



UNIVERSITY OF
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Physics Teaching In Schools

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Abstract

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1 Introduction

The teaching of physics in secondary schools is a discipline covering several hundred years of content. This huge collection of knowledge must be sifted to select the most relevant and appropriate subjects, these must be structured and organised so as to be easiest to understand, this content must then be delivered to a group of young people who, not counting the many pressures and excitements of life, must ingest this teaching alongside a bewildering number of other subjects, all of which vie for the top spot with respect to attention and time. All of this with the final goal of being able to present the information on demand in a series of tests designed to examine the information that has been retained.

Because of the scale of this challenge, of teaching what will be of most use to the pupils, a major requirement in the course of their time at school is learning how to do well in exams. In particular this means knowing what is being asked of them in a small number of possible variations of questions, and learning how to apply the content to these situations. To examine this effect, and to see how I could provide some assistance from the experience I have had at university, I observed and assisted in a number of lessons whilst at the school covering a range of age groups and gave a number of after school sessions for those interested so that they could gain some experience of the alternative thinking that is required outside the exam hall. I shall discuss the observations that I made in the lessons and some of the techniques that I was taught by the teachers and the responses they got from the students.

2 Observing

A physics teacher is usually required to teach a full range of age groups from the start of secondary school in year 7 at 11 years of age, up to the end of school in year 11 at 16 and on to sixth form to age 18 for those that are interested. This means that the content to be taught must be aimed appropriately. A large portion of this work is done by the government in the syllabus of work that is provided and details the subjects that must be covered, but the exact specifics of how this is expressed to the students is down to the teacher. This means that there is always a great diversity of teaching styles between teachers, and so I visited a number of teachers' classes to observe these variations and the benefits they bring.

2.1 Lower School

I visited a number of younger students' classes in years 8 and 9 and observed the lessons. Here the dynamic is very much centred on the teacher passing information to their pupils with an emphasis on making the content interesting and current. A big difference to the older students here was that the sciences are not yet separated. The separation of the sciences - physics, chemistry and biology - provides an opportunity for concentration on each separately, but before the students are old enough for this to be useful, a basis in scientific principles, and their place and importance in society and prominence in much of life, must be expressed.

A lot of the content that I was involved in helping with in these lessons is designed to be relevant to modern concerns or applicable to the lives of all those present so that the content is easier to relate to. For example, using the current prevalence of global warming in the media to teach about the earth and such topics as the atmosphere, and then using this as a spring board to move on to related topics such as the place of the earth in the solar system and then the solar system as a whole. This approach, though more reliant on the teacher being able to make the topics accessible and in line with the syllabus, has the benefit of being very "current" and easy to relate to, meaning that the learning process can be aided and assisted outside the classroom by parents. This was demonstrated particularly by a piece of homework that a year 8 class was given, to teach the content they had been learning to a parent, using their work book as a guide and be given a score by the parent and any notes relating to information forgotten or incorrect.

2.2 Upper School

For the majority of my time in the school, I was working with students in years 10 to 13. These classes required a different technique for teaching physics as the demands of the syllabus are higher. Since the subjects are divided between the sciences, an emphasis can be placed on examining a topic within that subject and following the natural progression of that subject. For example, studying light and the nature of radiation and allowing this to progress on to experiments with light and lasers and hence onto phenomena such as Young's Double Slit experiments and from here to an introduction to quantum mechanics and wave particle duality. When this style of teaching is done well, the students are almost unaware of the fact that they are being taught to a syllabus, and also provides a natural progression when revising, giving them a structure to attach topics to and aid in recollection later on.

Unfortunately, this type of subject based learning can lead to confusion if not structured clearly enough. When the pupils are not aware of the division between subjects, and can not see a progression in their own learning, where they can mentally cross areas of study off as finished, the volume of content that they are required to know can become daunting when looking back, especially during revision.

Another challenge that must be met when teaching a group of older students is coping with the range of abilities. When observing the younger classes, it was clear that the teacher was confident that the whole class would benefit from the same teaching, both content and style, and so the lesson could be delivered accordingly. When in the older classes, however, I found that I could be of much more immediate use to the teacher in the classroom as the group as a whole was much more distributed in the speed with which a new topic was learnt. This meant that an extra person, able to answer the queries of the students when they ran into difficulties was very useful, whereas in the younger classes, though there were questions that could be answered, there was

not the same distribution in uptake of the information. This variability, as pupils exhibit their natural abilities, or lack of abilities, in a subject means that the teacher must be careful not to progress faster than a slower to learn student can keep up, whilst not remaining static on one subject for too long so that the more able students become bored. This is where techniques that I observed, such as extension work for those performing quickly, and extra attention for those struggling, become important, and it is essential for the teacher to be able to recognise these requirements in their class.

