent on science. In state-funded schools only 10% of respondents reported being very satisfied with their funding, compared with 61% of respondents in independent schools.

There are some particularly concerning data on the amounts that schools are spending on practical science, which varies greatly from institution to institution. In state-funded secondary schools the reported spend in 2011/12 varied from 75 pence per student up to £31.25, and in independent schools from £7.18 to £83.21.

The research also shows that many state-funded secondary schools lack essential support from qualified technicians to carry out practical work, with just over a quarter of respondents reporting that they need at least one additional technician. It is also clear that inadequate facilities are limiting the practical work that can take place, with over a quarter of respondents reporting dissatisfaction with their laboratory facilities. All of the reported problems in this area related to the design and set-up of laboratories, in particular insufficient bench space, the inability to black out labs and insufficient space to run long-term experiments.

In many schools, practical science is a low priority when it comes to allocating budgets.

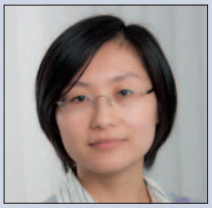
Professor Julia Buckingham, chair of SCORE, says: "We need teachers to feel that they can make a strong case for practical-science spend when school budgets are being decided. To support teachers in this, SCORE has produced a set of benchmarks for both primary and secondary schools that provide common guidance on what levels of resourcing should be expected to ensure all pupils receive a well-rounded science education. These outline the quantities and specifications for equipment and facilities that we consider reasonable to enable teachers to provide engaging and inspirational lessons across the sciences."

For more information: affiliated schools will have received a copy of the full *Resourcing Practical Science at Secondary Level* report in this mailing. To download the reports and the benchmarks, go to www.score-education.org.

The latest physics education news, resources and classroom ideas — from the IOP education team

In this issue

Editorial



Welcome to the 25th edition of *Classroom Physics*. It's hard to believe that the newsletter has been going in this format for more than six years, when so many other things change so rapidly! When we started the newsletter, we did not know that the work of the education department of the Institute would expand in the way it has done, but this newsletter has been the way to keep you up to date with all our support and activities.

Our front page story looks at the SCORE report on resourcing school science. We now have the evidence to support those battling to improve the practical resources at their disposal.

You will know that the Institute has been working hard on the girls-in-physics issue for a number of years. There is an update on a workshop run at the Big Bang Fair (p3) to help girls understand the opportunities that physics can offer. We are continuing to develop some projects in this area and aim to bring you more news of these in 2013/14.

If you know of a colleague or sixth-form student that would like to extend their physics knowledge, then there is more information about Open University short courses on p5. There is still time to book to attend the two-day ASE celebration event (p2), the Charterhouse physics booster course (p6), or one of the many one-day conferences taking place around the country over the next few weeks (p7). We are also asking more schools to volunteer to take on a prospective teacher for a short period of observation (p6), to help encourage the next generation of physics teachers.

News of other resources to enhance your teaching include new upd8 resources and physics in sport resources from SEPnet (p4), as well as Zooteach, a new website of resources from the Zooniverse team (p4).

Have a good summer!

Clare Thomson, editor (tel (0)20 7470 4981, e-mail clare.thomson@iop.org)

Manchi Chung, assistant editor (e-mail manchi.chung@iop.org)

Conference

Join ASE Summer Celebration

The Association for Science Education (ASE) will be celebrating its 50th anniversary with a one-off CPD event for science educators – the ASE Summer Celebration Conference, 27–28 June, University of Hertfordshire. The conference will include debates, practicals, workshops and opportunities to discuss the future of science education.

Notable sessions include:

- Astonomer Royal, Prof. Lord Martin Rees of Ludlow, and Salters' Professor of Science Education at the University of York, Prof. Robin Millar, debate the 80:20 divide.
- Brenda Keogh and Stuart Naylor from Millgate House challenge perceptions of school science.
- Prof. Sir John Holman, chemistry professor and senior education adviser for The Wellcome Trust, focuses on accountability in science.

The Institute will also be present at the conference showcasing our Promoting & Interpreting Physics Education Research (PIPER) project, which aims to engage teachers, teacher trainers and CPD providers in accessing and working with the best available research in physics education, and launching an exciting new enrichment resource to support student engagement with physics.

