Dos and don'ts for consulting girls to encourage their increased take-up of physics

What can go wrong?	How can these dangers be avoided or minimised?
Creating expectations that cannot be met	The purpose of any consultation should be made clear from the outset, if it is simply to ascertain perceptions and expectations, then this should be explicit. However, often consultation is used to engage girls in contributing to the design of learning environments or individual lessons, or their evaluation. In which case this, again, should be explicit.
Asking leading questions	Questions used in consultation should be as open as possible to avoid the danger of girls telling facilitators/researchers what they think they want to hear.
Inhibitions among girls	Creating an environment in which it is safe to give honest opinions. In the establishment of and recruitment of members to focus groups and other consultation forums, it is important to consider how participants might influence one another, for example, girls may be less confident about expressing their views in mixed groups. Similarly the presence of teachers may influence responses.
Vested interests on the part of facilitator(s)/researchers	The person undertaking the consultation should be known by the girls to be able to be neutral. Experience shows that girls are prepared to open up in their peer group.
Other outside influences on the opinions of girls	Persons designing consultation activities should be aware that, although they might be trying to engage girls, there may be other parallel influences that need to be considered as part of the design of the consultation activities. For example, in the case of girls, parents or peer groups might have an important influence.
Unsuitable environment for consultation	Consultation strategies need to be designed to make it as easy as possible for girls to participate.
Failure to provide feedback	Girls are less likely to contribute to consultation if they feel that nothing is going to happen as a result. It is therefore very important to provide clear feedback and evidence that action has been taken.
Setting a negative tone	It is easy to set a negative tone. The question: "Why don't you want to do A-level physics?" can be reformulated as "What would help you and other girls to consider doing A-level physics?". Asking negative questions sets a negative tone and makes it difficult to engage girls in positive solutions-oriented responses to problems.
Not replacing national research	Consultation is often carried out as part of qualitative large-scale research. However, it is also often undertaken at local level as a preliminary to identifying barriers and designing positive action. In the latter case, it should not be used to replace national research. In particular, at local and institutional level, consultation is a valuable way of establishing institutional cultures and designing initiatives that build from these.

What can go wrong?	How can these dangers be avoided or minimised?
Issuing questionnaires without a "warm-up" period	Using questionnaires is a relatively inexpensive and efficient way of undertaking consultation. However, the quality of responses to questionnaires can be enhanced by preceding them with focus groups or discussion groups, which encourage girls to debate and reflect more deeply around the issues being addressed. For example, girls responses to a questionnaire about the most effective way of learning physics might be quite superficial. However, if this is preceded by a discussion about the relevance of physics to real life and potential physics-related careers, girls are likely to approach the questionnaire more thoughtfully.
Making assumptions about what girls know already	One of the dangers of consultation is that sometimes girls do not know what they do not know. If, for example, girls are being asked to state preferences with respect to different learning activities, it is important that they should have information about the range of possible learning activities so as to be able to make an informed decision.
Failure to triangulate	Decisions about change within schools are rarely taken by one group of stakeholders in isolation. Therefore, if girls are being consulted about, for example, single sex lessons, it is important that the outcomes of these consultations are "triangulated" with the views of other stakeholder groups, for example, departmental and school managers.
Failure to clarify the parameters of the consultation	As a further dimension relating to raising expectations that cannot be met, it is important at the outset to clarify what will and what will not be addressed as part of the consultation. For example, "this discussion will be about how you learn physics, it will not be about what is in the syllabus because that is decided by the government."
The wrong message source	People respond to information differently depending on who gives that message; a message from a teacher or head teacher might be interpreted differently from that given by a fellow learner or parent. When giving information or feedback as part of consultation it is useful to consider whose message is likely to be received most positively.

Guidelines for using positive role models to encourage girls in physics

What are the benefits of using positive role models as a means of engaging girls with physics?

- Many girls do not have access to women in their families or communities who have been successful in pursuing studies in physics or a career in a physics-related occupation.
- Research has shown that girls perceive physics to be a "male" subject and sometimes stereotype physicists as "old men with white beards and glasses".
- Positive female role models are a powerful tool for challenging these stereotypes.

