PHYSICS TEACHING AND ASSESSMENT IN THE UK AND THE USA

(REPORT FROM SABBATICAL LEAVE MAY/ JUNE 2007)

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INTRODUCTION

The purpose of my research was to see how NZ physics teaching, learning and assessment compare with similar practices in the Northern hemisphere English speaking countries such as the USA and UK.

My main finding is that although we have changed our assessment system in NZ, the learning and assessment of physics is not radically different from the above countries.
I think this is important because even in today's environment where communication is facilitated by the Internet there can be the feeling in NZ that we are isolated and falling behind the rest of the world in terms of our educational standards.
I feel, though, we must not be complacent in our outlook, particularly as regards recruitment and retention of teachers, which is a world wide problem.

BACKGROUND

I was awarded the long service one term sabbatical for which my salary was paid although no funds were provided for travel. I have taught physics and science for 37 years, 35 in NZ and 2 years back in the UK in 1974 and 1980 and I wanted to see how our system, particularly in light of recent changes, compared to overseas.

Recent changes in the NZ curriculum leading to changes in subject prescriptions and the huge change to the assessment system have led to such uncertainties within our system that NZ Schools have turned to overseas assessment systems thinking they have more rigorous standards. I wanted to find out if such fears are justified. I have family and friends in Singapore, the UK and the USA, so decided to combine catching up with friends and family with visiting schools and talking to teachers in these areas.

DATA COLLECTION/ ACTIVITIES UNDERTAKEN

I used the Internet to help research curricula and prescriptions and visited 4 schools on my trip. All the schools were identified through friends or family and e-mail contact was established well before my trip. I sent the schools an e-mail resume of my background and the purpose of my visit. All the schools were most welcoming and I am indebted to the teachers I talked to for giving of their time so freely.

I spent time at each school talking to physics and science teachers. I looked at schools generally and physics labs and departments in particular.

Visiting northern hemisphere schools in term 2 of the NZ school year is probably not the best time in terms of observing teachers in action with their senior classes, as the senior students are either in revision mode or sitting tests for graduation. This situation did, however, allow more time for the teachers to talk to me.

I studied the media, particularly newspapers, in the UK to find out the current state of education and educational research.

I also used the time for reflection about the teaching profession and what I consider to be important in the classroom.

The schools I visited were:

Singapore American School

The school population is 3,700 students, 300 teaching staff and with the whole range of ages from preschool to high school, approximately 300 students at each level. There were 50 student nationalities but 80% held USA passports. Class sizes at the High School level were between 18 and 20. This was the only fee paying school I visited, with the High School fees set at $23,000.

Gunnersbury Catholic Boys School, London, UK

The school population is 1,132 students with a yearly intake of 184 pupils. This is a year 7 to Year 13 school. The 6th form (Year 12 and 13) comprised 205 boys and 25 girls. There is a teaching staff of 67.

King Edward VI Community College (KEVICS), Totnes, UK

The school population is 1,700 students with 100 teachers and support staff. This is a Year 7 through to Year 13 school. There is an intake of 270 students per year.

Sunset High School, Portland, Oregon, USA

There are 2,122 students on the roll and 90 teaching staff. This is a Grade 9 through to Grade 12 school. (Year 10 through to Year 13).

FINDINGS

I have divided the findings into four categories: discussion with teachers, prescription and syllabi, assessment and media comments.

(A) Discussions with teachers

I would like to summarise here some of the comments that arose from the discussion with teachers.

- Physics teachers complained that the students lacked the mathematical rigor to tackle physics at A-level. In the UK, to popularise physics, to attract more students and make it seem less 'hard', it was taught as a contextual subject in double science at GCSE (NZ level1), which means that the students were poorly placed to cope with AS (NZ level 2) and A-level (NZ level3).

- There is a shortage of physics teachers in both the UK and the USA. This is a result of a number of factors..
    - There are better paid jobs in industry.
    - Education is not seen as an attractive career at the moment.
    - According to the latest information universities are closing their physics departments. In the UK 30% of physics departments have closed since 1992,

most notably my own alma mater Reading University which is closing in 2010. 28 chemistry departments have closed in the last 9 years. At this stage there are 35-40 physics departments in the UK universities. By 2014, the best case scenario is that 20 physics departments will be left and in the worst case 6! This is obviously affecting the number of physics graduates and therefore the number available for teaching.

- ❖ There were 3526 student applying to do physics in 1997, there were 3165 in 2003, not a huge drop off but it must be remembered that the number of students studying at university in the UK has increased hugely in the last 20years.

- Efforts are being made in the UK to recruit, retain and train teachers in the areas they are needed, that is, physics, chemistry, maths, ICT and languages. Monetary incentives to train in the UK include £9000 for the training year plus £5000 on completion of one term in the second year. Other schemes involve removing 10% of the teacher's student loan for each year that is taught.