3 University Physics Sessions

At the school I was visiting, there are approximately 10 to 15 applicants to Cambridge and Oxford universities alone per year. There are another 20 who apply to study physics at universities around the country and on average, 18 are accepted to study at university level. Despite this, there is no specific tuition or assistance available for these students to prepare them for the change to university level, or the entrance exams that many of them require. This is the same at almost all schools simply because of the extra time and commitment required to offer this extra service to the students, and because of the constantly changing nature of these processes as the universities change their requirements.

Having observed a number of lessons of different age groups, and of a range of abilities, I started an after school session for those who were interested, where the students had the opportunity to attempt some questions representative of the types of questions that would be asked at university level. These were very informal opportunities to look at a few questions and discuss the process that is needed to be taken to reach the answer as establishing the correct answer. I wrote a number of problem sheets for these sessions and then used a number of the questions to discuss. The emphasis of the sessions was to try to get the students, who were all considering taking physics further to university level, to think about the problem that was being asked of them and how they would solve it, as opposed to the sort of questions that they are used to where the solution is clear either from the way the question is asked, or the topics that are stated as being covered. Since the questions were much more open in their possible scope, there were not always a single method for solving them and so some of the discussion was about relative benefits and pitfalls of some of the methods suggested. The students also had the opportunity to attempt some of the questions outside the sessions, along with a suggested answer, and then discuss how they got on with the questions and if they agreed with the method I had used to answer them.

The aim of these sessions was to show the students the alternative type of learning and answering questions that would be expected of them at university, which almost all new university students are required to learn in the first weeks of study, which is very different to that which they are taught up to this point in their school career. This, I felt, the sessions achieved since many of the students were surprised by the difficulty of answering the questions to start with, even though, once some discussion had let them understand the question more, they were able to answer with relative ease.

Another area that I noticed that many of the students had difficulty with, and so I tried to incorporate into the after school sessions, was the concept of estimation and “order of magnitude” calculations. This skill, which is one that during a physics degree must become second nature was difficult for the students to grasp. To start with, most of them were dubious that such a process is necessary and instead argued that any situation which involved calculations would

benefit from using exact values. This view, I felt, reflected the style of questions at GCSE and A-level where all of the relevant information is given to the student in the question and they are rarely required to remember values of constants. Though this is sensible in the majority of cases, when learning just numbers to arbitrary numbers of decimal places is not useful, having the knowledge to quickly apply an approximation or estimate to speed up calculations, can be extremely useful.

One example of this that I taught the students is the approximation of the number of seconds in a year as being $\pi \times 10^7$. The actual value of 31 557 600 s is easy to calculate, but this simple and very small piece of knowledge can cut out those few seconds whenever the number of seconds in a year is required. A related area of mathematics that is very applicable to physics is dimensional analysis. Though we only touched on the subject to a very simple level, using the example of the equations of motion using constant acceleration, I showed the students how they could use the units of the answer, for example metres per second, ms^{-1} , to check that the equation they were using was correct. This simple example can then be expanded to cover a large number of cases where the simple checking of dimensions can remove errors that would otherwise give meaningless results.

3.1 Response from the Students

The general response from the students, to start with, was one of surprise at the length of time that they were able to discuss certain questions that initially had seemed incomprehensible to them. This was a point that I was eager to point out to them because, often, with a difficult problem, starting to think about the elements involved can lead to the correct answer as you think about it. It was this mentality of thinking about the problem itself, and learning how to apply their knowledge to it, that I was trying to give a flavour of in these sessions.

Because many of the questions that I gave the students to try were similar to the questions asked in first year degree level, the students were also surprised at how many of the questions they were able to answer. Though this was generally a collaborative effort, it showed them that despite their scepticism, they did have the knowledge necessary, but that it was the skills needed to apply that knowledge which they most needed to learn, and which, I felt, was the biggest subject area lacking in A-level science subjects at school.

4 Conclusion

During the nine weeks that I was in the school, I observed a wide range of age groups being taught physics and other sciences by a number of teachers. The skill of the teachers was apparent through their control of, and engagement with, their classes, as well as their ability to incorporate many different techniques for expressing the topics that the young people were learning. There are a huge number of topics and subject areas that are taught through the school time of a student, but as I remember from school myself, and as I was reminded of during the time I was visiting, so many of them are taught so that the students can answer a limited number of different style of questions in an exam which marks the culmination of a year or two years of study.

Though I have no qualification in teaching, and far inferior teaching abilities, I do have the advantage over the teachers at the school of being a current student myself and so gave a number of informal classes to demonstrate how the physics that the students have learnt can be applied

to more situations than those they have specifically learnt about. The skill to apply learning in this different way is one that is essential at degree level physics and can be very useful elsewhere and so I felt that this term was a good opportunity to explore how it can be explored, before it is required, at school level.

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