There are only 500 places available at the conference and delegate packages start from £285 for ASE members.

For more information: and to book online, visit www.ase.org.uk/conferences/summer-celebration/.

Project

Wondering where to start your lesson planning? How about beginning with assessment?

The aim of the York Science project is to develop teaching resources that will help teachers to improve the quality of their students' learning in science.

Based on research evidence and experience, two of the principal keys to improving learning are:

- having clear and precise learning outcomes in mind for every teaching episode;
- monitoring students' learning during the teaching process, so that you (or they) can immediately act on what you find.

At a time of curriculum change, when schools are anticipating rewriting schemes of work across all key stages over the next few years, a "backward design" approach might appeal. If you are wondering where to start your planning, we suggest beginning with assessment. What do you want your students to be able to do at the end of the topic or course? Do not just write a list of objectives, or even outcomes. Identify the questions and tasks that will show evidence of learning. Knowing exactly what you want students to do gives a focus to planning the teaching activities.

A set of assessment items that will give precise information about where students are in their learning can form the backbone of a teaching scheme. Diagnostic questions can reveal which students hold common misconceptions and which students are moving towards a scientific understanding. Used as an integral part of the lesson, the response from a class to the question gives the teacher information that can determine what happens next in the lesson – truly embedded formative assessment.

The assessment items being developed by the York Science project at the University of York will help teachers identify those students who understand the important ideas in science and are ready to move on. These assessment materials are not intended to be used as paper-and-pencil tasks to be set as homework or in end-of-topic tests (although some of them could be). The items are designed to be used during the course of the teaching – embedded into the lesson so that teachers (and students) can act immediately on the information revealed by the assessment.

Mary Whitehouse, project director

For more information: including details about when and where the project team are speaking and running workshops, visit www.yorkscience.org.uk.

Policy

IOP continues to encourage girls into physics

Working with Intel and WISE, the Institute has been developing a new workshop for girls aged 11–15 years old. The workshop invites girls to debate the issue of female underrepresentation in key areas of STEM. It also aims to make girls more aware of the variety of careers that are opened up to them by pursuing STEM subjects.

We held pilot sessions at the Big Bang Fair in London on Thursday 14 and Friday 15 March. The girls were shown the notorious *It's a Girl Thing* video, produced by the European Commission, and asked to discuss some of the shocking statistics on girls and women in STEM. They were also confronted with some controversial opinions on girls and science and asked how they would react. This was intended to help develop awareness of gender stereotyping and their gender identity.

As well as having their say on the issues, the girls had the chance to spend some time with women who work in STEM. A group of female "role models" were acting as facilitators throughout the session. They ranged from a forensic scientist to a civil engineer, with many other roles represented in-between. The girls were invited to quiz the facilitators on their careers and lives, finding out how they got to where they are today and about all of the challenges they faced along the way.

More than 100 girls attended a session and we had some very positive feedback. We are now planning to develop the workshop into a model that teachers can run in their own schools.

For more information: on the Institute's work on encouraging more girls into physics, visit www.iop.org/girlsinphysics.

IOP

Girls attending the jointly organised IOP, Intel and WISE workshop at the Big Bang Fair.

Careers from science

WISE support for careers

If you ask young people to name the jobs you can do with science qualifications, doctor usually comes top of the list. They are highly unlikely to say building-services designer, epidemiologist, geotechnical engineer, oceanographer or science communicator. Do they even know what these jobs are? How much would you be able to tell them about these roles or the many other opportunities available to people with physics A-level?

Earlier this year, WISE produced a poster listing 101 jobs involving science and maths, designed to raise awareness of the range of opportunities available. Details of the poster are available on the WISE website (www.wisecampaign.org.uk/education/schools) with links to online case studies and a suggested lesson plan on how to use these resources in the classroom. The poster is available free to schools.

