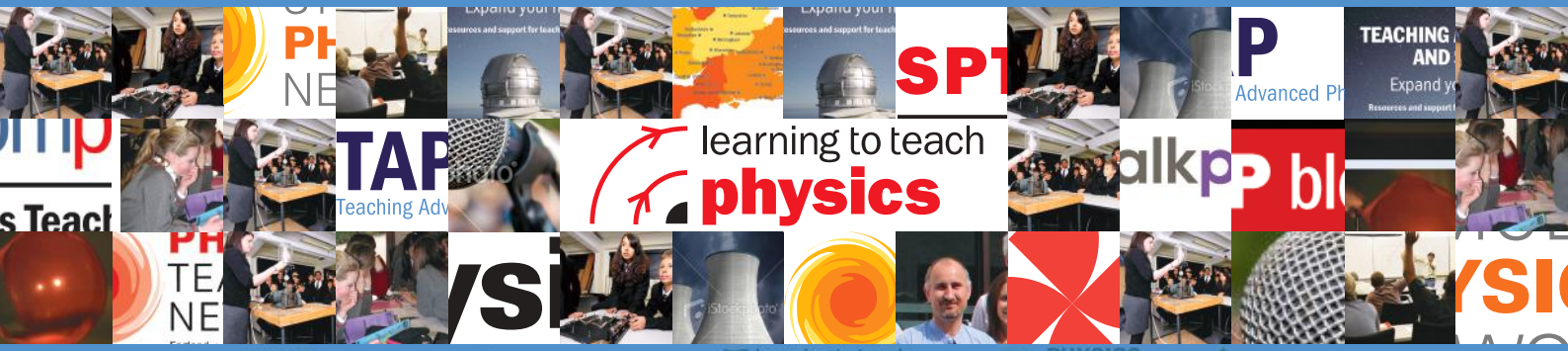
Learning to Teach Physics

A guide to support for newly qualified science teachers



IOP Institute of Physics

Teaching physics is doing physics

Dear new teacher

Congratulations on completing your training.

We are delighted to welcome you into the physics community. We value all teachers of physics - even if physics is not your specialism - for two important reasons:

1. **Simply by discussing physics with your students, you will be doing physics.**
2. **You will be the single biggest influence on the physics future of your students.**

You will be showing your students what it is like to think like a physicist, helping them to see the world in a physics way and – best of all – demonstrating the beauty of a physics explanation.

And, as a classroom teacher, you are directly improving the health and prospects of physics in the UK, Ireland and globally.

In this booklet, you will get a taste for just some of the ways we can help, from practical teaching tips for new teachers to network-building and CPD. You will see that we work with teachers of physics at all career-stages, offering a wide range of support and resources.

We're looking forward to working with you.

Charles Tracy
Head of Education
Institute of Physics

IOP support for NQTs

Cost-free support for all teachers who are learning to teach physics.

learning to teach **physics**

We'll send you news, resources and invitations to events which are all geared towards early career teachers of physics. Register with the IOP whatever your specialism at **iop.org/student-teacher.**

School Affiliation

Join the 1700 UK and Irish schools & colleges affiliated to the IOP. Your school will get posters, our latest resources, our teaching magazines & journals, discounts at IOP events and more. Sign up at **iop.org/affiliation.**

STIMULATING **PHYSICS** NETWORK

If your school lacks specialist physics teaching, join SPN for bespoke support. Plus regional CPD, events and workshops open to all. Find out more at **stimulatingphysics.org.**
(England only)

PHYSICS TEACHER NETWORK
England • Ireland • Scotland • Wales

Over 50 highly experienced physics teachers offering local CPD, support and advice across the UK and Ireland. Get in touch with your nearest Physics Network Co-ordinator at **iop.org/network**

@TakeOnPhysics

Our Twitter feed is ideal for new teachers of physics. We use it to share ideas, events and resources. Follow **@TakeOnPhysics** to build your own teacher network and connect with the wider physics community.

talkphysics

Our online community of over 10,000 teachers of physics and their supporters is a secure space to ask questions, share ideas and access teaching resources. Sign up at **talkphysics.org.**

Teaching resources

Finding your own materials can be a minefield. Fortunately, IOP has everything you need to teach physics at all levels.