What are the different contexts in which female role models can be used?

Female role models can be used both in the school and outside in the following ways:

- to contribute to individual lessons, presenting information that illustrates the relevance of physics to everyday life, as well as physics-related careers;
- to contribute to careers events or sessions for parents to explain and demystify physics-related careers;
- to participate in mock interview panels;
- as mentors;
- to participate in simulation/enterprise activities, for example, the Ashfield Music Festival;
- to host industrial visits, work placements and shadowing opportunities;
- to participate in specific project activities, for example, to be interviewed by learners;
- to contribute photographs, interviews and articles to websites and publications;
- to contribute to STEM club activities, and competitions and projects.

How should positive female role models be identified and selected?

Ideally, positive female role models should be chosen with the aim of challenging stereotypes both about what kind of people become physicists as well as demystifying the applications of physics. In particular, they should be someone whose age, background and experience schoolgirls can readily identify with. Bearing this in mind, positive role models should be able to:

- present a modern and gender-neutral image for physics;
- describe physics and its applications using language, images, examples and analogies that are accessible to schoolgirls;
- share their experience of overcoming barriers to girls and women in physics;
- provide advice and guidance for girls interested in furthering their study of physics.

Finding suitable role models

The STEM ambassador scheme should be able to help. Visit **www.stemnet.org.uk/** and click on "teachers" and then "STEM ambassadors" to find out more, including local contact details.

What sort of preliminary briefing is useful for positive role models?

It should not be assumed that every female physicist or woman in a physics-related occupation finds it easy to relate to schoolgirls with a limited knowledge and understanding of physics and its applications. Therefore, schools and teachers using positive role models should bear in mind the following.

Provide information about the curriculum

- Positive role models coming into school to participate in physics-related activities find it useful to know what girls have covered in the curriculum and, where appropriate, to link their input to this. For example: "To be a sound engineer you need to have an understanding of wave properties and acoustics." (Only years 12 to 13 may know what is meant by acoustics.)

Allow pupils to interview role models

- Positive role models need to be provided with an opportunity to "tune into" girls in the audience. This can be done by getting the girls to interview role models thus ensuring that girls' immediate concerns and interests are addressed.

Role models should personalise their experience

- Positive role models can be encouraged to take steps to bring their area of expertise alive, for example, by describing a typical day or a typical week.

Use resources from, or photographs of, the working environment

- Positive role models can be encouraged to stimulate girls' imaginations by showing them photographs or materials from their work environment, for example, a civil engineer may use pictures of themselves on a site visit, or a medical engineer may bring in stainless steel hip, knee and elbow joints and ask girls to guess what they are.

Don't over-simplify complex issues

- Positive role models can be guided to avoid over-simplifying complex issues. For example, in response to the question: "Is studying physics at university difficult?" instead of saying "yes" or "no", role models can be encouraged to elaborate and encourage by saying things such as, "if you enjoy solving problems, it's a good subject to study"; or "you do a lot more practical and lab work than in a lot of other subjects".

Role models should share their experience of being in a predominantly male environment

- Positive role models can be encouraged to reflect and share their experience of surviving in a predominantly male environment. For example: "I sat at the front of the class so that I didn't see the faces of the boys when I answered questions," or "I worked with the only other girl in the class and we gave each other moral support."

Getting more girls into physics – one-day workshop to make more girls aware of physics-related careers

Aim

To provide girls with a positive perspective on physics-related careers by making them aware of the rewarding and enjoyable careers that are open to women.

Participation

Girls are selected on the basis of showing potential to progress to A-level physics either from one school or several.

Venue

School, university or in a company.

Date and times

One full day, off timetable, with a morning session of roughly 2 hours and an afternoon session of $1^1/_4$ hours. The lunch break (1 hour) could include an exhibition of careers information provided by the role models or others.

Objectives

By the end of this workshop, participants will have:

- examined the links between studying physics and their career aspirations;
- become aware of a range of careers for which a qualification in physics is an asset;
- interacted with female role models with careers where they apply their knowledge of physics;
- designed and planned an activity to make younger learners aware of physics-related careers.