WISE promoting female talent in science, engineering and technology from classroom to boardroom

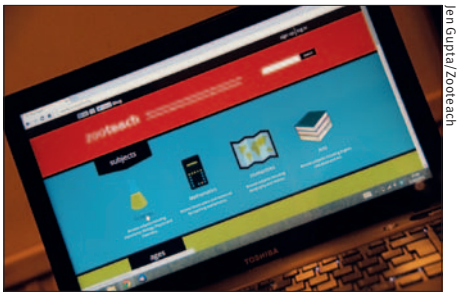
WISE is an organisation that aims to inspire women and girls to pursue STEM as a pathway to exciting and fulfilling careers. Their WISE Awards are an opportunity to recognise inspiring individuals actively addressing the core concerns of WISE – promoting science, technology, engineering and mathematics to girls and young women. This year's WISE Awards include a new WISE Girl category as well as WISE Adviser (to acknowledge the key role played by teachers, advisers and mentors who inspire girls and young women to pursue science, maths and technology, particularly in areas where girls are under-represented).

For more information: visit www.wisecampaign.org.uk to find out how to nominate a student or colleague for a WISE award. For copies of the poster, send an A4 self-addressed envelope with a large-package postage stamp to: WISE, Quest House, 38 Vicar Lane, Bradford BD1 5LD.

Resources

New website supports classroom astronomy

The Zooniverse is a collection of online citizen science projects that allow anyone with an internet connection to contribute to actual research. Starting out with the hugely successful Galaxy Zoo project (where participants classified galaxies based on their shape), the Zooniverse projects have diversified to now include activities where young scientists can identify whale sounds or transcribe wartime ship logs. In addition to Galaxy Zoo, there are currently five other astronomy-related projects (Moon Zoo, Planet Four, Solar Stormwatch, Planet Hunters and the Milky Way Project), enabling physics teachers to bring real science into the classroom.



Jen Gupta/Zooteach

Find and share lesson plans at zooteach.org.

zooteach.org is a new website where teachers and educators can share lesson plans and resources that link in with the Zooniverse projects. Zooniverse team members and collaborators are developing a range of lesson plans for *zooteach.org*, but support from the teaching community will be important to its success. If you use Zooniverse projects in the classroom then please upload lesson plans, ideas, links, worksheets or comment on any existing *zooteach.org* resources. *zooteach.org* workshops for teachers are also available.

For more information: visit www.zooteach.org and www.zooniverse.org or contact Dr Laura Whyte (e-mail laura@zooniverse.org).

Student competition

Physics in sport is still a sure-fire winner

Love it or hate it, the summer of 2012 will be remembered as the summer of sport. Last year, the South East Physics Network (SEPnet) joined in the excitement and ran a London 2012 competition for teams of sixth-form students. A total of 45 schools took part in eight heats across the south-east region. Each heat was based on the physics behind a different Olympic sport. The winning team from each heat then attended a final competition round that looked at the Paralympic sport of boccia.

The legacy of last summer continues, with record numbers of young people signing up to take part in their sport of choice and many more sporting events being hosted by the UK. Sport therefore remains a relevant context for physics and attractive to a range of pupils. The Physics in Sport Competition for teams of sixth-form students will also run again this year on 17 July at several SEPnet partner campuses.

SEPnet

Winners from the Royal Latin School with Daniel Bentley, a member of the London 2012 boccia team.

Based on feedback from teachers who attended the competition last year, SEPnet has adapted the competitions into hour-long activities for KS3 students. The focus has been to provide reasonably cheap and simple-to-run activities that can be carried out in the classroom, illustrating various aspects of physics through sport. Resources outlining each activity will be available from the National STEM eLibrary (www.nationalstemcentre.org.uk).

SEPnet is a consortium of university physics departments in the South East working together to promote physics in the region.

For more information: and to book onto the competition, please e-mail outreach@sepnet.ac.uk or visit www.sepnet.ac.uk/outreach.

Resources

Physics lessons smooth the way to GCSE

New from the upd8 store – dozens of year-9 physics lessons to smooth the transition to GCSE. They illuminate the ideas, cover the content, and sharpen the skills, to equip students for the written and practical assessments in all specifications. Each lesson is set within a highly motivational context and is structured to help all abilities master the material.

