On the Map: Problems and solutions for high school physics in Turkey Personality: Neil Linford - archaeologist with a specialism in geophysics Starting Out: Physics to avoid daytime TV? Starting Out: What Katie did next Teaching Anecdotes: Ernest Rutherford

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ON THE MAP

Physics education at schools and colleges in different climates and cultures. Tell us about your school!

Problems and solutions for high school physics in Turkey

Turkey, in common with other European countries, has problems with physics education. Teacher and student perceptions of physics are very important, so we used a questionnaire to research the views of the 70 teachers and 940 students in and around our city, Afyon, in the Midwest of Turkey.

The students were studying at 45 different high schools including those offering vocational programmes. Most of the students lived in towns (56%), with 25% living in city centres and 19% in the countryside.

Following questionnaires a group of interested academics, teachers and students were invited to attend a one-day seminar entitled ‘The Problems in Physics Education and Teaching in High Schools and Their Solutions’. Nine teachers, five students and six academics presented papers in three sessions entitled Physics Education, Physics Instruction and the Course Settings.

Figure 1 shows that classical teacher-centred teaching is used commonly; most students are subject to passive learning.

According to the teachers, the students perceive physics courses as unnecessary: students expect a tough course with little relevance to everyday life. Students, with a consequent negative attitude, underperform and then see physics as meaningless. This contrasts strongly with the personal view of teachers, which shows them seeing great value in the study of physics.

Typically, teachers found their students having most difficulty with electromagnetism, with most interest in electricity, optics and motion. They felt that students needed to be interested and should have good guidance before embarking on a physics course, making them aware of the importance of physics in everyday life. The students pointed out that their priority was to pass the University Entrance Exam (UEE): for them, studying physics topics that would not be examined was pointless. No surprise, then, that the subjects the teachers found difficult to teach were those very topics. Noisy, crowded classes were problems for both teachers and students.

Afyon, Turkey:

- Turkey: population 66 million
- GDP per head: $6200 (cf USA $33900)
- Compulsory school age 6–14
- There are 3874 senior high schools with 1.7 million students

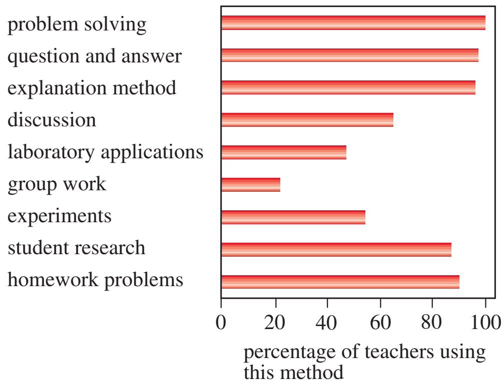

Figure 1. *Results from the teacher questionnaire on the techniques used by teachers. The questions used are presented in table 1.*

Table 1. Some of the questions used in the teacher questionnaire.

	% in agreement
Teachers' views of the importance of physics	
Do you agree that physics is the total of knowledge providing the analysis and comprehension of life to students?	94
In teaching physics, perceiving basic subjects and observing these in life is necessary	100
Learning physics can change someone's view of life	99
I follow contemporary events, scientific books and periodicals	43
I consider concepts and details of my subject	82
I follow daily and weekly lesson plans	81
I can give contemporary examples	75
Teachers' views of the education system	
Our education system has features that are a handicap to the teaching of physics	87
Number of students in the class can affect learning	85
Number of lessons given by teachers can affect efficiency	84
Weekly lesson hours are sufficient for physics education	32
Students need the right level of knowledge and maturity to study physics	99
In physics books, I approve of the explanation and the order of subjects	47
Contents of physics books and the order of subjects can affect efficiency of education	97
My course sources and physics books are clear and comprehensible	60
Physics curricula and plans are realistic	65
Being in touch with other physicists can affect the efficiency of physics education	100

How to make physics more attractive

What can be done to make physics lessons enjoyable to students? The teachers' views were in complete agreement with the students': experiments, lab work and contemporary examples. Yet many schools do no lab work because of their poor facilities. In the seminar we considered setting up well-equipped regional laboratories in the city and the town centres instead of the insufficient laboratories currently in schools. The alternative solution is the computer-based laboratory. When computer-based physics lessons were introduced to the teachers attending to the seminar, they found this method applicable and suitable. It is possible that computer laboratories in high schools can be used as physics laboratories. We also feel that technological equipment such as computers and audio-visual equipment should be used effectively because they will attract students.