Delivery team

- External or internal facilitators, which could include physics teachers and careers teachers – at least one per group.
- Female role models from a variety of backgrounds (including STEM ambassadors).

Preparation

- Venue needs to be booked and lunch arrangements made.
- Other schools to be invited after previous liaison with them.
- The role models need to be recruited and briefed about the purpose of the day and their role within it.
- If a careers exhibition is planned for lunchtime, then arrangements are needed for provision of resources and displays (provided by the role models?).
- *Expand* leaflets need to be available (can be ordered from the Institute of Physics).
- Quiz sheets need to be copied (one for each group).
- Post-it notes or similar in two contrasting colours, to be distributed to each group – enough for one of each colour per student.

Outline of day

Morning session

Introduction (20 minutes)

- Introduction to the programme for the day (by facilitators).
- Explanation of the rationale for a girls-only day, i.e. under-participation of girls in A-level and undergraduate physics.
- As a means of doing a "before and after" evaluation, ask girls who are considering doing A-level physics to hold up a post-it note in one colour, and not considering it in another colour.
- Introduction of the delivery team and their roles.
- Mutual introductions. Participants to be divided into three/four groups, each with a mix of schools. Participants to be asked to pair up with a learner they do not know and find out their name and what they like about learning physics, and one thing they would change if they could. Debrief in groups and facilitators note responses for later reference.

What sorts of careers are open to you if you study physics? (30 minutes)

Participants are asked to remain in the mixed-school groups as before. With a facilitator, they are asked to "brainstorm" jobs where a knowledge of physics is useful. Their responses are recorded on flip chart by a facilitator. They are then issued with a copy of the *Expand* leaflet and asked to identify and record any careers that they did not identify before; these should be added in a different colour on the flip chart by the facilitator for the group.

Next, each group participates in a quiz about the careers on the leaflet. (The purpose of this is to get them to read the leaflet carefully.) The group with the highest number of correct responses wins. In the feedback, the facilitator should pick up on and emphasise in particular the bit about studying A-level physics keeping your options open, and elicit some further examples of transferable skills. The answers to the quiz for each group will be collected by the facilitator for that group and announced to the plenary by that facilitator.

How do you find out more about different careers that require a physics qualification? (15 minutes plus 1 hour)

Facilitators should explain that they are going to have an opportunity to interview a number of role models (the number chosen will depend on the number of students attending the workshop). The role models could include, for example, civil and medical engineers, meteorologists, radiographers and astrophysicists, as well as role models who have applied the transferable skills they acquired through learning physics, for example, women who have been successful within the financial or legal services. In preparation, participants will be asked to work in small groups of about five people to prepare questions for the role models. Initially they can be left to form their own questions, then facilitators may work with them to add where necessary, prompting them to ask questions such as:

- what sorts of activities are done on a particular job?
- what knowledge of physics and/or training is needed?
- what is a typical salary for someone just starting and later on?
- what is a typical week?
- what career progression opportunities are there?
- are there perks, such as travel?
- what is the gender balance at your work?
- how have you coped with being a girl/woman in your workplace?
- if they have children, what work/life balance arrangements have they and their employers put in place?
- what transferable skills does learning physics provide and how can these be applied in the workplace?

Then questions will be collated on a flip chart and participants will decide who asks what and who will chair.

Interviews with role models will then be conducted on a carousel with a maximum of 15 minutes per group (about 1 hour)

Lunch and careers exhibition (1 hour)

Afternoon session

How can we encourage other girls to consider studying physics? (about 1 hour)

The girls are now divided into groups representing the different schools (if appropriate). Each group will be asked to prepare a short activity for a group of younger learners. Their brief is to imagine that the girls with whom they will work believe the following:

- that physics is mainly only useful if you are going to work in a university for the rest of your life;
- that physics does not have much relevance or use in the modern world;
- that studying physics at A-level and university is more suitable for boys than girls;
- that women are not usually employed in jobs that require physics qualifications.