For example, in upd8's "Daredevil" lesson, students take on the role of working on set with a stunt team and camera crew to ensure that the stunts specified by the director can be achieved. Students are assigned a car-chase stunt. They must ensure that the cameras are in the right locations to get the required shots and that the "hero" knows when to act his key scenes. To do this they will plot distance–time graphs.

In upd8's "Hot Stuff" sequence of lessons, students learn about energy transfer as they explore the range of cooking techniques used by top chefs. They carry out a series of heat experiments in the lab, to meet the challenge of explaining cooking techniques in terms of particles, conduction, convection and radiation.

Each set of enquiry-based activities is priced from £7.99.

For more information: visit http://store.upd8.org.uk/.

Exhibition

Experience the heart of the LHC at exciting new exhibition

Science Museum/Nissen Richards Studio

One of the rooms from the Science Museum's new CERN exhibition.

Last year particle physics made headlines worldwide when scientists in Switzerland announced the discovery of the Higgs boson. From this November, students can be transported to the machine that discovered the elusive boson, the Large Hadron Collider (LHC), via an immersive, dramatic exhibition at the Science Museum in London.

Visitors will be transported from the CERN control room into the heart of the world's largest experiment. They will be able to explore the LHC tunnel, through which beams of protons travel at nearly the speed of light, and see real parts from the machine. They will be taken to the heart of the LHC's giant detectors and experience a collision, where new particles are made from the energy of the incoming beams.

The LHC uses key concepts from A-level physics – magnetic and electric fields are used to manipulate the fundamental particles that make up our universe. The exhibition will show how material learned in the classroom is part of cutting-edge research. Objects from the LHC and its four enormous detectors will be brought to life by the physicists and engineers who operate the machine. CERN scientists will provide a unique insight into working as part of an enormous international collaboration, driven by curiosity about how the universe works.

Visitors will be taken to the heart of the LHC's giant detectors and experience a collision.

Characters include Christoph Rembser, a German physicist who built detector parts in collaboration with Russians and Americans, and Marta Bajko, a Hungarian engineer. She will explain the huge forces that the LHC tames with its superconducting magnets. The exhibition opens in November 2013 and will run for six months.

For more information: call (0)20 7942 4777 to book. Tickets cost £4 per student. The target audience is 16+, although younger groups are welcome.

Online courses

OU short physics courses prove popular with students and teachers alike

Since 2005, more than 18 000 sixth-form students have studied short science courses with the Open University (OU), covering a range of topics including astronomy, genetics and the frozen planet. The courses have proved to be popular with schools as they have challenged their more able students and developed their abilities as independent learners, an important skill needed at the higher-education level. The courses have also been popular with teachers, who have studied them as part of their professional development. For example "Understanding the universe" has been taken by many physics teachers whose physics/astronomy degrees have included little cosmology.

The courses take a topic-based approach, developing learning through a range of media (including videos, audio recordings, interactive questions and activities and small projects), all of which are embedded in the OU's online Moodle-based learning platform. Students are offered online academic support from an OU learning adviser and can check their understanding via an interactive online quiz that offers differentiated feedback, before downloading evidence of their study of the course. Of the 10 courses, four are physics-based: learn about sport; nuclear energy; galaxies, stars and planets; and the weather. Each course supports 80 to 100 hours of study over a flexible period (from six to 18 months) and can be started at any time.

hidesy/iStockphoto.com

A sunburst fossil shell.

The recent change to university funding in England has meant a big increase in fees for most university courses, but as these are online courses and do not offer formal accreditation they are being offered for a reduced fee of £150 each, which may be reimbursed in England via the Education Funding Agency.

A number of these courses still exist in the form that offers 10 university credits (CATS points) provided the formal assessment is passed. In this form the course fee has increased to £427 for students in England, but government funding in Scotland, Wales and Northern Ireland enables the course fees to remain at their pre-October 2012 levels (now £185) and there are various funding sources that schools may be able to apply to.

For more information: visit www.open.ac.uk/science/schools or contact Liz Whitelegg, science short course director, (e-mail Science-Schools-Enquiries@open.ac.uk).

Teacher training

Schools' support for the teachers of tomorrow

One of the most important things that teacher trainers look for in a potential teacher is that they have made the effort to visit a school prior to applying for their training. Not only does this confirm in the minds of potential teachers that teaching is for them, it also highlights an individual's commitment to and understanding of the profession.