There is a direct relationship between Physics and Mathematics, and a lack of understanding in maths was noted as a big problem for learners. Students' physics books are not sufficient, either: the books lacked contemporary examples and need to be written to complement the curriculum and with the UEE in mind. There was a clear need for a more thoroughly planned curriculum.

Another problem, not mentioned in the questionnaire, is that teachers do not feel ready to teach physics effectively immediately after graduating from university. During their BSc studies the teachers were not taught how to teach physics effectively and the subjects taught at high school level were not parallel with the subjects they had studied.

Table 2. Numbers for the education year 2001–2002.

Type of school	Schools Number	%	Students Number	%	Teachers Number	%
Science High School	54	0.9	11 082	0.5	953	0.7
Anatolian High School	558	9.2	278 005	12	14 764	10.6
Public High School	1560	25.7	1129 238	48.8	48 764	35.1
Vocational High School	2837	46.7	683 095	29.5	55 976	40.3
Multi-Programmed High School	591	9.8	138 800	6	10 200	7.4
Private High School	465	7.7	72 051	3.2	8 128	5.9
Total	6065	100	2312 271	100	138 785	100

Did the type of school affect the students' views?
There is surprisingly little difference in the student responses from the different types of schools. Multi-Programmed High Schools spend less time teaching physics, so the subject is not taught in the same detail as at other schools. Thus students are able to understand more of the material they are taught. Science High Schools spend most of their time solving difficult physics questions in preparation for the UEE, so although the students are better at physics they find it equally tough.

When it comes to seeing a teacher out of class for help, there is a significant difference of 22% between the students of city centres and towns in Public High Schools. Students in the city centre Public High Schools have generally have good communications with their teachers and thus they make use of their teachers' knowledge more effectively. Very few students make use of periodicals related to physics regularly and this is clearly related to their availability in schools and libraries. However, it is also related to how students perceive the world and their attitudes.

Recommendations

- Teachers: physics teachers are limited in their effectiveness by their classroom management skills and training. Future physics teachers should be trained and taught in accordance with careful planning.
- Students: Students should stop having to learn by rote and they should be taught how to find out for themselves and to use this knowledge effectively.
- Teaching environment: Physical conditions, the necessary equipment for teaching and the available laboratories should be sufficient.

By meeting these conditions we form a firm basis for improvement, our problems will be overcome in the middle and long terms and physics education will be successful.

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Appendix. High school education in Turkey
Compulsory education in Turkey consists of a five-year primary school programme and three years at Junior High. There are then six types of high schools in Turkey (table 2).

Science High School: Admission is competitive by government examination, and applicants must have good grades following their compulsory education. According to the data for the year 2001, 247 821 students took the Science High School entrance exam and 8184 students (1.5% of all students) were successful and had the right to attend these schools. Science High Schools are the most prestigious and the most difficult to enter of all High Schools in

Turkey. Students attend for four years and study a broad science curriculum and foreign languages.

Anatolian High School: These schools also select by the government entrance exam and applicants must have completed their compulsory education without repeating any year. 35 284 (7.47% of total) students out of 472 283 taking the exam were successful and had the right to be enrolled. Although they are less prestigious than Science High Schools, Anatolian High Schools cover a similar four-year programme.

Super High School: Any student who has not been admitted to the Science or Anatolian schools, but graduated from junior high with 4/5 points has a right to be enrolled.

Public High School: Any students who have taken the government entrance exam have a right to be enrolled.

Vocational High School: These schools consist of Vocational and Technical High Schools, Trade and Tourism High Schools, Religious High Schools, Special Education High Schools and Medical and Health High Schools. Vocational High Schools are schools aiming at training and educating students for employment.

Multi-Programmed High Schools: A combination of general, vocational and technical high schools in thinly populated areas where only one school is economically viable.

Mevlut Dogan, Bekir Oruncak and Ilhan Gunbayi
Afyon Kocatepe University, Turkey

PERSONALITY

A closer look at the people involved with physics and physics education

Neil Linford—archaeologist with a specialism in geophysics

Kerry Parker talks to Neil Linford, archaeological geophysicist

What do you do?