The task is to prepare a five minute or more activity for younger learners. Their activity(ies) must challenge the four statements above. They can do this in any way they wish, using pictures, simulations, experiments, posters, drawings, role plays, demonstrations, role models.

Allow 20 minutes preparation and 5–10 minutes presentation time per group.

Evaluation (15 minutes)

- Facilitators ask the groups to reflect on what they have learned during the day and what the most significant things were for them.
- Students feed back to the whole group the differences between their knowledge of physics-related careers at the beginning of the day and the extended list at the end of the day.
- Ask for a second show of post-it notes to see how many are now considering whether they might do A-level physics.

Close

Expand – physics at A-level, the logical choice

You will find the answers to all of these questions by reading the leaflet.

1. Name three modern gadgets that would not have been invented without a knowledge of physics.

2. How has a physicist revolutionised the way that the world communicates?

3. Why does an astrophysicist have to travel to other parts of the world as part of their work?

4. How does a physics background help with studying law?

5. As well as problem solving, what other transferable skills can you gain from learning physics?

6. How does a clinical scientist help with finding ways to diagnose and treat heart disease?

7. Why is it important for a sound engineer to have an understanding of physics?

8. David says that studying physics at A-level helps you to keep your options open; explain why?

9. What other subject is the most important to study at A-level if you have already chosen physics?

Ensuring 'girl-friendly' learning in the physics classroom – a checklist for teachers of physics

Background

This checklist is a set of questions designed to help teachers of physics to record and extend their own girl-friendly or gender-inclusive practice. It summarises some of the different strategies that teachers are using to create more girl-friendly learning environments in physics. Teachers report that many of these strategies equally benefit boys' learning. The checklist is aimed primarily at teachers of physics, but it may also be helpful for use in appraisals by line managers, as well as for use by teacher trainers and inspectors.

Check your girl-friendly or gender-inclusive practice in schemes of work and individual lessons	I do this routinely	Needs further development
Have you asked your classes what they think physics is and why physics is useful to study?		
Did you monitor the answers from the girls and boys? Are they different?		
Have you got real-world examples to use to introduce each new topic?		
Do you select analogies, examples and themes for assignments that both genders will be able to relate to (e.g. music and health in addition to football and cars)?		
So that work has a clear rationale, do you make a point of following the sequence: applications – principles – applications?		
Do you give examples of careers that use the knowledge and skills developed in the topic?		
Do you draw attention to female role models in the topics you are teaching?		
Do you use a variety of questioning techniques, including a growing proportion of open questions?		
Do you adopt styles of questioning that take account of some girls' stated preferences for time for reflection and discussion?		
In group and project work, do you ensure that roles are rotated so that girls have equal access to equipment?		
In group and project work, do you ensure that roles are rotated so that boys as well as girls do the note taking and other clerical activities?		
Do you monitor the proportion of time when you interact with boys in comparison with the time spent interacting with girls?		

Forces: Olympic cyclists

Learning objectives

Develop a medal-winning cyclist using existing knowledge of:

- balanced and unbalanced forces;
- streamlining and air resistance.

Starter

Clip of cyclist training for the 2012 Olympics.

Question: how can she win gold?

Relevance

Main

- Class is split into teams (fours) – single sex.

Group by gender

- Each team member has a specific role.

1. Bike engineer
2. Clothing manufacturer
3. Fitness instructor
4. Dietician

Careers

- Stimulus material provided. Higher ability – newspaper (availability – need more basic facts and costing – students decide and cost up their designs). There are many news articles online, for example:

1. News coverage of Beijing Olympics
   www.independent.co.uk/sport/olympics/britains-cyclists-better-by-design-889327.html
   Use of wind tunnel and modifying cyclist's riding position
2. **www.guardian.co.uk/environment/hicallivingblog/2009/jul/28/victoria-pendleton-bike-blog body shape/mass distribution**

- Must justify their choices, e.g. low weight bike – less force needed.
- Produce poster/pitch to convince the sponsor to pick their team.

Plenary – Dragons' Den. Sell their bike and clothing & fitness plan to the Olympians' sponsors. Who will get the contract?

Used to assess knowledge of pupils because no information is given, it is all student led.