To support potential physics teachers through this process, the Institute has used its links with teachers and schools across the UK to develop the School Experience Programme. With more than 650 registered schools nationwide, the programme involves matching a prospective teacher to a local school to gain the necessary experience.

As the programme grows in popularity, the Institute continues to look for more schools to be part of the programme. If your school is happy to help the Institute, we would add your school to the database and let you know when we pass on your details. If at any time you are unable to commit to a visit we will find another school for the prospective teacher to visit.

IOP

For potential teachers who have struggled to arrange school experience, this programme has been a lifeline.

For more information: If your school is able to take part in the programme, please register at www.iop.org/sepschools.

Professional development

Week-long course will boost your physics subject knowledge

The Charterhouse Summer Residential Course is a successful week-long course and is free of charge (except for travel to/from the venue and cover) for newly qualified physics teachers from state schools. Prospective teacher-training students from nearby universities also attend.

The course aims to boost subject knowledge and confidence in teaching KS3 and 4 physics. Hands-on practical lab work, lectures and group discussions develop insight and understanding of the subject. Each day focuses on a major part of the physics curriculum and the week culminates in a practical investigation carried out by delegates in small groups. Each group reports its findings, giving physics explanations to illuminate their results. This year, the programme will be themed around "using new technology effectively".

The course uses the well-equipped labs in the school and is generously staffed with experienced state and independent schoolteachers. Each week-long course is highly rated by attendees and will run twice this term: on 1–5 July and 8–12 July, at Charterhouse in Surrey. New this year, an A-level course will be run on 8–12 July, if there is sufficient interest. The content will be determined by the requirements of participating teachers. Please contact Steve Hearn for further details.

For more information: and to book your place on a course, contact Steve Hearn (e-mail sth@charterhouse.org.uk).

Charterhouse

Experienced teachers deliver lab-based sessions covering the basics of KS3 and 4.

School partnerships

Connecting classrooms

Would you like your students to study climate change in a real-life global context? Are you interested in how physics is taught in other countries? Would you like to visit an overseas school and share your classroom experiences? If so, then an international schools partnership could be for you.

The British Council has 30 Bangladesh schools looking for a UK partner school. Apply now and you could receive a £1,500 grant to visit an overseas partner school through the Connecting Classrooms programme, which supports schools and colleges to connect with a school overseas, develop global citizenship and skills in students, and support professional development of teachers in the UK.

For more information: visit www.britishscienceassociation.org/connecting-classrooms-british-council or contact the British Science Association (e-mail crest@britishscienceassociation.org).

EVENTS FOR TEACHERS

Physics Big Day Out
Cosford RAF Museum, Shropshire
5 June
Free teacher event featuring make-and-take workshops, talks and support on how to teach tough topics, e.g. physics of flight.
Details and booking: contact Tom Dawson (e-mail physicsiseasy@googlemail.com).

25th Annual Rugby Meeting
Rugby School, Warwickshire
6 June
There will be lectures by leading research physicists and physics-education experts, hands-on workshops and an exhibition.
Details and booking: visit www.iop.org/rugby.

ASE Northern Ireland Conference
St Mary's University College, Belfast
7 June
The conference includes IOP-led sessions "Make-and-Take Physics and "Science Fair Project Generation" and a talk by entrepreneur Hugh Cormican.
Details: visit www.ase.org.uk/conferences/ase-northern-ireland-conference-2013/.

Space as a Context for Teaching Science
The Royal Observatory, Edinburgh and National Science Learning Centre, York
9–11 June and 7 October
Teachers can see the observatory facilities and meet scientists and engineers working on the James Webb Telescope.
Details and booking: visit www.slcs.ac.uk/go/nat/dnac12159.

Teacher Network for North Wales Conference
Bangor University
11 June
Talks and workshops for all who teach physics. The speaker will be Prof. Lyn Evans.
Details and booking: contact Andrea Fesmer (e-mail andrea.fesmer@talk21.com).