As an archaeological geophysicist I take the techniques of geological physics and scale them down to look for things in the first metre of the ground.

Where do you look?

When we go to a location it is usually because we have a clue that something will be there. We found a Roman mosaic last year after the discovery of a Roman building: we knew that there wouldn't have been just one building, so we were looking for what else might be there.

How much time is spent in the field?

On average I do about a week's fieldwork each month. You go out to the field and get your GPS system out, you lay out a grid in a series of survey lines, test the equipment and start taking measurements. The rest of the time is spent back in the lab, sorting out the data and image processing—there is lots of work on processing algorithms. It's a bit like looking through a frosted glass window—if we can describe the frosting precisely we must be able to remove the effect of the frosting from the picture. The final stage of the job is writing reports—anyone who is interested can look at them on our website.

Neil Linford.

How do you decide which technique to use?

The technique we use depends on what we are looking for, and on the soil and the weather. If we are looking for a ditch or covering a large area we usually use a magnetometer, which picks up small changes in the magnetism of rocks. Resistivity tends to be better for mapping buildings—the buildings

My first big break was a huge contract to survey the area around Stonehenge for the changes to the road routes that were planned there.

dry out the soil, increasing its resistivity. Ground-penetrating radar is used more sparingly because it is so time-consuming. So you might do a magnetometer survey first to get an idea where the buildings are, then go back over to map the villa using resistance, and finally before excavation we might do a radar survey to get the maximum amount of information.

What do you do when you find a potential archaeological site?

If we find anything interesting in our surveys we hand over to our colleagues, who are digging archaeologists. However, we always like to go back and check what we call Ground Truth, to compare what we have seen on our surveys with what is excavated, and we are, of course, very interested so see any artefacts that are found.

Do you have any particular interests?

One of my great research interests is magnetic mud, soils and archaeological sediment. Sometimes on a site we only locate some of the ditches: when digging starts other ditches are uncovered that didn't show up on our surveys. I'm interested in knowing why. I'm trying to see what was different between the two ditches – the one we detected and the one we didn't – could we have found them with a more sensitive magnetometer? I'm trying to find out whether we should in fact be investing in increasing the sensitivity of the instrumentation.

How did you get into archaeological geophysics?

I took a degree in Natural Science in which I studied mainly physics but I was also able to take some wider courses. One of those courses was in archaeological science. That got me interested. There was a very good geophysicist there and for one of my undergraduate dissertations I was able to do a geophysical survey. When I left university I got a bit of work with English Heritage for odd weeks and work from private contractors. My first big break was a huge contract to survey the area around Stonehenge for the changes to the road routes that were planned there. Eventually EH gave me a year's contract, which led to a permanent job.

Is there a career there for today's physics students?

Archaeological geophysics is a growing area. There are a dozen or so companies that do it commercially now. Bradford University have started running a masters course in archaeological prospection—that's one way in now. I'd guess that there are about 50 people who are professional archaeological geophysicists at the moment in the UK. But if you are good and you are committed you can get into it if you're lucky. Britain has a well-developed structure for using geophysical surveys within a commercial context.

Working for English Heritage I only work in England, but lots of the people, especially people in universities, get to travel to more exotic locations like Egypt. The resistance techniques don't work so well in the desert, but there is a conductivity technique that uses an induction coil and measures the phase and the amplitude of the signal that comes back. Magnetic techniques also work extremely well. For example, ancient adobe mud bricks were originally made by being slapped into the moulds. This produced a shock remanence in the magnetic materials, and we can pick this up. They have found entire mud brick cities. Radar also works incredibly well. The dry sand attenuates the signal very little.

Is archaeological geophysics any use?

Surprisingly few people complain that all this work is a waste of time and money. The popularity of TV programmes like *Time Team* shows how much people are interested. We sometimes survey farms where the farm has been in a family for generations: the family is always fascinated when we find evidence of farming dating back to the iron age.

Of course, tourism is a very big business and 85% of tourists say that our cultural heritage is one of their reasons for coming to Britain. If they go to see a monument like Stonehenge they want to see it in context, they don't just want to see some stones. There are questions that they want answered and archaeology is one of the ways to answer them. We can justify what we do as a sort of shop window display for English tourism.