- The subject of my sabbatical leave was of considerable interest to the USA and UK teachers as no such systems exist in these countries. We are well behind Australia in terms of sabbaticals, so we need to formalise and expand on what we are developing. Two systems used in Australia are effectively half a year on sabbatical after teaching 10 years, or more recently, teaching for 4 years on 80% salary and then the 5th year on sabbatical at the same salary. These are the incentives that would attract young people into teaching in the first place and also retain teachers in the profession. You can use all the jargon and buzz words you want but teaching is about the energy and enthusiasm of the teacher in the classroom.

- Several teachers in the UK directed me to a book called "Teaching Secondary School Physics" editor David Sang (John Murray Science Practice). I looked at it briefly on my trip and have ordered it through Amazon but it has yet to arrive. It did look useful.

The comments I make here are that we in NZ are going to have to get serious and innovative about the recruitment and retention of specialist science teachers. Sabbaticals, monetary incentives and improved conditions are what today's students require to attract them to the profession. Recruitment from the USA and UK is going to become increasingly more difficult.

(B) Physics prescription and syllabi

I compared the Advanced Placement (AP) (US), International Baccalaureate (IB) (worldwide) and Advanced Subsidiary and Advanced (AS and A Level) (UK) prescriptions with our own Level 2 and Level 3 courses. There is a great similarity between these overseas courses in their core area with a small variation in their optional structures. The core is very similar to what we teach at level 2 and 3.

Brief comments on each of the courses:

- **AP** consists of 2 courses: Physics B which is very similar to our Level 2 and 3 courses and Physics C, which includes calculus ideas and only looks at Mechanics and Electricity.

Some topics that we do not cover from Physics B: the coefficient of friction (static and dynamic), conservative and non conservative forces, angular velocity vectors, fluid mechanics (Bernoulli's theorem), kinetic theory and from Physics C: Gauss's law, Bio-Savart and Amperes laws, Maxwell's equations and Compton scattering.

- **IB** consists of a core similar to our level 2 and 3, with Standard Level options which we cover and Higher Level options including Biomedical Physics, Astrophysics, Relativity, History and Development of Physics, and Optics, of which the students have to study 2.

Some topics that we do not cover from IB are density (we cover this in NZ Level 1), I=neva, resistivity, Kinetic model of gases and the gas laws, 1st and 2nd law of thermodynamics, polarisation, de Broglie wavelength, Open and Closed Universes.

- **AS and A** level have the prescription set by the Qualification Curriculum Authority (QCA.org.physics) and various examining agencies (Edexcel, AQA, OCR, CCEA and WJEI) set the AS and A Level exams. AS and A Level comprise a 2 year course similar to our Level 2 and Level 3 courses.

Topics that we do not cover include: Avogadro constant, phases of matter, deformation of solids, ideal gases, temperature (NZ level 1), polarisation and some electric field work. The topic 'Application of Physics' which includes 'Gathering and Communication of Information' and 'Remote Sensing'

*The comments I would make here are that the prescriptions/syllabi used overseas are very similar to each other. The option areas offered obviously differentiate the courses and add to them in terms of content and context. The core of these courses is very similar to our Level 2 and 3 courses. However I did find much greater detail in the overseas prescriptions, with regards what has to be taught, than that stated for the NZ Achievement Standards**.** I also noticed that lessons were based on recommended and recognised textbooks which to be honest I found a bit regimented. It did give those students who missed any classes a chance to catch up.*

(C) Assessment

I then considered how each of the courses was assessed.

AP Physics.

Physics B: one 3 hour exam:
70 multiple-choice questions and a free response section of 6 x 15 minute questions
Single grade awarded.
Physics C: one 3 hour exam:
Mechanics 1.5 hours 35 multiple-choice questions (50%) and 3 free response questions (50%) and then a similar paper for electricity. A grade is awarded for each paper.

AP Grades.	5	extremely well qualified	13%	These %'s do vary
	4	well qualified	18%	from subject to subject
	3	qualified	30%	and from year to year.
	2	possibly qualified	14%	
	1	no recommendation	25%	

IB Physics

Standard Level (SL) (equivalent to Year 12)
Paper 1 (1 hour) 30 multiple-choice (20%)
Paper 2 (1 hour) 1 data based question, several short questions and 1 extended response question from a choice of 3.(32%)
Paper 3 (1 ¼ hour) several short answers, 1 extended response question on each of the 2 options studied. (24%).
Practical assessment (24%)

Higher Level
Paper 1 (1 hour) 40 multiple-choice and 1 data based question. (20%)
Paper 2 (2 ¼ hours) several short answer questions plus 2 extended response questions from a choice of 4. (36%)
Paper 3 (1 ¼ hours) several short answer or structured questions and 1 extended response questioning each of the 2 options studied. (20%)
Practical assessment (24%).