SPT / Supporting Physics Teaching

The **SPT** materials have been developed for all new teachers of physics, boosting subject knowledge, highlighting common problem areas for pupils and offering teaching strategies.

Explore SPT online at **supportingphysicsteaching.net**.

All levels up to age 16

TAP
Teaching Advanced Physics

TAP resources will help you to plan lessons for students aged 16+. They don't assume that you have lots of equipment or advice from experienced colleagues. Adapt them for your own lessons.

Download the resources (Word documents) at **tap.iop.org.**

Secondary level over age 16

PRACTICAL PHYSICS

Practical work is a vital part of your students' experience. **Practical Physics** is a collection of proven experiments that work in any school lab, with advice on health & safety and teaching & learning issues.

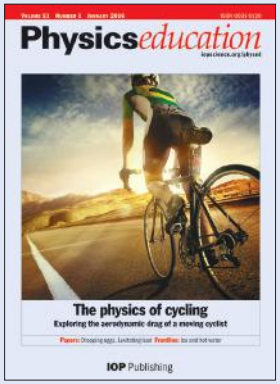
Visit **practicalphysics.org.**

All secondary levels

Classroom Physics is our quarterly teachers' newsletter with news of IOP resources and initiatives and other organisations plus teaching tips, student worksheets and events listings.

Read it online **iop.org/classroomphysics** (IOP Affiliated schools receive paper copies).

All secondary levels



Physics Education is our international journal on research into physics pedagogy.

Stay on top of the latest ideas in teaching physics and keep your teaching fresh by reading it online at **iopscience.org/ped** (IOP Affiliated schools receive paper copies).

Secondary level and introductory undergraduate

Visit our **teacher webpages** to see the full range of IOP resources to support teachers, from curriculum-based physics teaching to science clubs, enrichment and student careers advice.

Browse at **iop.org/teachers.**

All levels pre-19

Who gets to do this every day at work?

Like every NQT, Adrian's first year teaching physics involved many hours preparing lessons and learning to manage his classroom. He advises new teachers to have some fun every day whatever the circumstance so that, like him, you'll find it fun to teach physics. Here are some of his highlights:

- Melting chocolate in a microwave to calculate the speed of light
- Getting a chatty student to walk to the end of the corridor then telling them they are still not far enough away to represent an electron's distance from the nucleus
- Rubbing balloons on each other and using the static charge to stick them on the wall or pick up sugar
- Fishing for paperclip fish with magnets then electromagnets to see who can get the most
- Blasting a long-haired student with an airzooka all the way down the corridor and the students going "wow!"
- Blowing a dog whistle that they can hear but you can't because you're older, then using it to keep the class quiet for the rest of the lesson
- Using a long rope and a slinky with the students to generate waves
- Standing in the court yard yodelling at the wall to measure the speed of sound
- Blasting paper tube rockets down the corridor with compressed air
- Watching a candle flicker in front of a 15 inch subwoofer speaker playing "All about that bass" whilst watching the output on the oscilloscope
- Getting the local fire station to come in to demonstrate their thermal imaging camera
- Holding up an X-ray of someone's large intestines then telling them it was me
- Sticking masking tape on the corridor floor to mark the path of a green laser bouncing off mirrors stuck on the skirting board