Personalised learning

Lesson sequence

1st lesson – Big picture of the physics involved in winning a gold medal.

Relevance

2nd lesson – Revisit forces involved and introducing the correct terms, equations and diagrams, etc. See *Supporting Physics Teaching: Forces* for more on force arrows, balanced and unbalanced forces.

3rd lesson – air resistance and streamlining.

- Dropping helmet-shaped plasticine through oil.

Modelling

Radioactivity and medical physics

Starter: group discussion with a spokesperson

Identifying misconceptions

Alternatives to questioning

- Student ideas – true/false activity (e.g. *Teaching Advanced Physics* episode 509)
- With individual whiteboards: what is radioactivity? **No hands up and open-ended**

Students' experience of radioactivity (using everyday language)

Relevance

- Medicine, movies and media
- Link to BBC coverage of Litvinenko and review science content. Opportunity for student discussion **http://news.bbc.co.uk/1/hi/sci/tech/6190144.stm**
- **www.upd8.org.uk/activity/195/Isotope-kills-ex-spy.html**

Macroscopic treatment

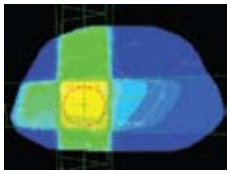
Avoiding use of formulae for macroscopic treatment, reinforce underlying physical principles first. Source – radiation – detector.

Ensure essential terminology is clearly defined: difference between irradiation and contamination.

Practical

- Radioactive material and radiation.
- Background radiation (measured with GM tube). Measure count rate from students/packed lunch/pencil case.
- Potassium chloride, solution and salt, and a banana. **Potassium ^{40}K is radioactive, present in tiny amounts (0.0117%).**
- Inflate balloon, charge by rubbing and take count rate after 30 minutes hanging next to wall.

Microscopic treatment



Modelling

- What happens to a radioactive source when radiation is emitted?
- Is it still radioactive? Half-life simulation using dice **www.practicalphysics.org/go/Experiment_579.html**
- What happens when radiation is absorbed?
- How can radiation cause as well as cure cancer?

Interactive radiotherapy

Relevance

Careers

Treat a tumour using X-rays Position 3 beams and patient to effectively treat a lung tumour. Whole class with web access or interactive whiteboard
www.ucl.ac.uk/medphys/dept/schools

Futher information

Teaching radioactivity: includes links to PEEP (Physics & Ethics Education Project)
www.iop.org/activity/education/Projects/Other%20Resources/Online_Resources/Teaching_radioactivity/page_31313.html

www.teachers.tv/video/27400 30 minute video of teaching radioactivity

Radium girls **www.peep.ac.uk/content/878.0.html**

Marie Curie **www.peep.ac.uk/content/876.0.html**

The sound of music

Starter

Hearing test (*Supporting Physics Teaching: Sound*)

Everyone standing, eyes closed, sit down if you can hear response.

All engaged at start of lesson

Demonstration

Wobble board (*Supporting Physics Teaching: Sound*). Large-scale representation of what's happening to the air particles – pupils can feel air moving to-and-fro, good for students with fine, flyaway hair (touch and visual). **Move around the room so that they all have direct experience.**

Practical work – appeal to their senses

Experiments

From the Institute's MODEL project

Bouncing rice: glass jar, cling-film top sprinkled with rice;

Seeing sound: tin can open both ends, balloon, small piece of mirror, torch and a clamp stand.

Both involve varying loudness and pitch, there will be some shouting involved – popular with all ages; cheap apparatus and fun introduction to amplitude and frequency.

Equal access to practical equipment

ICT

Free oscilloscope software
http://zeitnitz.de/Christian/Scope/Scope_en.html

This turns what used to be a poor demonstration around an old-fashioned piece of kit into something fun and personal. Use a *Singstar* microphone and bring the X factor to your classroom (listening and visual).

Personalised learning

- Octave slides, using the frequency window, sing a low C, slide up to a high C (frequency doubles – reinforce by playing the same notes on a single string of the guitar).
- Students print screenshot and can work out frequency and wavelength of a note they have sung or played, then check in the frequency window.
- Instruments – exploit your pupils' musical talents.
- Recording – allows time to prepare a piece that can be used with the software. Pupils could bring in mp3 of their own compositions.