A Day for Everyone Teaching Physics
Durham University
20 June
Explore new resources for teaching physics and some of the latest physics developments.
Details and booking: visit www.sciencelearningcentres.org.uk/northeast or contact Nicola Hall (e-mail n.l.hall@durham.ac.uk or tel (0)191 370 6200).

Liverpool Annual Physics Teachers Conference
University of Liverpool
20 June
Open to all science teachers, the day will include lectures and workshops.
Details and booking: contact Lucas Hayhurst (e-mail lht@blueyonder.co.uk).

South West Physics Teachers' Conference
St Luke's Campus, Exeter
21 June
This popular, free event will be a mix of practical workshops, inspiring talks and congenial networking – all teachers, technicians and trainees are very welcome.
Details: visit www.sciencelearningcentres.org.uk/centres/south-west/courses-and-events/45545-60335.

8th Annual Charterhouse Physics Subject Knowledge Boosters
Charterhouse School, Godalming, Surrey
1–5 July and 8–12 July
Free, residential KS4/A-level subject-knowledge courses that involve hands-on lab work and theory/pedagogy sessions. This year, the theme will be "using new technology effectively".
Details and booking: contact Steve Hearn (e-mail sth@charterhouse.org.uk).

Summer Physics Update
University of Leicester
12–14 July
This three-day course will be hosted by the physics department and features a mix of talks, practical workshops and ample opportunity to share classroom experiences with fellow physics teachers.
Details: visit www.iop.org/update.

National Space Academy Physics & Astronomy CPD Sessions
National Space Centre, Leicester/Rutherford Appleton Laboratories, Oxfordshire
Various dates
These sessions will take you through activities, demonstrations and other resources needed to bring space science and astronomy alive in the classroom.
Details: visit www.nationalspaceacademy.org or contact Lisa Colford (e-mail lisac@spacecentre.co.uk).

Frontiers of Physics: Teachers of Physics Annual Conference
University College Cork
28 September
A day of lectures, demonstrations and workshops for all teachers of physics, including Junior Certificate Science.
Details and booking: visit tinyurl.com/frontiersofphysics.

EVENTS FOR STUDENTS

Schools and Colleges' Lecture – Defying Gravity: Make Physics Your Launchpad
This free lecture for 14–16-year-olds, given by Laura Thomas, will explore how scientists and engineers have used physics to make the dream of space exploration a reality.
Details: visit www.iop.org/schoolslecture.

SEPnet GCSE Physics Taster Events
Various locations and dates
These half-day energy-related events are best suited to students who are just about to start or are just starting their GCSEs.
Details: contact SEPnet (e-mail gcse@sepnet.ac.uk) or visit www.sepnet.ac.uk.

UK Space Industry Careers Events
National Space Centre, Leicester
24 June, 1 July and 8 July
These events are aimed at high-ability year-10 students. Speakers who work on planetary and solar space missions and earth-observing platforms will give talks.
Details and booking: contact Lisa Colford (e-mail lisac@spacecentre.co.uk).

"It's Not Unlucky 2013" Year-9 Physics Competition
2 July – King Edward VI School, Bury St Edmunds
5 July – Uppingham Community College, Rutland
This competition is open to teams of four students. Book by 14 June to secure a place.
Details: contact Gerry Blake for the East of England competition (e-mail gerry.blake@iop.org) and Helen Pollard for the East Midlands competition (e-mail helen.pollard@iop.org).

Particle Physics Masterclasses
University of Sussex
2 July – for AS-level students
3 July – for year-10 GCSE students
Each day includes experiments, computer simulations, talks and discussions. There will be opportunities to discuss experiments at the Large Hadron Collider, CERN.
Details: contact Darren Baskill (e-mail physicsoutreach@sussex.ac.uk).

Year-12 Physics in Sport Competition
Various locations
17 July
The challenges will be based on the physics found in sport, with each site exploring a different activity.
Details and booking: contact SEPnet (e-mail outreach@sepnet.ac.uk).

Space School
University of Kent
3–4 and 10–11 August
The programme will include rocket building and astronomical observing using the University's telescopes.
Details and booking: visit www.kent.ac.uk/physical-sciences/spaceschool or contact Sharon Humm, Space School Administrator (e-mail spaceschool@kent.ac.uk).