IB Grades (7 down to 1) 7 is excellent, 4 is average and 1 is poor.
To get an IB Diploma a student has to get 24/45 credits (i.e. 6 subjects at an average grade of 4)

Advanced Level (Year 13)
Advanced Level Subsidiary (Year 12)

The information given below is for a typical set of papers because the core curriculum is set by the QCA and examined by 5 examining authorities in the UK, as mentioned previously, of which Cambridge is one.

Paper	Type of paper	Duration	Marks	Weighting	
				AS Level	A Level
1	Multichoice	1hour	40	31%	15%
2	AS structured questions	1hour	60	46%	23%
3	Advanced Practical Skills	2hours	40	23%	12%
4	A2 structured questions	1 3/4 hours	100		38%
5	Planning, analysis and evaluation	1 1/4 hours	30		12%

Paper 1 is 40 multiple-choice from the AS syllabus
Paper 2 is a variable number of structured questions from the AS syllabus
Paper 3 consists of 2 experiments.
Paper 4 Section A (70 marks) on the A2 core and Section B (30 marks) based on Applications of Physics.
Paper 5 consists of 2 questions of equal mark value based on the practical skills of planning, analysis and evaluation.

AS candidates take papers 1, 2 and 3 (yellow section). Those that pass can take their AS marks forward and just take papers 4 and 5 in their final year. It is possible to take all the papers in a single session.

A Level Grades.

A above 80%, B above 70%, C above 60%, D above 50%, E above 40%, U is anything lower. 96% of candidates get between A and E!

The comments I would make here I have bullet pointed below

- *All methods of assessment seem to be spread over two years. They comprise 3 to 4 hours of testing including practical assessment. The exams are broken into smaller modules either by type of questioning or content (i.e. mechanics split from electricity.)*

- *All the overseas exams use multiple-choice questions in some part of the exams. For some reason this method of testing has lost favour in NZ. I think for science and engineering students it teaches logic and decision making which is an important skill in these subject areas.*

- *The questions in the exams that I looked at related to our curriculum seemed on a par generally with those being asked at Level 2 and 3 NCEA.*

- *The grades offered in AP are 5-1, in IB are7-1, in A Level A-E (U), that is either a 5, 6 or 7 point scale. We offer a 4 point scale with E, M, A and NA. I would suggest that our scale needs expanding a little to correspond with overseas trends.*

- *All overseas exams are marked with a mark system 1, 2, or 3. We have made a rod for our backs by introducing such a convoluted system of marking, particularly in Physics where both calculations and explanations are considered separately.*

- *The majority of students in the USA graduate from their High Schools through their own internal exam systems. Their entry to University is already decided by the SAT's that are completed earlier in the year. This does take some of the pressure off the USA students at exam time at the end of the year.*

(D) **Media comments.**

The Daily Telegraph in the UK publishes an excellent educational section and I will mention a couple of the articles that have appeared recently.

One article commented that schools under Labour have turned into 'factories' that churn out exam results but fail to educate children properly. A recent survey indicated that British school children were the unhappiest in the Western world. Five year olds were being drilled to pass National tests. It appears that English children are among the most tested in the world.

In another article, some schools were considering re-introducing separate sciences at GCSE level. Separate sciences were considered difficult and to be discouraging students from studying science at A-Level. As a result 'double science' was introduced involving contextual science and debate about science related issues. Unfortunately this led to students not being well prepared to study at A-Level physics and the number of pupils taking A-Level physics has fallen by 56% (and chemistry by 36%) in the past 10 years.

The final article I will mention concerned a television documentary that explored the perceived gap between the state and private education. In an experiment three white, middle class students from a private school in Wells (fees £29,000) switched with three Asian students from a top 2% state comprehensive in a working class, ethnically mixed area of north-west London. There were many comments to come from this experiment, which had flaws in terms of its methodology. (An outstanding comprehensive was compared to an expensive but not academically elite independent school.)

The private school students were surprised at the work load they experienced and they didn't think there was much difference between the schools. Similar sentiments were expressed by the Asian students and one of the girls felt she was not being challenged enough. This same girl summed things up by saying that the private school students were paying for facilities. An example she quoted was that in biology they each had a heart to dissect but at her comprehensive they had watched the teacher dissect the only one available.

CONCLUSIONS AND RECOMMENDATIONS

- ***The teaching and learning of physics does not vary greatly around the world and we are fairly well placed as regards what we are doing. I consider that the students I teach in the NZ system who do well here would be able to study physics in both USA and UK universities without any difficulty.***
- ***We do need to detail our Achievement Standards more vigorously to help teachers particularly those new to the profession.***
- ***The assessment system we use is different! No one else in the world uses one similar and I'm not sure whether this is a good thing. I certainly think the scale should be expanded from a four point system and the unusual marking method particularly in physics needs to be addressed.***
- ***There is going to be a shortage of physics teachers and we are not going to be able to address this by recruiting overseas as there is a shortage in both the USA and UK. The profession has to be made more attractive by having smaller classes and a structured sabbatical system. I also favour the reduction of student loans for teachers, for example, 10% off the loan for each year of teaching after training.***

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