What do you like most about archaeological geophysics?

When I left university I didn't really have a clue what I wanted to do. I knew what I didn't want to do, and I was keen to use my science and find something interesting. This proved to be a perfect combination—being able to apply physics and having this wonderful detective element in what you are doing. When I go out I never really know what I am going to find.

One of my favourite finds was a ditch that contained magnetic bacteria. The technique I use hasn't been proven yet: magnetic bacteria were only discovered in the mid 1990s. I was able to date the ditch with a very statistically tight date, and this disagreed with the excavation. I dated it in the late iron age, but it contained lots of bits of bronze age material; the environmental archaeologist looked at the bugs and pollen and thought that it was bronze age. Just recently we got the radiocarbon dates back and this showed that I was right! That was nice, and that sort of detective work keeps me going. Not every result is exciting but at least one survey a year pulls up something really unexpected.

Starting Out

A forum for newcomers to physics teaching to share tips, ideas, survival strategies and experiences.

Physics to avoid daytime TV?

Tellytubbies, children's television and waking up in the early afternoon…what do you think I am, an arts student?! As anyone who has had the remotest bit of contact with physics will realize, when you study physics life is *not* about watching home improvement programmes on TV! I am currently in my second year at the University of Warwick studying for a BSc in physics. “So what are the good things about being a physics student, and also being a woman in physics?”, I hear you ask. I hardly ever have to open a door in the physics department, and I am guaranteed to be greeted with shock when answering the question ‘so what do you study then?’. Of course, the reply ‘physics’ is an instant conversation killer, either because of the perceived sheer intelligence (and arrogance) us physicists are all born with, or because we are assumed to eat, breathe and die physics and therefore could not possibly have anything in common with the rest of society!

My A-levels in Physics, Pure Maths and Art have given me sufficient grounding to be able to appreciate the value of physics and also to understand how creative and amazing the subject is. However, what the careers advisers don't tell you is that it changes your way of thinking and puts words like ‘orthonormal’ and phrases like ‘well obviously that is subjective’ and ‘damn that man Schrödinger’ into your everyday vocabulary and it makes you visualize the Dirac Delta function in your sleep. You learn to accept that Gauss and Einstein are your enemies, that they are out to burn any shred of understanding you may previously have had from studying A-levels!

With this in mind, I am very glad that I studied Further Maths at A-level and would recommend anyone thinking of a physics degree to take it as an investment for your future sanity. My A-level education was adequate but did not prepare me for my degree. This is not a criticism of my school or my teaching, only that one of the hardest things I found in my first year was learning the process of thinking like a physicist. The actual subject matter can be learnt, the equations can be reproduced and the definitions committed to memory, but when it comes to exams the ones who succeed are those who think physics. I realize now the importance of assumption, context and the ability to think rationally and objectively about what you are learning and not just reproduce material. However, no-one told me this when I started: that's why I am telling any potential undergraduates who might be reading this!

The bane of my second year has been the importance of report writing and essay writing. Although I can perform an experiment well and keep a good lab notebook I still lack the part of my brain that makes good lab reports. In my view, this is the area to which my tuition fee definitely makes no contribution. I receive little, if any, guidance on report writing. During my GCSEs and A-levels I was taught to keep a lab book and the process of attacking experiments, but at no point was I given help on scientific writing. I can write a lovely essay on 'how the *Lord of the Flies* symbolizes the second world war', but make me write 3000 words on ultrasound and my A in English Literature is as useless as is my AA in Science.

With these points in mind I would not change my degree for any amounts of daytime TV, and intend to entice and persuade more young people into studying physics! I want to inform young people of how lucky they are to be able to appreciate the present and to be part of shaping the future whilst giving themselves the opportunity to choose amongst the most diverse careers that a degree can allow.

I have now finished part of a pilot teaching programme to earn 20% of a postgraduate teaching certificate whilst studying for a physics degree, having completed a three-week block placement, teaching secondary science at Myton School in Warwick. I would recommend anyone who is thinking of teaching to get on a programme that gives you a taster for teaching. It will help you to identify your own qualities and ambitions without having to experiment for a year learning to teach, only to find that, perhaps, you are not suited to it!