Doing actions to memorise the electromagnetic spectrum

- Gamma: hands round the throat
- X-ray: crossed arms
- Ultraviolet: slip, slap slop as they put on suncream
- Visible: hands make a telescope
- Infrared: shivering
- Microwave: twisting the knob on a microwave and going ping
- Radiowave: body wave from left hand to right hand and back again
- Standing in the court yard hitting eggs and foam balls with a tennis racket to talk about elasticity, impulse and momentum
- Sporadically yelling MMMeeeeeoooowwww after I've explained the Doppler effect and the students doing the same all together
- Teaching pressure by asking students to blow up balloons until they burst and watching them cringe as they wait for the bang
- Throwing eggs round the classroom (inside plastic bags with wipes and paper towels on hand) to talk about de-egg-celleration
- Demonstrating the speed of sound by watching back a slow-motion video of a line of students reacting to a clap, seeing the ripple go down the line (best recorded outside where you can space the line out)
- Playing pass the ping-pong ball balancing on a stream of air from a hair dryer set to cold maximum flow
- The class in open competition playing online games on their mobile phones to revise a topic

Thoughts from recent NQTs

Halfway through their NQT induction, we asked a group of new science teachers how they were finding their first year of teaching. Here are some of the responses.

Best aspects?

Being free of all of the paperwork that was involved during my PGCE.

Having my own room, making my own decisions as to how I teach my own groups.

One observation per half term is manageable, much better form of feedback.

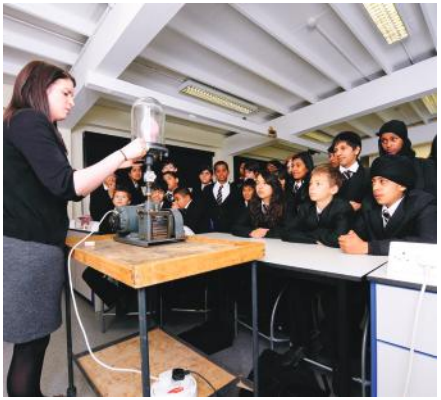
Moments when I could step back while my class was working and realise that I was actually enjoy what I'm doing.

How your view of teaching changed?

I've realised it's not about the work, it's about relationships. I work in an inner-city school and if you don't take the time to build up the relationships, the learning doesn't follow.

I've had to realise it's OK if we don't meet all of the learning objectives because they can be picked up on in the next lesson.

I'm more aware that teachers don't necessarily have much more knowledge on a topic than the pupils, but can still use that knowledge to produce outstanding lessons.



What has surprised you most?

The state of my school's science department – definitely not transparent at interview!

How some pupils speak to teachers: I only experienced high set classes in placements, so seeing how some of the bottom set classes behave is a surprise.

That I can cope with a timetable and my own groups! I was really worried that I wouldn't be able to before I started my job. My subject knowledge is also a lot better than I thought too.

The way I can change what would normally be classed as a boring subject into something fun and exciting.

The to-do list is never finished but everyone is in the same situation.

And lesson planning...?

I tend to design my own lessons rather than spending hours scouring others, but I use existing worksheets and rarely make my own.

I can now plan a 100 min lesson in less than 30 mins, which I'm very happy with!

We have brought in schemes of work (SoW) which I adapt and take ideas from. Each lesson is my own twist on existing ideas.

How does IOP help you?

The Learning to Teach Physics e-mails are a useful reminder of what's available and a reminder of where things are is good.

I tend to visit **www.iop.org** when I need resources or lesson ideas. Since our SoWs are all relatively new, I go online when I need practicals to explain certain concepts.

Tackling the marking mountain

Marking is one of the major pressures on all teachers' time. It can seem like it is eating too much of your time, both inside and outside school. But there are a few tricks from the physics-teaching community that you may find useful.

Think about why you're setting the homework

A lot of homework is set with no particular purpose other than to generate a mark and that usually means teacher marking. It's worth asking the question – what is the purpose of homework? I imagine that most enlightened senior leadership teams would like teachers to spend time planning and would be dismayed if the marking load was getting in the way.

Research evidence shows that Assessment for Learning – giving feedback that focuses on what a pupil can do to improve – is one of the most powerful ways a teacher influences their students' learning. There are no shortcuts as each student will have different needs, but if you are going to spend time marking I recommend this approach where possible.