Relevance

Slinky "wave changer" – model of what happens inside an oscilloscope and how the software works. Pupils are often confused by what seems to be a transverse wave representing a longitudinal sound wave on an oscilloscope screen.

Modelling

Who would use this – as well as the good people in the gaming world?
Auto tuner – smoothing software in the recording studio

Sound engineers

Careers

Series and parallel circuits

Lesson 1

Learning objective

Understand how series and parallel circuits differ.

Starter

The lab is in darkness – students are set a task to attach the string from the generator (matchbox) to various points on the desk – straws. Problem – it's dark! There may be classroom management issues depending on your teaching group and working in darkness.

Pose the problem: remote British village needing lighting. There is only one generator and at least 20 cottages. How are we going to help?

Main

Ask students to build what they have modelled from electrical components. Some have difficulty in translating a small circuit diagram into equipment. Use of transfers/large laminated circuit symbols and leads to arrange on bench, components positioned on top – should reduce tangle of leads. Or use lining paper to draw a life-sized circuit diagram.

Lesson 2

Learning objective

Understand the need for parallel circuits.
Students will need prior knowledge of what a parallel circuit is.

Learning outcome

Report to parish council about your model.

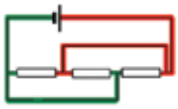
Starter

Teacher sets the scene – all blinds shut, lab in darkness, students to listen to teacher instructions to build a model using string, boxes and paperclips. Lead the students to explain the problem when doing this. It's really dark!

Main

Teacher explanation
Small groups (single gender) carry out their practical activity to build a parallel circuit for the village.

Voltage in colour (analogy)



Livewire is a piece of software that will colour voltages automatically **www.new-wave-concepts.com/** – free trial download.

Physics Education article *Phys. Educ.* (2003) **38** No. 3 191–193.

Link

Welsh village gets electricity at last
http://news.bbc.co.uk/cbbcnews/hi/sci_tech/newsid_2960000/2960430.stm

Practical work – appeal to their senses

Relevance

Access to practical work

Discussion

Equal access to practical work

Modelling

Take charge

Start with a question

- How are electrical impulses used to restart the heart?
- Why are electric eels electric?
- What happens if you are electrocuted?

"Human circuit", hold hands, touch nose or ear using a cosmic ball (a ping-pong ball with contacts that flashes/beeps when human circuit is complete. Visit **www.hawkin.com** to buy one.

Relevance

Demonstration

BIG circuit (SPT Electricity & Magnetism Episode 1 teaching approaches p5), visit **www.talkphysics.org** to download this resource

Identifying misconceptions

Modelling

Rope loop (modelling current) (SPT Electricity & Magnetism Episode 1 teaching approaches p7)

Experiments

Make something that mimics real-life and not a landing light switch. For example, alarm that triggers when someone enters the room; fridge light that is only on when the door is open; a baby incubator alarm that goes off if the temperature drops (extension). Choose single-sex groups for practical work with rotation of roles within the group so that everyone gets their hands on equipment that works.

Relevance

Access to practical work

Human battery (copper and zinc hand-sized plates)
www.exploratorium.edu/snacks/hand_battery/index.html

Personalised learning activities

This can also be run as a lie-detector test where learners answer five questions and deliberately lie for one of their answers.

You could use this to find out a bit more about your learners/vice versa.

Turn the tables and have them ask you the questions.

Alternatives to questioning

Physics is everywhere; in mobile phones, computers, mp3 players, CGI films and hospital equipment, to name but a few areas.

Find out more at the "study" and "careers" sections of **www.physics.org**.

Careers

Homework

Try doing without electricity for one day and keep a diary of changes to your routine.

Further resources

Electric dreams: follow a family's trip back to the 1970s to see how technology has changed
www.bbc.co.uk/electricdreams

Institute of Physics, the MODEL project
Practical Physics at Work – for more information contact **education@iop.org**