Much as I enjoyed my teaching placement I was shocked to find that I did not want to teach straight from university and I am now concentrating on working in IT for an investment bank. I have realized that I am not suited to teaching at this specific point in time, but I will seriously consider it as a career in five or six years' time.

Victoria Marie Folgate
University of Warwick

What Katie did next

It has taken me ten years, but I have finally decided to take the plunge, leave my comfortable desk job and embark on a Post-Graduate Certificate in Education (PGCE) course in physics teaching. Three weeks into my course—including an enjoyable stint in a primary school and a week of introductory lectures—I am very enthusiastic. Ask me again next term.

The course kicked off with a lecture in which Newly Qualified Teachers (NQTs) who trained last year spoke to us about the course and the slightly ominous-sounding 'school experiences'. Much of the advice was expected – buy a bumper pack of pens, take your own mug, and always carry a lighter if you teach science.

I was more surprised by how strongly they advised us to avoid the staffroom cynics, and not to be daunted by the horror stories that many teachers love to tell. One of the NQTs had told a teacher at her placement school that—in contrast with dire

warnings about the workload—she was coping well with the course, despite being a single parent. The teacher responded with menacing predictions that her first year of 'proper' teaching would be much tougher, but the NQT actually found that she was thoroughly enjoying it and was starting to find it easier.

I know that the PGCE and teaching will be demanding, but I hope that working with children will make it worthwhile. To my surprise, I am already an authority on marbles, and I was relieved to read in one girl's exercise book that 'Miss Pennicott looks quite healthy'.

Like all experts, the experienced teachers I have seen make their jobs look easy. Will I ever be able to juggle teaching, classroom management and discipline that fluently? On the other hand, I saw year-6 pupils struggling with concepts that I thought much younger children would understand. Both these observations have brought home to me just how much I have to learn over the coming year. It will certainly be interesting!

Katie Pennicott
Katie was previously Editor of PhysicsWeb (see physicsweb.org).

Good luck to Katie and trainee teachers embarking on a new career this year—Ed

TEACHING ANECDOTES

Anecdotes to enliven teaching by providing personal stories to flesh out the hinterland of a topic.

Ernest Rutherford

Name: Ernest Rutherford.
Born: 30 August 1871 in Spring Grove, Nelson, New Zealand.
Occupation: Physicist, conservationist, campaigner for women's academic rights.
Distinctions: Nobel Prizes, peerage, booming tones, inventor of the smoke detector.
Hobbies: Playing rugby at school and university, playing golf as an adult.
Loved by: His wife Mary and daughter Eileen, not to mention most of New Zealand, Cambridge, Manchester and Canada.
Hated by: No one.

Ernest Rutherford. (Photograph: UK Atomic Energy Authority, courtesy AIP Emilio Segrè Visual Archives, Physics Today Collection.)

Not to be confused with: Any member of the All Blacks.
Early life: Young Ern attended Canterbury College in Christchurch, where his mathematical ability won him the only scholarship in Mathematics available in New Zealand. This allowed him to stay on at university to graduate with first-class honours in both mathematics and physics.

He won a scholarship to England and chose to study at the Cavendish Laboratory in Cambridge with J J Thompson. He arrived with a reputation as a brilliant experimenter and was the first non-Cambridge graduate student at the Cavendish. He discovered that two different types of rays were emitted by atoms and named them alpha and beta. Barred from promotion in Cambridge he set off to Canada and promptly discovered radon! He was awarded the Nobel Prize in Chemistry for his work in radioactivity in 1908.
Defining moments: Returning from Canada to go to Manchester, Rutherford, with Geiger and Marsden, discovered that when alpha particles were fired at gold foil, some came straight back. It was a complete surprise. A shocked Rutherford said: "It was as if one had fired a large naval shell at a piece of tissue paper and it had bounced back."
Later life: After war work, Rutherford became in 1919 the Director of the Cavendish Laboratory. Under his leadership Cockroft and Walton split the atom and Chadwick discovered the neutron. Rutherford had been knighted in 1914 and was made a peer in 1931, his coat of arms featuring a decay curve. He became a tireless promoter of science and held numerous honorary posts including President of the British Association. Lord Rutherford died on 19 October 1937 and is interred in Westminster Abbey next to Newton and J J Thompson.
Legacy: Rutherford has received a large number of posthumous honours with buildings and laboratories named after him.

Steven Chapman