Sometimes you do need to set homework to create a mark, for example, before a parents' evening. But if that is your aim, is it worth you putting in lots of hours of marking? Self and peer-marking are excellent ways to get your marking done while ensuring your students engage with the assessment process!

Set homework that is efficient and effective

As an NQT, I advise you to prioritise planning lesson content and developing your teaching skills over marking. Only then can you start thinking about homework. When that is in place, think about tests. And only when all that is working well can you realistically start working on how to get each individual student's achievement levels up.

Physics has many mathematical elements, which can be easier to mark, so homework designed to test understanding does not need to be marking-intensive. Filling in the blanks, solving problems and questions requiring short answers can test a wide range of topics and pick up where they are struggling.

Think like a physicist

I often find myself saying the same things over and over again – underline headings, put units in, results table headings, etc. So I wrote a list of all the things that crop up and put them onto a PowerPoint loop. When marking the reports, I just annotate them using a code e.g. M2 is method point 2, G4 is graphs point 4 and so on. On receiving the books the pupils have to write out the points in full as targets for the next time they write a report. I find they take the comments more seriously if they've written them out themselves.

To read more about marking – and to find some marking coding schemes – join the TalkPhysics discussion "Making marking less of a mountain" by logging in/registering at **bit.ly/TPmarking.**

Fault-finding in simple electric circuits

Building simple electric circuits should be easy. But in practice, however well you and your lab technician have prepared, you're going to need to get good at trouble-shooting your students' attempts, says Alan Baugh, IOP Teaching and Learning Coach.

First and foremost, resist the temptation to start replacing components immediately. Look at what you have in front of you – a visual inspection may throw up obvious problems.

If you find circuits daunting, use our checklist below to help develop your fault-finding skills. Take it slowly, think logically and you'll find you can soon get those circuits working every time.

Checklist

1. If it's a complete bird's nest of wiring, don't even go there. Get the students to start again without using voltmeters. Then add voltmeters after the circuit is otherwise working properly.
2. Look for common mistakes such as:
   - incomplete circuit
   - reversed polarity components
   - a/c supply instead of d/c
   - accidental short circuits.
3. Verify that the power source (battery or lab pack) is producing the potential difference expected by using either a voltmeter or multimeter.
4. Use a voltmeter to check that the potential difference across individual components of the circuit is reasonable. There should be no p.d. across the connecting leads and contacts.
5. If you still haven't been able to identify the source of the problem, now is the time to try swapping potentially faulty components. Remember to do this one at a time!
6. Another approach that some teachers find works is to draw the circuit out on large pieces of paper and get the students to build their circuits over this "map".

Other common problems

- "Flat" batteries
- Apparently identical lamps with different current or voltage ratings
- Connecting leads with internal breaks
- Loose or corroded connections
- Faulty ammeter shunts, voltmeter multipliers and "flat" internal batteries (e.g. on digital meters)
- Finally, the most common problem of all: students. Sorry, but you can't replace these.

Get your pupils talking in physics lessons

This may seem strange advice when others talk about class control. But it is essential to recognise the extent to which subject-specific vocabulary and technical terms are an essential part of the physics curriculum, says Phil Badley, a Stimulating Physics Network Teaching and Learning Coach.

I have heard it said that pupils come across as many new words in KS3 science as they do in a modern foreign language. Pupils must be able to recognise the words, know their scientific meaning and be able to use them in appropriate scientific contexts.

This is particularly important in physics, where there are a lot of specialist words that are used in everyday talk. For example, **power, work, resistance** and **energy** all have very specific meanings for a physicist.

The development of appropriate literacy skills will take time and talk is an important element of the process. Use structured activities to encourage pupils to talk to each other about the physics they are learning.

Initial activities could involve identifying appropriate terms, sharing information from a comprehension or working together to match appropriate pieces of information. More advanced activities will involve discussion, role play, preparations for presentation and the analysis of information. Make sure that group tasks are sufficiently challenging to require group co-operation.