Visualising magnetic fields

Magnetism is a topic with plenty of opportunities for engaging practical work for students, but there are some potential pitfalls in helping them come to a good conceptual understanding of the phenomena. The Supporting Physics Teaching (SPT) materials have lots of good advice to offer.

Magnetic fields

A fascinating feature of magnets is that one can attract or repel another without being in physical contact with it. The magnetic force is one which "acts-at-a-distance".

The space around a magnet where the magnetic force acts is called the magnetic field. A magnetic field exists in a space if a magnet experiences a force when placed in that space. It is important to recognise that a magnetic field is not a tangible object (like an iron nail) but a theoretical concept, which we use to describe the physical world. We can point to the space around a magnet and claim (correctly) that there is a magnetic field in that space, but of course there is nothing there to actually see. Other "action-at-a-distance" forces are those associated with gravity and with electric charges.

Fields in 3D

You can use this activity to explore the magnetic field in the region of space around a magnet.

What to prepare

Per working group (pairs are best here):

- A bar magnet with the poles at the ends .
- A slab magnet with the poles on the faces.
- A small gimballed bar magnet free to spin in all three planes (a magnetic probe).

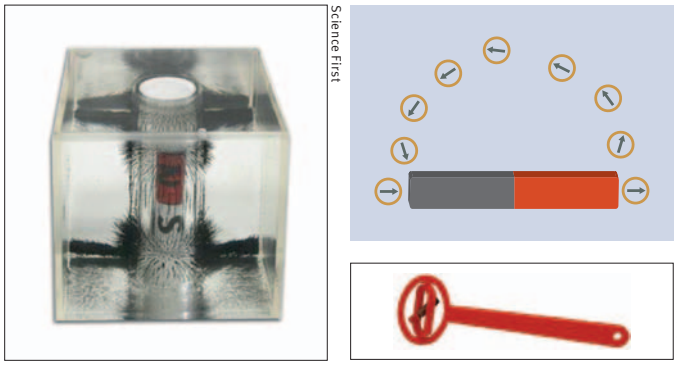
What happens during this activity

Pupils hold the bar magnet in one hand and trace out the magnetic field with the probe. You can model this first.

You might ask them to close their eyes and visualise the lines they have just traced out, or even have a wire and cardboard box model of it, but it would be unkind to ask them to represent this on paper. If you have a 3D field viewer you can show it to them.

Magnetic field diagrams

Magnetic fields are represented by diagrams that show patterns of magnetic-field lines. The magnetic-field lines show the direction in which the magnetic force is acting at any particular point. The density of the magnetic-field lines shows the strength of the magnetic force acting. If the lines are close together the magnetic force is great, if the lines are spread out the force is weak. From the magnetic-field pattern you can see that the magnetic field is strongest at the poles of a magnet.



(Left) A 3D field viewer. (Top right) Plotting compass demonstration. (Bottom right) A typical 3D magnetic probe.

Care should be taken in getting pupils to draw magnetic-field patterns. Rather than getting the pupils to start with iron filings and make their own drawings, try starting with a plotting compass demonstration, which helps pupils to understand and recognise what they are drawing, before progressing to drawing the iron filings.

Plotting-compass demonstration

Take a bar magnet and place it on the glass of an overhead projector. Switch on the projector and bring the magnet into focus on the screen. The idea is to use about 12 small plotting compasses to act as "magnetic-field detectors" to mark out the magnetic-field pattern. By placing the plotting compasses in key positions around the bar magnet it is possible to start sketching out the shape of the magnetic-field pattern, with magnetic lines of force following continuous loops from the north pole of the magnet round to the south.

Technician tips

- Plotting compasses can easily have their polarity reversed if a magnet is moved over the top of them. They will then need re-magnetising in the correct direction, so that the north end of the plotting compass needle points to the Earth's geographic north.
- Students should not handle iron filings directly as getting them in the eyes can be very painful. They can be sealed in plastic pockets or petri dishes for students to use for visualising field patterns.

For more information: register or log in to www.talkphyiscs.org and visit http://talkphysics.org/groups/1178 to download the SPT magnetism resource.

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