Activity ideas

1. Identify groups of words/terms from a list and explain reasons for groupings.
2. Match appropriate cards showing terms, definitions, units, etc.
3. Give each group three different sheets of information about a famous scientist plus a series of questions that can only be answered by sharing information.
4. Talking Points – a list of 10 statements about a topic that may be correct, inaccurate or just interesting. Groups discuss and then feedback their ideas.
5. Concept Map – key terms and words in a topic that the group arranges on an A2 sheet of paper and writes a link between the words.

Whatever the activity, don't assume pupils will already know how to organise themselves or how to tackle the task.

Plan the activity carefully:

- control the groupings with allocated roles to suit the task
- give clear expectations and explicit outcomes
- demonstrate and scaffold the appropriate skills
- hold a plenary/debriefing to support learning about the content and the process.

Finally, a warning from bitter experience

Pupils who have been sitting quietly and passively in classroom-based lessons all day may need extra management when they get up for practical work or are invited to talk to each other...DON'T get put off doing these activities. The buzz of a room full of pupils talking about physics will make it all worthwhile!

Improving Gender Balance

The progression of girls onto post-16 physics has been historically low, even though both genders do equally well up to this age. However you can make a difference, says Jessica Rowson, IOP Gender Balance Manager Pre-19.

Engage with the problem

Why don't girls choose physics? (Hint: it's not because they can't do it.) Read up on the available research to date at **iop.org/genderreports**

Do your own action research

What is happening in your own classroom? Does one gender dominate and shout out? Investigate by asking a student or colleague to keep count of interactions by gender, using our handy classroom interactions template at **iop.org/genderresources.** Share the results with your class and get them to take ownership of their behaviour.

Manage your unconscious biases

We all have unconscious biases. They inevitably, and unconsciously, affect the ways we interact with girls and boys from the assumptions we make to the advice we give. Being aware of your unconscious biases is the first step to reducing their impact in the classroom: test yourself at **bit.ly/bias_test.**

Monitor your classroom environment

Counterpoint the standard Einstein, Newton and Darwin rhetoric with women scientists (and scientists of colour) in your displays and stories. Are your classroom resources perpetuating stereotypes? Is John playing football while Jane uses the microwave?

Think practically

Boys tend to dominate practical equipment while girls tend to hang back and write down the results. Ensure that everyone gets to try all aspects of practical activities by assigning roles such as: **safety supervisor, technician, data analyst, scribe.** Rotate these roles regularly.

Encourage everyone to contribute

Students who feel less confident in their abilities are less likely to contribute in class. Research shows that girls often fall into this category, despite high academic performance. Empower the whole class using techniques such as think-pair-share or individual whiteboards or use internet-based activities such as **plickers.com** and **mentimeter.com** to pick up everyone's answers simultaneously.

Start a research-based science club

Structured research projects have been shown to attract a gender-balanced cohort. If you're looking for ideas, look into **crestawards.org** or **researchinschools.org.**

Challenge discriminatory behaviour

Sexist language is as unacceptable as racist and homophobic language. It's not 'banter' and it's not ok.

Joining the Institute

Once you gain Qualified Teacher Status we encourage you to join the Institute in the following ways:

- **If you have a degree in the physical sciences or engineering, you can apply to become an Associate Member of the Institute or, if you have an interest in but no formal background in physics, you can become an Affiliate Member. Both will give you access to IOP member benefits, such as publications, career advice, regional networks and discounted rates at meetings.**
- **If you are interested in subscribing to *Physics World*, join up as an IOPimember.**

For more details about joining the Institute, visit iop.org/membership.

The Institute also offers an affiliation scheme for schools and colleges. This entitles them to receive: *Classroom Physics*, *Physics Education*, *Physics World*, discounts on conferences and events, free resources and lots more. Contact affiliation@iop.org.

The Institute of Physics is a leading scientific society. We are a charitable organisation with a worldwide membership of more than 50,000, working together to advance physics education, research and application. We engage with policymakers and the general public to develop awareness and understanding of the value of physics and, through IOP Publishing, we are world leaders in professional scientific communications.

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